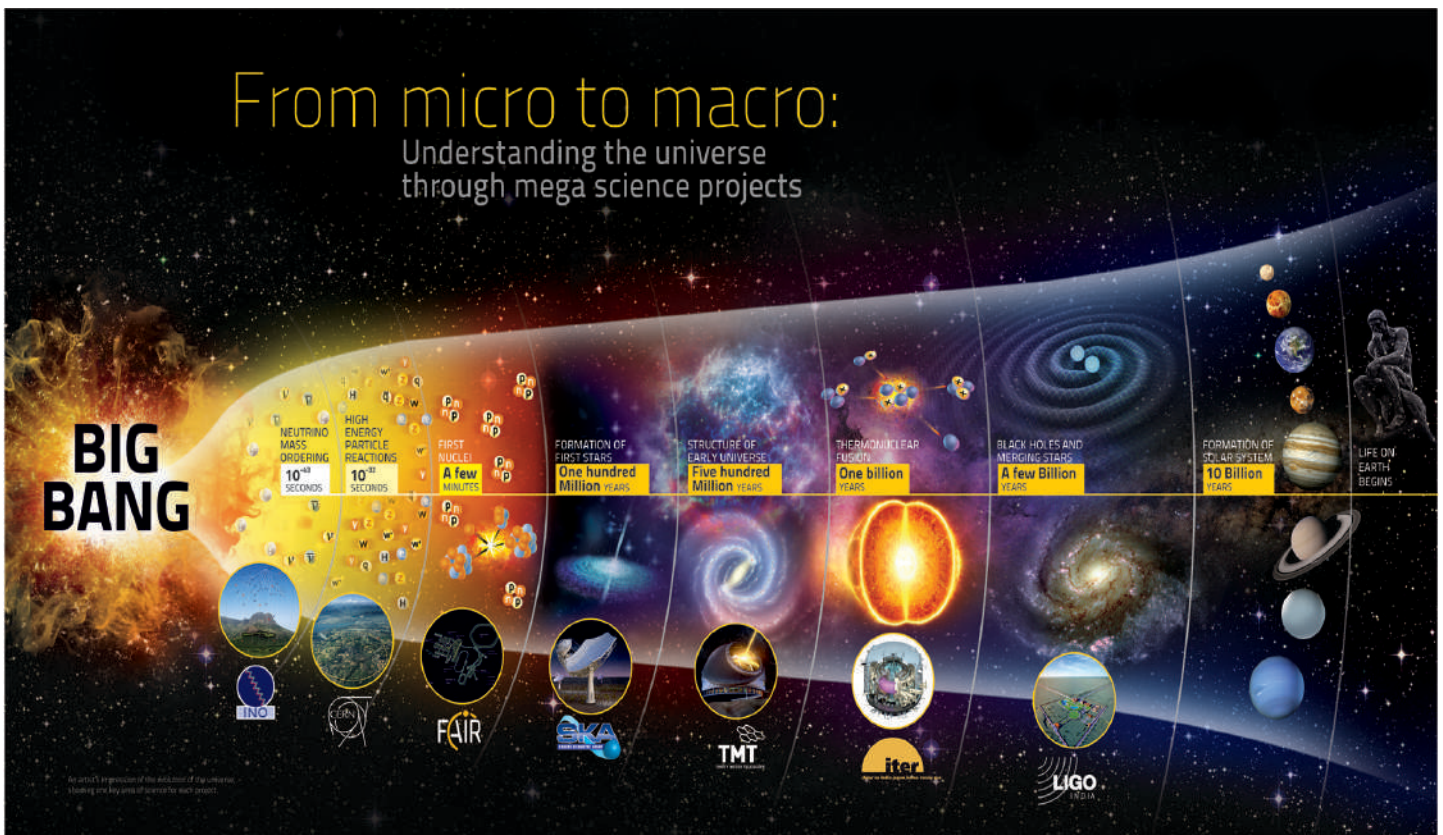


Annual Report 2019-20



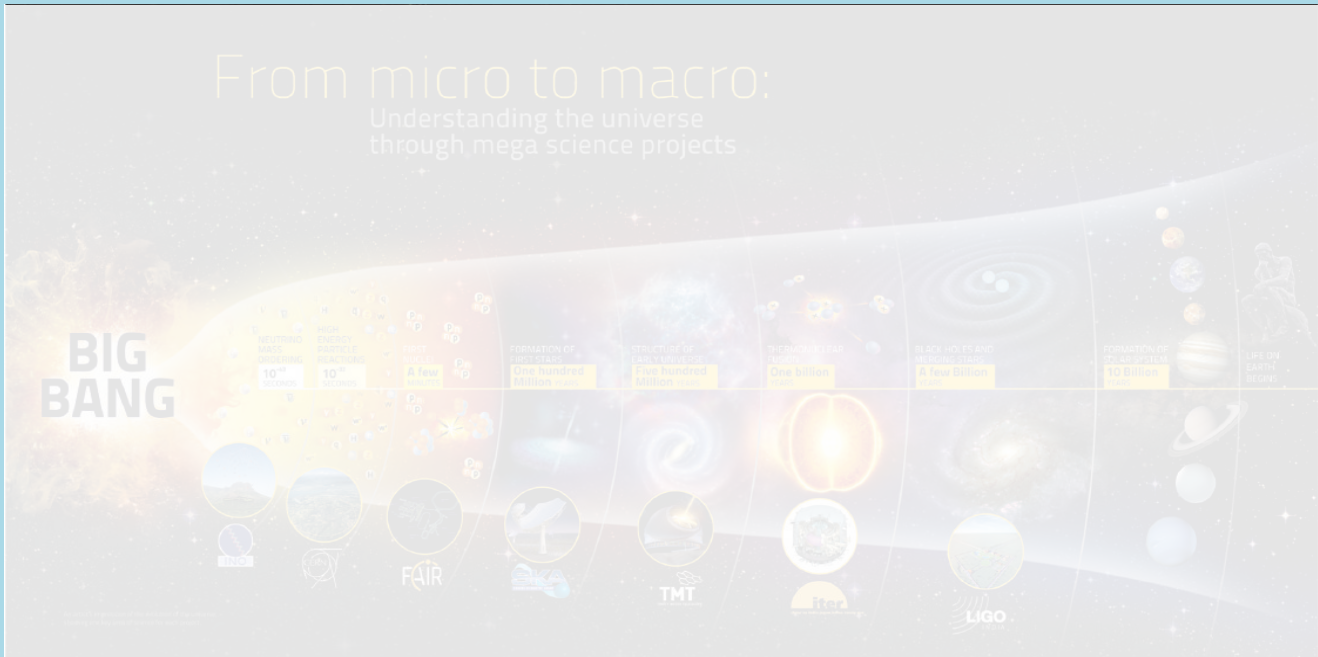
सत्यमेव जयते

Government of India

Department of Science & Technology

Ministry of Science & Technology

New Delhi



From Micro to Macro: Understanding the Universe through Mega Science projects: Mega Science projects showcased on a single diagram interestingly fall along the common thread of quest for the origin, evolution and functioning of the Universe. These projects are aimed at probing the science at the respective time scales shown in this diagram and throw light on crucial fundamental questions related to the evolution of Universe through its various stages since the time Big Bang has happened about 13.7 billion years ago. From the perspective of cosmic scales, our existence seems very small, but it goes to the credit of human civilization that we have been able to unravel, and we continue to unravel the mysteries of the Nature through different windows of scientific investigations employing specialized sophisticated instruments in these projects.

Annual Report 2019-20



**Government of India
Department of Science & Technology
Ministry of Science & Technology
New Delhi**

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OVERVIEW

The Department of Science & Technology plays a pivotal role in promoting new areas of Science & Technology and as the nodal department for organising, coordinating and promoting S&T activities in the country. DST also functions as the nodal agency to connect science and technology sector to different Government verticals. DST provides the largest extramural research and development support in the country to strengthen national S&T capacity and capability through a competitive mode to scientists cutting across institutions and disciplines. This strategically important function mutually reinforces outcomes of our country's educational, scientific and industrial R&D initiatives and helps transform the S&T landscape of the country.

While a detailed account of achievements of Department's activities during the year is presented in relevant chapters, some of the major achievements and initiatives of 2019-20 are briefly presented in the following sections:

Fund for Improvement of S & T Infrastructure (FIST) in Universities and Higher Educational Institutions is currently operated in competitive mode of support at four levels. The financial support circumscribes four basic purposes i.e. Equipment, Networking & Computational Facilities, Infrastructural Facilities and Maintenance. Depending on the level, the total financial support is limited to Rs 1.50 Crore, Rs 3.0 Crore, Rs 10.0 Crore and Rs 20.0 Crore for Level 0, Level I, Level II and Level III, respectively. 95 proposals out of 832 were identified through the evaluation process of the Program to consider financial support of varying quantum's at a total budget of about Rs 121 Crores for 5 years.

"Promotion of University Research and Scientific Excellence (PURSE)" is a proactive measure of DST to build the research capacity of performing Indian Universities. Using transparent criteria forty-four (44) performing universities have been supported ranging from Rs 30.0 Crores to Rs 6.0 Crores for 4 years' period based on publication output in Scopus International Database.

Sophisticated Analytical Instrument Facilities (SAIF) have been established in different parts of the country to provide services of the facilities of sophisticated analytical instruments. There are at present 15 Nos. SAIF Centres in the country. About 20,000 researchers from all over the country utilized and benefitted from the facilities during the year. These SAIF Centres have analyzed more than 1,25,000 samples during the year and have generated a revenue of about Rupees 10.40 crores in this year

State S&T Programme facilitates states to achieve the specific S&T objectives at their level.

28 State Councils for S&T were supported by providing grant in aid of Rs. 25.87 Crores. 24 new projects/ programme were supported to address the State Specific S&T challenges, S&T surveys and studies in the tune of 13.40 Crore. Annual Conclave of the State S&T Councils was organized at Telangana State Council for Science Technology, Hyderabad during 22nd to 24th August'2019 to review the progress of the various State S&T Councils in the country

Five **Policy Research Centers (PRC)** have ben supported by DST in institutions across the country to understand STI processes for making effective policies, strengthen them and link these evidences to policy making.

Centre for Human and Organizational Research Development (CHORD) conducts national surveys to generate and make available information on manpower as well as financial resources devoted to S&T activities. Launched the 2nd National Innovation Survey entitled '**India Innovation and Systems Survey 2019**'. The data collection for National Survey 2017-18 on resources devoted to research and development activities (launched both in print and e-mode) has been completed.

Under "National Programme for Training of Scientists & Technologists working in Government Sector", 40 training courses, benefitting about 800 scientists, were targeted under the programme. During the same period, under the Women Component Plan, 16 courses, benefitting about one hundred and eighty women scientists, were targeted.

KIRAN (Knowledge Involvement in Research Advancement through Nurturing) embraces women-exclusive schemes of DST with the mandate to bring gender parity in S&T through various mechanisms. 231 projects out of 720 applications were recommended with extensive as well as intensive scrutiny for support under WOS-A. Total 75 projects were recommended under WOS-B. Total of 114 women joined the 11th batch of WOS-C for one-month orientation programme held at New Delhi in August 2019. 20 women scientists (10 in each category) have been selected under the two categories of WISTEMM viz. student internship and fellowship. The DST launched **Vigyan Jyoti** Scheme to encourage girl students for STEM career especially in under represented areas for women. In the first phase 2500 meritorious girl students of class XI have been selected in 50 Districts in collaboration with NVS.

Innovation in Science Pursuit for Inspired Research (INSPIRE) is to attract talent to the study of science from an early age and build the required human resource pool for strengthening and expanding the R&D base and the Science & Technology (S&T) system of the country. About 98 INSPIRE Internship camps were organised during the year wherein about 20,000 students studying science in Class XI were provided an opportunity to interact with science icons from India and abroad including Nobel Laureates. 10,220 INSPIRE scholarships were offered during the year. 159 INSPIRE-Faculty Fellowships were offered during the year. Under the Institutional Mode, 982 ongoing Scholars received their Scholarship for taking up undergraduate/integrated post-graduate degree courses in basic and natural sciences.

3705 INSPIRE Fellows received their fellowship (including 952 new fellows) during the year. 562 INSPIRE Faculty Fellows received their Fellowship including 67 new INSPIRE Faculty Fellows.

Under **Swarna Jayanti Fellowship** 14 Fellows have been selected through a three-tier rigorous screening process from 443 applications.

New Program of International Bi-lateral Cooperation in Science & Technology were initiated with Brazil, Mexico, Philippines, Slovenia, Sri Lanka, Sweden, Switzerland and Uzbekistan. About 340 new joint projects and over 100 Joint Workshop/ Seminars were supported during the years. The 25th DST-CII Technology Summit with Netherlands as partner country was held in New Delhi during 15-16 October 2019.

The highlights of **International Multilateral and Regional S&T Cooperation** include the BRICS Science, Technology and Innovation (BRICS STI) Cooperation; India-EU Science and Technology Cooperation; India-ASEAN STI Cooperation; STI Engagements with the Group of Twenty (G20) countries. India hosted 12th India-EU Joint Steering Committee Meeting on 1st March 2019.

National Mission on Nano Science & Nano Technology supported 22 new individual scientist-centric R&D projects during the year. 46 new proposals from various institutes/ university across the nation are be supported under Nano Mission.

Activities under **Mega Facility for Basic Research** include its support for Antiproton and Ion Research (FAIR), Darmstadt, Germany, Experiments at the Large Hadron Collider (LHC) at CERN, Geneva, India-based Neutrino Observatory (INO), Madurai, Thirty Metre Telescope (TMT) Project, Laser Interferometer Gravitational-Wave Observatory (LIGO) Project, Accelerator-based Research Facilities, etc. 20 Actuators made in India by four Indian companies were shipped to the TMT Project Office, USA and these actuators successfully completed performance and life-cycle tests, paving the way for their production in India.

Under **Climate Change Programme**, two national missions on climate change under National Action Plan on Climate (NAPCC), viz., National Mission on Strategic Knowledge for Climate Change (NMSKCC) and National Mission for Sustaining the Himalayan Ecosystem (NMSHE) are being implemented. Several new initiatives were launched during the year 2019-20. These include; 03 Centre of Excellence, 08 Major R&D Programmes, 02 state network programmes and one vulnerabuiltiy profiling programme

Two Supercomputers named "PARAM Shakti" at IIT Kharagpur and "PARAM Brahma" at IISER, Pune have been installed.

The **Integrated Cyber Physical Security (ICPS)** programme intitiated during the year 2018-19 supported several projects in the areas of Data Science Research Initiative (DSRI), Internet

of Things Research Initiative (IoTRI), Cyber Security for physical infrastructure (CSRI), Quantum Enabled Science and Technology (QuEST).

Technology Development Programme has supported 28 new projects under Advanced Manufacturing Technology, 33 under Biomedical Device and Development, 15 under Device Development and 20 under Science and Heritage Research Initiative.

Under **Drugs and Pharmaceuticals Research Programme (DPRP)**, 22 project proposals have been recommended out of 159 proposals for financial support with the aim of enhancing capabilities of institutions and Industry towards development of New Drugs in all systems of medicine.

Patent Facilitation Programme (PFP) has provided financial support to 24 Patent Information Centers established at various State Councils to the tune of Rs. 6.5 Crore. During the period 16 Indian Patents have been granted to respective applicants and facilitated filing and prosecution of the patents.

Seven new test facilities were granted the **Good Laboratory Practice (GLP)**-compliance status. As on date, there are 50 GLP certified test facilities in the country.

Clean Energy Research Initiative (CERI) covers the research spectrum of entire gamut of clean energy viz. smart grid, off grid, energy storage, building energy efficiency, cleaner fuels, clean coal and energy materials. The initiatives include Syste Mission Innovation Challenge: Smart Grids and Affordable heating and cooling buildings, Clean Coal technologies, Methanl & Methyl Ether, Solar Energy, etc. **Water Technology Initiative** aims to find out appropriate technological solutions through field level interventions to demonstrate technical, social, environmental and eventually economic sustainable solution for water challenges. Several technologies have been developed and deployed under the programme.

Natural Resources Data Management System (NRDMS) Programme aims at promoting R&D in emerging areas of Geospatial technologies and applications. 12 R&D projects have been supported to various institutions to undertake research work under GRACE, 10 Research and Development projects to develop an early warning system for landslide at various sites.

DST has been pioneer in establishing a network of Technology Business Incubators (TBI) and Science & Technology Entrepreneur's Parks (STEP) across the country under the **NIDHI program**. These startup incubators support and nurture knowledge driven innovative startups into successful enterprises. **Nanoclean Global Pvt. Ltd**- a seed supported startup at FITT, IIT Delhi has developed a Nasofilter to for surface filtration and auto-cleaning itself while one exhales. 9 Accelerator programs were supported in the areas of Digital technologies, Climate Change, Energy, Entrepreneurship and Innovation, Health, Waste Processing, Water, Health tech start-ups Manufacturing Sector, AgriTech, CleanTech, Food Tech, Health & Sanitation, benefitting 152 startups.

National Council for Science and Technology Communication (NCSTC) largely aims at communicating and popularizing science and technology (S&T) to masses and stimulate scientific temper amongst them. DD Science has been launched and available on DD National from 5 pm to 6 pm, Monday to Saturday since January 15, 2019. Wikipedia in Indian Languages to popularize science and technology through Wikipedia in Indian languages.

Science for Equity for Empowerment and Development (SEED) scheme supports several field based programs with the application of S&T linked to directly benefitting the society has been implemented under. Long term Core Support is extended under Technological Advancement for Rural Areas (TARA) programme to 26 S&T based NGOs primarily to provide affordable technological solutions to challenges in rural as well as remote areas. About 60 projects have been recommended for support under Scheme for Young Scientist and Technologists (SYST) focused towards encouraging, nurturing and mentoring young scientists addressing societal challenges through S&T based solutions. A total of 2000 SC farmers has been trained in *standardization of large-scale microbial technology of agro waste using microbiological and composting techniques*. 7500 households have been benefitted in improved socio economic status with a significant improvement in skills, building on local innovation & local knowledge under Tribal Sun Plan (TSP).

Five **Technical Research Centres (TRCs)** were established in 5 DST institutions in 2015-16. The TRCs have developed and transferred some significant technologies to industry during the period.

The Exhibition Cell of DST participated in four major national and international events during the year.

The Department of Science and Technology nurtures 25 **Autonomous Bodies (ABs)**. These include 16 research institutions, 4 specialized knowledge institutions and S&T service organizations and 5 professional bodies. These institutions have a long and varied history and their variety of activities significantly contribute to the S&T eco-system of the country. The activities and achievements of the autonomous institutes during the year are presented in the report.

The **Science and Engineering Research Board** has come up with several innovative programmes and schemes to identify potential scientists and support them for undertaking R&D in frontier areas of Science and Engineering. The Board interventions are primarily focused to expand the research base in the country without compromising the quality of research. Special attention has been given to invest in young minds; and, to strengthen new areas of science. Some of the important programmes include flagship programmes like Early Career Research Award, National Postdoctoral Fellowship, Ramanujan Fellowship, Visiting Advanced Joint Research (VAJRA) Faculty Scheme, IMPRINT (Impacting Research Innovation and Technology), Mathematical Research Impact Centric Support (MATRICS)

Scheme, International Travel Support (ITS) scheme, etc. SERB Board has adopted a Scientific Social Responsibility (SSR) policy as an integral part in SERB Programmes. SERB-TETRA, SERB-SUPRA, SERB-VORTEX & SERB-STAR are the new initiatives during the year. SERB connects the S&T system through 34 Schemes and Programmes catering to different segments of S&T ecosystem.

The Department has made every effort to utilize the allocated budget fruitfully to implement its planned activities and programmes during the year.

S & T INSTITUTIONAL & HUMAN CAPACITY BUILDING

1.1 R&D Support (FIST, PURSE, SAIF)

Department implements couple of Programs dedicatedly for Scientific Infrastructure Building i.e Fund for Improvement of S & T Infrastructure in Universities and Higher Educational Institutions (FIST), Promotion of University Research and Scientific Excellence (PURSE), Sophisticated Analytical Instrument Facilities (SAIF). During the current year, a new major R&D infrastructure initiative of DST has been the launch of SATHI Program “Sophisticated Analytical and Technical Help Institute”.

1.1.1 *Fund for Improvement of S & T Infrastructure in Universities and Higher Educational Institutions (FIST)*

“**Fund for Improvement of S& T infrastructures in Universities and Higher Educational institutions (FIST)**” Program is the major infrastructure augmentation program of Government which facilitates support towards augmenting basic infrastructural facilities for conducting research in basic or applied science areas at the university and academic sectors.

At present, the Program is operated in competitive mode of support at four levels i.e. Level 0, Level I, Level II and Level III covering six subject areas (Life Sciences, Physical Sciences, Chemical Sciences, Engineering Sciences, Earth & Atmospheric Sciences, Mathematical Sciences) and PG Colleges. While support under Level 0 is provided to all PG Science & Applied Science Departments as a composite project in “Colleges as a whole” mode, supports under Level I/ Level II/ Level III are meant for Science/ Applied Science Departments of Universities/Academic Institutions. The financial support circumscribes four basic purposes i.e. Equipment, Networking & Computational Facilities, Infrastructural Facilities and Maintenance. Depending on the level, the total financial support is limited to Rs 1.50 Crore, Rs 3.0 Crore, Rs 10.0 Crore and Rs 20.0 Crore for Level 0, Level I, Level II and Level III, respectively.

During April - May 2019, the call for submission of proposals (last date 15th May 2019) under this Program was announced in the leading newspapers and Website. Around 832 Proposals in different subject areas Life Sciences, Physical Sciences, Engineering Sciences, Chemical Sciences, Earth & Atmospheric Sciences, Mathematical Sciences and PG-Colleges have been received online from departments of universities and academic institutions exclusively. A total of 95 proposals were recommended in seven subject areas including PG Colleges with

an amount of Rs 120.94 Crores for a duration of 5 years for Scientific Infrastructure Building in various academic institutions, Universities Departments and PG Colleges. During the current year, FIST Advisory Board endorsed the concept of Scientific Social Responsibility in recommended level II departments. The review of 163 projects were carried in seven subject areas during the current year.

Since the initiation of the program in 2000, nearly 2912 S&T departments and PG colleges have been supported/recommended. About 480 PG Science/ Engineering/ Medical Colleges have undergone rejuvenation of teaching and research facilities since initiation of the program.

FIST Program has been instrumental in establishing state-of-the-art facilities for performing high end research and have thus benefited academicians and researchers across the country. The Program has made significant research impact in many departments across the country to carry out advanced research in contemporary areas of science and technology. The researchers are benefited so that their potential is tapped for scientific advance and innovation. Some of the major facilities supported under the Program are: High Resolution Powder X-Ray Diffractometer, Single Crystal X-ray Diffractometer, Automated DNA Sequencers, Ultracentrifuges, FACS, Scanning Probe Microscope, Molecular Imaging System, Thermo-mechanical Simulator, Liquid Nitrogen Plant, Liquid Helium Plant, 400 MHz & 500 MHz FT-NMRs, Mass Spectrometer, Universal Testing Machines (UTMs), EPMA, Confocal Microscope, Field Emission Scanning Electron Microscope, High Resolution Transmission Electron Microscope, Protein Sequencing Platform etc.



Electric Universal Testing Machine with Furnace acquired under DST FIST at Department of Metallurgical and Material Engineering, Jadavpur University, Kolkata



Four mirror optical floating zone crystal growth system acquired under DST FIST at Anna University Chennai

The realm of the FIST Program has produced scientific infrastructure in many prestigious medical/ veterinary/ paramedical institutions in the country like All India Institute of Medical Sciences, New Delhi; Sanjay Gandhi Post Graduate Institute of Medical Sciences, Lucknow; Postgraduate Institute of Medical Education and Research, Chandigarh; Maulana Azad Medical College, New Delhi; University College of Medical Sciences, Delhi; Mahatma Gandhi Institute of Medical Sciences, Wardha; JIPMER, Pondicherry; Christian Medical College, Vellore; Cancer Institute, Chennai; All India Institute of Speech and Hearing, Mysore; Institute of Post-Graduate Medical Education & Research, Kolkata etc.

Further, several departments of renowned Agricultural Universities have been regular recipients of the FIST Projects. This Program has significantly contributed to the enhancement of teaching and research infrastructure in many agricultural Universities including Assam Agricultural University, Jorhat; University of Agricultural Science, Bangalore; University of Agricultural Science, Dharwad; CCS Haryana Agricultural University, Hisar; CSK Himachal Pradesh Krishi Viswavidyalaya, Palampur; Dr Y S Parmar University of Horticulture & Forestry, Solan; Punjab Agricultural University, Ludhiana; Tamil Nadu Agricultural University, Coimbatore; GB Pant University of Agriculture, Pantnagar etc

Over the years, the FIST Program has played a pivotal role in strengthening of both the teaching and research infrastructure in different academic and research institutions and changed the infrastructure landscape of these organizations, across the Nation.

2.1.2 Promotion of University Research and Scientific Excellence (PURSE)

“**Promotion of University Research and Scientific Excellence (PURSE)**” is a proactive measure of DST to build the research capacity of performing Indian Universities. The main objective of the scheme is to pro-actively support for strengthening the R&D base of the performing Universities in the country with adequate financial support and associated flexibility. It is formulated on the basis 10 years aggregate publications and h-index towards creating and nurturing the research ecosystem among performing universities in the country.

Under PURSE program large investments have been made to encourage, nourish and sustain research performance of the leading universities. The support under PURSE to acquire research equipments, research man-power cost, augmentation of computational facilities, establishing research infrastructure, acquiring research consumables, fund for travel, organizing workshops and conferences, contingencies and maintenance of the facilities. Total investment of Rs 1220 crore was planned for performing Universities identified under PURSE, so far, an amount of Rs 900 Cr has been made available to the performing Universities this scheme. Regular reviews of the PURSE Projects at various Universities have been performed by Programme Management Board on PURSE. In the current year, support to ongoing projects under PURSE have been provided. Final review of PURSE Projects have been carried for University of Delhi, Delhi and Jawaharlal Nehru University, New Delhi by Programme Management Board on PURSE.



Fig. Mobile Ambient Air Pollution Monitoring System established out of DST PURSE at Mahatma Gandhi University, Kottayam Kerala

Mahatma Gandhi University, Kerala has come up with a new facility under DST PURSE for air pollution monitoring. The newly installed mobile ambient air pollution monitoring system is able to observe different air pollutants, such as PM₁₀, PM_{2.5}, SO_x, NO, NO₂, NO_x, CO, CO₂ and O₃ simultaneously. This is the only mobile continuous monitoring facility in the state to measure air quality. The mobile unit can be transported anywhere, which helps monitor air pollution in locations where no monitoring was conducted earlier. The continuous sampling is supposed to provide more data on specific locations, which specifies the peak time of emissions on that particular location. This enables public to take precautionary measures for better health protection.

In the coming years, the Department plans to reorient PURSE. Introduction of I₁₀ index of faculty members in the University, along with the H index may be used to formulate the new criteria for assessing the performance of Universities under PURSE and Mission mode-based restructuring of PURSE Universities to focus on thrust areas which align with National priorities of Excellence in Manufacturing, Waste processing, Clean Energy, Water and Start up India are some of the recommendations suggested Third Party Evaluation of DST Schemes.

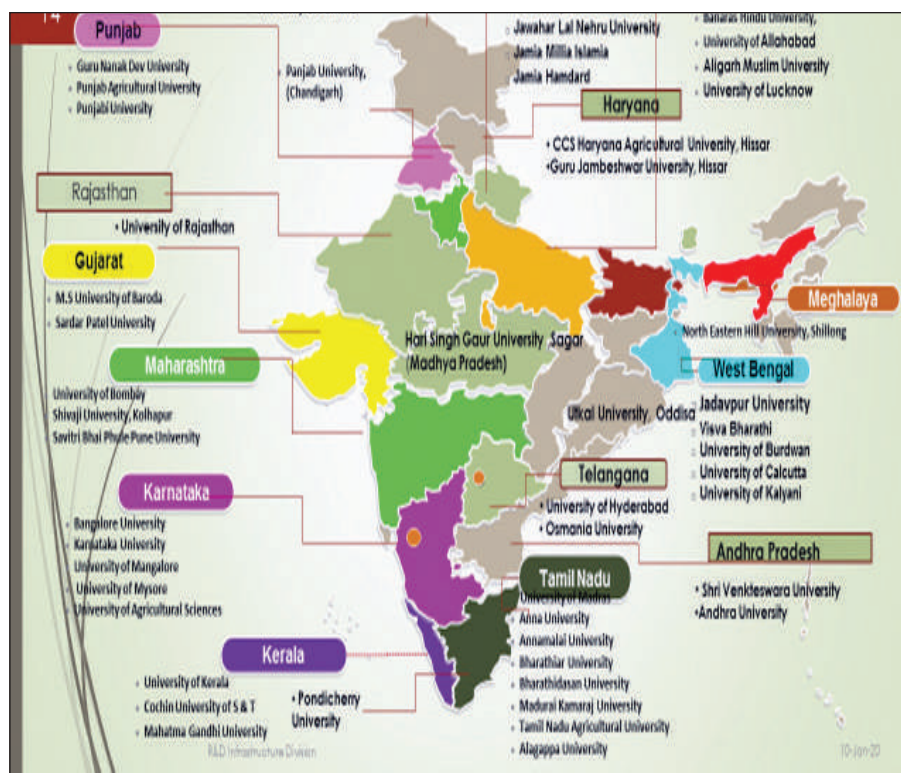


Fig. Landscape of PURSE supported Universities across the country

2.1.2 Sophisticated Analytical Instrument Facilities (SAIF)

Many academic institutions including Universities in the country still lack the existence of specialized facilities to carry out both basic and advanced research in contemporary areas of science and technology. The Department has thus setup Sophisticated Analytical Instrument Facilities (SAIFs) in different parts of the country to provide services of the facilities of sophisticated analytical instruments to the researchers in general and specially from institutions which do not have such instruments and enable them to pursue R&D activities requiring such facilities and keep pace with the developments taking place globally.

There are at present 15 Nos. Sophisticated Analytical Instrument Facility (SAIF) Centres in the country viz. at IIT, Chennai; IIT, Mumbai; CDRI, Lucknow; Panjab University, Chandigarh; NEHU, Shillong; IISc., Bangalore; AIIMS, New Delhi; Gauhati University, Guwahati; CVM, Vallabh Vidyanagar; Sophisticated Test and Instrumentation Centre (STIC), Kochi; IIT, Patna; IEST, Shibpur; Shivaji University, Kolhapur; M.G. University, Kottayam; and at Karnataka University, Dharwad.

SAIFs centres are equipped with high end analytical instruments such as Nuclear magnetic Resonance Spectrometers, Scanning Electron Microscopes, Transmission Electron Microscopes, Secondary Ion Mass Spectrometer, ICP, EPR Spectrometers, Mass Spectrometers, Nano LC-

MS/MS, X-ray Diffractometers, Dual Beam FIB-FEG SEM, ICP-OES Facility and Thermal Analysis Systems etc. to meet the needs of the researchers in various areas of Science and Technology and emerging needs of Research Community. The instrument facilities at the SAIFs are accessible to all the users irrespective of whether they belong to the host institutes or are from the outside the host institutes and are being used extensively by the researchers from Academic, R&D labs., and Industry all parts of the country. Efforts are being made to augment these facilities with the state of art instruments.

The instrument facilities at SAIFs are meeting the analytical needs of scientist in various areas of S&T. A wide range of Analytical techniques/methods for chemical/material analysis/testing/ characterization including qualitative/quantitative elemental, molecular/compound analysis, structure determination, microstructure analysis and surface topographic studies, study of physical, optical and electrical properties of materials etc. are available to pursue research in various frontline areas of S&T.



Fig. ICP-MS in SAIF-Kochi

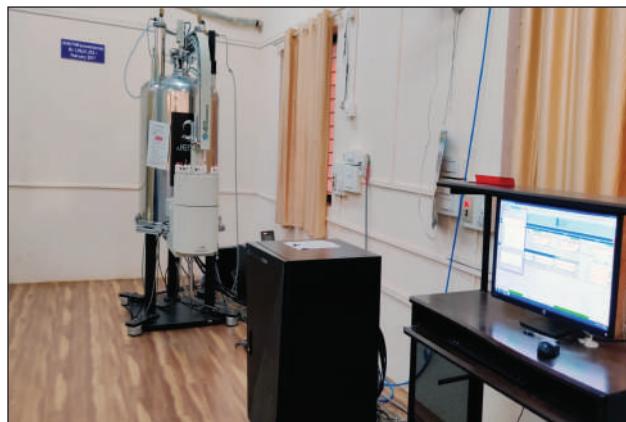


Fig. 400 MHz FT-NMR spectrometers housed at SAIF, Karnatak University, Dharwad

In the current year, Facility Management Meeting were held at AIIMS, New Delhi, IIT Bombay, CDRI Lucknow, University of Guwahati, Karnataka University, Dharwad, Shivaji University, Kolhapur, Vallabh Vidhyanagar; Sophisticated Test and Instrumentation Centre (STIC), Kochi; STIC and IISc Bangalore to monitor the technical progress and suggest futuristic directions. This year about 20,000 users from almost all academic institutions, industries and R & D Labs utilized these SAIF Facilities. On an average out 1,25,000 samples are being analysed at these centres. Every year, about 2000 research papers (partial number) are being published by the users of the SAIFs with the support from these facilities.

In an addition, about 30-35 workshops and training programs are organized by the SAIFs every year towards maintenance/repair/operation of instruments for researchers and application of various instruments and analytical techniques to create awareness among the research community about them.

2.1.4 *Sophisticated Analytical & Technical Help Institutes (SATHI)*

The Department of Science and Technology (DST) has initiated of setting up a shared, professionally managed, Science and Technology infrastructure facility, which can readily be accessible to academia, start-ups, manufacturing units, industries and R&D Labs. Such S&T infrastructure will be known as **Sophisticated Analytical & Technical Help Institute (SATHI)**. These Centres will be equipped with major analytical instrument and advanced manufacturing facility, which is usually not available at Institutes / Organisations. SATHI is a revolutionary preposition of DST for taking experimental research in the country to the next level.

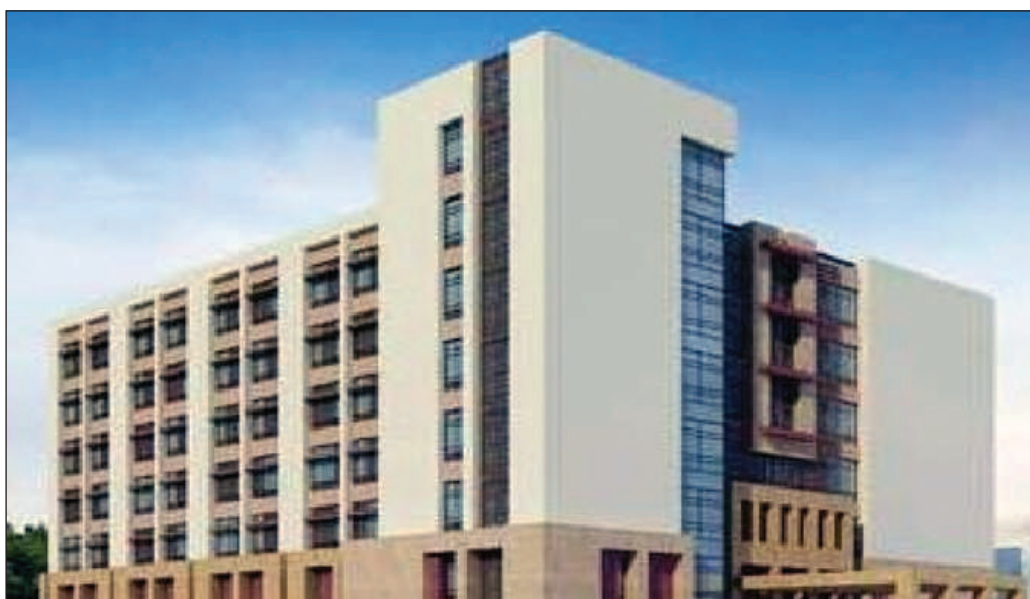
SATHI is to provide shared, professionally managed services and strong Science and Technology infrastructure / facilities, with efficiency, accessibility and transparency of highest order under one roof to service the demands of faculty, researchers, scientist and students of Host and User institutes / organisations (including other academic institutes, universities, national laboratories, start-ups, manufacturing and engineering industries, SME's, R&D Labs) to enable them to carry out activities on a round the clock basis with minimum downtime. Each SATHI centre is supported with Rs. 125 crores spread over 3 years duration, starting from current FY 2019-20. SATHI facilities will be used for 80% of their available time by External Users i.e. out-side of the Host Institutes and rest 20% of available time for Internal Users of the Host Institute. The usage of the facility will be guided by the basic principle of maximum and effective utilization and accessibility to all. The users will be able to do online booking for using these facilities from any part of the country.

As recommended by high level Expert Committee, in the current period, SATHI facilities are being set-up at **IIT-Delhi, IIT-Kharagpur and BHU- Varanasi**.

SATHI @IIT Delhi is set up in a state-of-the-art building at Sonipat campus having residential facilities for large number of users. This centre will provide fabrication, testing and sophisticated analytical facility, along with providing expert advice, mentoring to help and promote entrepreneurship, small scale and medium scale industries towards innovation and product development. The Centre will have facilities covering diverse areas as bio-functional materials, nanotechnology, battery materials, sensors and devices for energy, water, environment and health applications.

SATHI @IIT Kharagpur is set-up to house sophisticated equipment for research, characterisation, scientific analysis, generation / interpretation of data, knowledge sharing & its dissemination. It will focus on Materials Science & Engineering. In addition to the above cutting-edge research areas other areas like nano-scale imaging & spectroscopy, biological & soft matter, quantum opto-electronics, high frequency electronics etc are also set-up at a high-tech building at Kharagpur. Eventually the centres will also house facilities for developing prototype models, rapid prototyping, and smart fabrications.

SATHI @ BHU Varanasi envisage to provide quantum leap to its innovative and translational research outputs, and to cater to the needs of Indian industry by providing globally acceptable analytical services related to drug discovery, and testing of food, nutraceuticals, drugs, biological and materials under GLP certification and NABL accreditation. It will be the major node of a unique interdependent ecosystem in the state-of-art central discovery centre (a six-floor building) to nurture innovation, entrepreneurship and start-ups under one roof. The centre will provide centralized facilities, guidance and hand-holding for promoting innovation in BHU and to the motivated researchers of other institutions of the region. Facilities across the SATHI centres are likely to change the research eco-system of the country.



Central Discovery Centre (CDC) at Banaras Hindu University, Varanasi where facilities acquired under SATHI shall be housed and will have transparent access.

Hon'ble Union Minister for Science and Technology, Earth Sciences and Health & Family Welfare Dr Harsh Vardhan remotely dedicated Micro industrial complex for sustainable rural industrialization as one of the viable technology option at an event held at ICAR CAZRI Jodhpur on 6 December 2019. A micro industrial complex has been set up at Malunga, Jodhpur which utilizes local produce for value addition through efficient use of renewable energy, conserving water without generating waste. This complex has been set up with an investment of Rs 6 Crore under Science Bridges Program implemented by R & D Infrastructure Division, DST.

1.2 State S&T Programme

This Department has been playing a proactive role in addressing Centre-State S&T cooperation

through State S&T Programme (SSTP). Through this programme, State S&T Councils are provided core support for their S&T human resources and some infrastructure besides funding support for location specific research through liaison with Central/State academic institutions & laboratories, technology development and demonstration. The programme also supports studies and surveys on local S&T related issues etc.

As a result of the support, the State S&T Councils perform activities to strengthen the bottom of the pyramid of State S&T landscape viz. awareness, creation, capacity building etc., the R&D ecosystem and the innovation ecosystem in the State. In the year 2019-2020, (a) 28 State Councils for S&T were supported by providing grant in aid of Rs. 25.87 Crores for their human resources, (b) 24 new projects/ programme were supported to address the State Specific S&T challenges, S&T surveys and studies in the tune of 13.40 Crore and (c) the Annual Conclave of the State S&T Councils was organized at Telangana State Council for Science Technology, Hyderabad during 22nd to 24th August'2019 to review the progress of the various State S&T Councils in the country. Around 27 States & Union Territories Councils participated in the Conclave and discussed the future course of actions to be taken for S&T development in States.

(A) Significant achievements of some of the State S&T Councils under the State S&T Programme during 2019-20:

Meghalaya

A. Activities To strengthen the bottom of the Pyramid of State S&T landscape:

1) Eco Clubs:

The State Council is motivating science and environment (SCSTE) activities in 100 school eco clubs across the State with an objective to spread the scientific temper and environmental consciousness among the school children in the State. In the year 2019, Ms. Belinda Kharsati, founder of Eco Club at Pomlahier Secondary School, Mawryngkneng village has been conferred with the prestigious National Award under Swachh Bharat Mission (Grameen).



2) Earthian -Wipro's Sustainability Education Programme for Schools:

Organised the 'Earthian' Programme which is the WIPRO's Sustainability Education Programme for Schools. The objective of the programme is to empower students and teachers to take up activities and solution in their local context and environment like water and biodiversity. Recently, Mawphlang Secondary School, Meghalaya have been judged the winner for the 2019 Earthian school program under the theme "Biodiversity".

3) Technology On Wheel-Go Green:

Under this mass outreach programme appropriate technologies are taken at the door steps of villagers especially in far flung remote rural areas where road connectivity is limited. Skill training on appropriate technologies was organized in 7 districts of the state covering 12 blocks and 31 villages.



B. Activities to strengthen the R&D ecosystem in the State:

1) Waste water treatment plant at areca nut fermentation pond, Pongtung village:



SCSTE, Meghalaya has taken up an action research In Khasi and Jaintia regions to employ technology intervention by construction of a waste water treatment plant using locally available resources and bio-filter constructed at the vicinity of the areca nuts pits/ fermentation tanks so as to filter the foul smelling water into clean odorless water.

2) Action Research on Dew-Fog Technology:

SCSTE, Meghalaya have taken up an action research in Dew-fog technology to trap precipitation in the form of dew and fog and store them so that they can be used in off-season to provide micro-irrigation and support livelihood of small farmers. Action research at Sohra, Mawsynram, Skentalang and Laitlum have shown promising results and this technology will be upscaled in 2020.



C. Strengthening the innovation ecosystem in the State:

1) Partnership with National innovation Foundation (NIF), Assam:

SCSTE, Meghalaya have partner with NIF, Assam to scout for local innovation throughout the state of Meghalaya with an objective to scouts for grassroots innovators

and identify them so that their work get recognized and replicated for the welfare of the society.

2) North East Innovators Meet & Technology Innovation Entrepreneurship Expo, 2019:

SCSTE, Meghalaya on the occasion of National Science Day, 2019 organized the North East Innovators Meet & Technology Innovation Entrepreneurship Expo, 2019 during 28th February to 2nd March, 2019 at North Eastern Hills University, Shillong. The Expo was inaugurated by the Chief Minister of Meghalaya, Shri Conrad K. Sangma. 20 innovators from Meghalaya and 29 innovators from the other north eastern states coordinated by NIF participated. 5 CSIR Laboratories and 8 numbers of technical NGOs attended the programme.



3) National Innovation Foundation Partnership Award:

SCSTE, Meghalaya was awarded the NIF-India Partnership Award for its initiative in furthering the cause of the grassroots innovation movement in the State of Meghalaya.

4) MY SPACE (Meghalaya Youth – Specific Project Aimed at Creating Entrepreneurs) - Setting-up of Incubation Centre:

SCSTE, Meghalaya has come up with the innovative idea to create entrepreneurs owing to the fact the rise in unemployment especially educated youths with S&T background. These entrepreneurs would evolve from youths trained and incubated in different technology sectors like Green technologies, Micro-Hydro power.

5) Establishing Livelihood Incubation Kendras (LINKS) at C&RD Blocks, Meghalaya:

SCSTE, Meghalaya has come up with a plan of setting up of Livelihood Incubation Kendras (LINKS) which is a multitude upscale of these CFCs by restructuring and re-orienting the existing CFCs so as to achieve a higher aims and objectives. It will also act as incubator for start-up based on the block/cluster/village with potential for value chain.

Nagaland

- a) **Activities to strengthen the bottom of the pyramid of state S&T landscape viz., Awareness creation, capacity building, etc.**

- i. Celebration of National Science Day.
- ii. Celebration of National Mathematics Day.
- iii. Popularization and Training programmes in Biotechnology.

b) Activities to strengthen the R&D ecosystem in the state:

b.i. R&D Projects undertaken with reference to National & International Relevance

1. Chemical ecology of the North East Region (NER) of India: A Collaborative Programme Linking NER & Bangalore Researchers in the following areas
 - i. Chemical Ecology Study of Oak Borer Larva with its host & the associated organisms.
 - ii. Aquarium-assisted Evaluation of Fish Poisoning Plants against Fishes.
 - iii. Chemical Ecology Study of Dazo Nha- A Potent Anti-rheumatic Plant.
2. Understanding adaptive plant pollinator networks among the understory perennial gingers using a field & molecular ecology approach.
3. Climate Change Studies & Knowledge Solution Centre under National Mission For Sustaining Himalayan Ecosystem (NMSHE).
4. Monitoring Integrated Water Management Programme (IWMP) project using Geospatial technologies.
5. Wetland mapping – 2nd Phase
6. Water Quality Mapping under Rajiv Gandhi National Drinking Water Mission (RGNDWM)- IV Phase

b.ii. Location Specific Problems and alleviation based R&D Projects:

1. State Referral Laboratory for Water Quality Checking & Monitoring.
2. Investigation of the antioxidant capacity of some Medicinal Plants used by Naga people.
3. Mass Spectrometry analysis of bioactive constituents of extract of P. Molle.
4. Water mill Based Animal feed crusher Production Unit .
5. Development of Electronic Load Controller.
6. Soil Microbial Diversity Assessment in Alder Based Farming System in Nagaland.

7. Study of in-vitro enzymatic inhibitory activities of selected indigenous plant extract.

c) Strengthening the Innovation Ecosystem in the state

The Department of S&T, government of Nagaland has adopted a policy to promote innovation ecosystem in the state in 2018 and as follow-up of the same, Nagaland S&T Council organize “Nagaland Innovation Expo” every year. The 2nd Edition of the Nagaland Innovation Expo-2019 was organized at Kohima Science College, Jotsoma, in collaboration with National Innovation Foundation (NIF) on 23rd March, 2019.

Assam

A) Activities to Strengthen the Bottom of the Pyramid of State S&T Landscape.

i) ARYABHATTA SCIENCE CENTRE (BLOCK LEVEL) IN ASSAM

219 numbers of Aryabhata Science Centres in 219 development blocks of the State are functioning since 2008 to strengthen science, technology and innovation among the school students and the common people of the state.

ii) SCIENCE & MATHEMATICS FACILITATORS FOR SCHOOLS OF ASSAM

Science and Mathematics Facilitators are working in the schools of different Legislative Assembly Constituencies of the state since 2010 for strengthening the science and mathematics education with new pedagogical approach.

iii) ASSAM SCIENCE FESTIVAL

Last festival was held at Tezpur Central University during 23 – 25 March 2019.

b) ACTIVITIES TO STRENGTHEN THE R&D ECOSYSTEM

RESEARCH & DEVELOPMENT (R&D) PROGRAMME

The Council has initiated supporting Research & Development Programme in selected areas which are related to location specific problems and also in the emerging areas of agriculture, horticulture, sericulture, health and nutrition. Pure and basic research in science and engineering are also supported under this scheme.

A few examples of the supported projects:

- To study the anti-inflammatory effect of crude extract of colocasia sp. using murine macrophase cell line (RAW 264.7).
- Colour pure near UV light emission enhancements from ZnO based thin film devices.
- Edible coating optimization for enhancement of post harvest storage life of few indigenous fruits (Averrhoa Carambola, Flacourtia Jangomos and Citrus Limon) of Assam.

- Carbon sequestration in soils of agro-ecosystems of Assam as a measure to control climate change.

Karnataka

Technology areas supported:

- **Water** – Rain Water Harvesting Technologies, Restoration and rejuvenation of traditional water bodies (RWH – Assisted the state government in implementing RWH; end-to-end solution i.e., R&D, Patent, Awareness & capacity building, Training, Policy, Implementation and Enforcement)
- **Education** – Funding to final year engineering students’ projects, Faculty Development programs, Start-up initiatives and support to innovation, IPR and Commercialization projects under Student Project Program since 1977. Established E-learning centers for high school students.
- **Geo-Information Communication Technologies (Geo-ICT)** - Application of Geo-Information Communication Technologies (Geo-ICT) for decision-making; Mandatory geospatial action plan for line departments for taking up all physical activity; geospatial cloud and National Data Registry; 3D Laser scanning of archaeological sites for restoration and rejuvenation.
- **Energy** – New and renewable energy (R&D and support to state government in implementing renewable energy programs i.e., Energy efficient stoves, Biogas plants, Gasifiers, Solar and Wind energy, fruit/vegetable dryers and Bio-energy).
- **Housing** – Energy efficient building technologies; use of construction and demolition waste and non-organic solid waste (involved in R&D, training and dissemination) -over one lakh houses built so far using these technologies.
- **IPR** –Support to inventors in patenting their inventions, patent & prior art search, patent laws etc.; IPR awareness and capacity building; Establishment of IP cells in universities/ engineering and degree colleges.
- **Cyber Security** – Awareness and capacity building, Cutting Edge R&D, Start-up ecosystem, Deep connect with Industry.
- **Science Popularization** – Science/Mathematics day, Vigyan Darshan, Radio serial on S&T programs, Teachers enrichment programs etc.

Madhya Pradesh

A. Activities To strengthen the bottom of the Pyramid of State S&T landscape:

- (i) **International Travel Grant:** A total of 60 researchers were sponsored under travel

grant scheme.

(ii) **Seminar/ Symposium/ Workshop and popular lectures etc. :** A total of 76 seminar, symposium, workshop etc. were sponsored to scientific institutions and societies of M.P.

(iii) **Scheme for Promotion of Young Scientists (Young Scientist Congress):**. 34th MPYSC was organized at Rajiv Gandhi Prodigiki Vishwavidyalaya, Bhopal during 28 Feb & 01 March 2019. 207 young researchers have presented their research papers in 17 disciplines. Total 28 researchers conferred with M.P. Young Scientist Award.



(iv) **Training for Young Scientists:**. 11 young scientists were sponsored under this scheme.

(v) **Vigyan Mantha Yatra of students under Mission Excellence Programme:**

- 13th Vigyan manthan yatra : 10th October 2019 to 18th October 2019. Total 563 students and 46 science teachers visited scientific institutions at Ahmadabad, Chandigarh, Lucknow, New Delhi & Hyderabad.



B. Activities to strengthen the R&D ecosystem in the State:

- Supporting Research and Development: A total of 42 new research projects were sponsored.
- The following technologies have been developed through supported projects:
 - Life Saving device for bore whole fallen kids
 - Waterless Toilet

- c. Water conservation by paddle operated tap
- d. Pit for dry toilet
- e. Automatic paddy sowing machine



Life saving kit for fallen kids into Borewell



Pit for dry toilet



Water conservation through Paddle operated water tap

C. Strengthening the Innovation Ecosystem in the state

- iii. 25 days' training programme for skill development/ skill upgradation and entrepreneurship development. This training was attended by 28 iron craft workers mainly drawn from Agariyas & Vishkarma communities of Anuppur and Shahdol districts. They are capable of preparing world class steel.
- iv. 48 trainings for farmers on low cost technologies for preparation of compost from bio-waste (vermi composting technology, waste decomposer bio dung method, biodynamic method, cpet pit) were organized in the villages of 11 districts located in adjacency to Narmada River.
- v. 06 Training Programmes on "Scientific cultivation of lac" were organized in 06 villages of Anuppur district.

Bihar

A. Activities to strengthen the R&D ecosystem in the State:

- i. National Science Day 2019 was celebrated on 28th Feb. 2019 at Patna .
- ii. Popular Lectures: Series of lectures on Science Communications by Dr. Santosh Takale, Senior Scientist, BARC, Mumbai was organized at various Engineering Colleges and Polytechnics all over the state.
- iii. 27th State Level Children's Science Congress organized during 8- 10 November, 2019 at Regional Secondary School, Madhubani. Cash award of Rs. 5,100/- each was given to 30 Child Scientists representing state in the National Children's Science Congress 2019 at Thiruvananthapuram, Kerala.

- iv. National Mathematics Day was celebrated on 22nd December, 2019 jointly with University of Engineering & Management, Jaipur/Kolkata in Patna.
- v. An exhibit stall featuring activities of BCST was put in the 107th Indian Science Congress – Pride of India Expo during 3-7 January, 2020 at University of Agricultural Sciences, Bengaluru.

B. Activities to strengthen the bottom of the Pyramid of State S&T landscape.

- i. To facilitate aspiring researchers and teaching faculty of the state with the state-of-the-art laboratory facilities.
- ii. BIRSAC is the nodal agency for procurement of hardware and software in the field of Remote Sensing and GIS in the state of Bihar. It has linkages with Central and State Govt. departments/agencies like DOS, NRSA, Agriculture, Road Construction, PHED, PWD, Irrigation Dept. etc.

C. Strengthening Of Innovation Ecosystem:

- i. Policy guidelines for supporting grass-root innovators to convert their innovative ideas into prototype (field tried) model has been notified.
- ii. 10 innovators have been supported in establishing laboratory and Infrastructural facilities.

Telangana

Strengthening R&D Ecosystem:

- i. Telangana State Council for Science & Technology (TSCOST) is implementing the Project “Kitchen Waste Operated Biodigester Plants (a safe, clean and wealth generation & Swatch Bharat initiative) costing Rs. 1.60 crore sanctioned by Department of Science & Technology (DST), Govt. of India for establishment of 20 Bio-digester plants in the state of Telangana over a period of 2 years. TSCOST established 15 cu.mt capacity Bio-digester plants (technology which is eco-friendly and provides scope for generation of wealth from waste) for conversion of kitchen waste into combustible gas at Centre for Cellular & Molecular Biology (CCMB), Hyderabad and at National Institute of Rural Development & Panchayat Raj (NIRD & PR). Implementation is also being done in Telangana State Residential Educational Institutions and NIT, Warangal.
- ii. TSCOST is implementing the project “Proactive mitigation of gray mold (*Botryotinia ricini*) disease of castor (*Ricinus communis* L.) crop in Telangana State using dynamical disease forecast” sanctioned by Department of Science & Technology (DST), Govt. of India in association with Indian Institute of Oilseeds Research (IIOR), Govt. of India, New Delhi.

- iii. TSCOST is coordinating with the Department of Atomic Energy (DAE), Govt. of India and Bhabha Atomic Research Centre (BARC), Govt. of India and line departments, universities, research institutions and district administration with regard to the utilisation of radiation processing technologies developed by BARC and the constituent units of DAE for societal applications in the areas of Agriculture, Food Preservation, Water, Waste Management and Health Care etc in the state of Telangana.

Strengthening Innovation Ecosystem:

- iv. TSCOST initiated the activities relating to protection of Intellectual Property Rights (IPRs) as a part of the DST, Govt. of India sponsored Patent Information Centre (PIC) project.

Strengthening Science Popularisation and Science Communication:

- v. TSCOST is implementing the activities and programs of Regional Science Centre (RSC), Warangal including its operation and maintenance. Programs of the RSC include Demo of Scientific Principles, Visits of Students, Teachers, General Public to the RSC, Workshops/ Face to Face/ Programs on Science Popularisation & Communication and Visits of Students to Scientific Institutions, Interactive sessions on S&T.
- vi. TSCOST is implementing a number of activities such as National Children's Science Congress, National Science Day Celebrations, National Mathematics Day Celebrations, World Environment Day Celebrations, S&T Awards, Fellowships, Support for S&T based Seminars, Workshops, Symposia, Training Programs, Skill development/ up-gradation programs etc.

Maharashtra

A) Activities To Strengthen The Bottom Of The Pyramid Of State S&T Landscape Viz. Awareness Creation, Capacity Building Etc.

Awareness Programmes

- a. National Science Day and National Mathematics Day, Science popularization programmes were celebrated.
- b. Commission has been setting up Science and Innovation Activity Centres (SIAC) in Maharashtra which has a mandate for undertaking Science awareness activities.

Schemes for Capacity Building

a) Cillage based Area Development Programme (CADP):

Rajiv Gandhi Science and Technology Commission has supported Science and Technology Based Area Development Programmes. This is based on the concept of providing city amenities in villages. During the year 2019-20, this activity is being carried out in 73 villages

of Nandurbar district, predominately tribal area, in Maharashtra. The program is anchored by Kavayitri Bahinabai Chaudhary North Maharashtra University, Jalgaon in association with three other agencies including NGO's.

b) Science & Technology Resource Centre (STRC):

Commission has setup Science and Technology Resource Centre (STRC) in Gadchiroli district of Maharashtra for sustainable value creation and generate livelihood opportunities by deploying appropriate Technology. The focus is on sustainable and productive use of forest and other resources. This autonomous centre has been created under Gondwana University, Gadchiroli. IITB Mumbai, Maharashtra Animal and Fishery Sciences University, Nagpur and Forest Department are contributing to this activity.

B) ACTIVITIES TO STRENGTHEN THE R&D ECOSYSTEM IN THE STATE.

“Assistance for S&T Applications through University System”

To encourage R and D activities at smaller institutes such as science and engineering colleges and even polytechnics and to encourage application oriented project activities, linked to local resources and problems, Commission has launched this scheme. Under this Scheme, Universities in Maharashtra are provided lump sum grant to support projects at affiliated institutions. This is expected to encourage focused research activities. During 2019-20, it has been implemented in 10 Universities of Maharashtra.

RGSTC/TIFAC MSME Internship Programme in Maharashtra

- a) In order to encourage Industry -Academia interaction for collaborative research projects, Commission has been implementing RGSTC - TIFAC MSME Internship Programme in Maharashtra. This pilot programme is being implemented at two Engineering Colleges and 2019-20 was the 5th year.

C) STRENGTHENING THE INNOVATION ECOSYSTEM IN THE STATE.

Innovation and Technology Transfer Cell

- a) Technology Transfer Cell has been setup at Maharashtra Chamber of Commerce, Industries and Agriculture (MCCIA), Pune. 3 seminars on specific technologies were organized in which potential entrepreneurs participate

Science and Innovation Activity Centres (SIAC)

- a) To encourage Science popularization activities and to promote activity based learning, Commission has initiated a scheme to setup “Science and Innovation Activity Centres” (SIAC). These centers are also expected to help in promoting entrepreneurship in school

children. These centers are setup at prominent institutions having secondary school.

Patent Information Centre (PIC)

- a) 6 IPR Cells are being set up at universities to identify patentable research outputs at various institutions in the State and provide help to file patents. Training programmes are conducted for resource persons from universities.
- d) **Activities to strengthen the bottom of the pyramid of state S&T landscape viz., Awareness creation, capacity building, etc.**
 - a. Celebration of National Science Day.
 - b. Celebration of National Mathematics Day.
 - c. Popularization and Training programmes in Biotechnology.
 - d. Awareness and Capacity building programmes on Climate Change.
 - e. Awareness on promotion of Intellectual Property Rights in the state.
 - f. Awareness and training programme on water quality and Sanitation.

Punjab

A. Strengthening Innovation Ecosystem in Punjab:

1. Mission Innovate Punjab

Punjab State Council for Science and Technology (PSCST) has launched Mission Innovate Punjab to develop a robust ecosystem for research and innovation to enhance competitiveness, boost economic growth, create quality jobs and achieve sustainable development goals in the state.

2. Patent Facilitation

About 38 patent searches, 4 trademark searches and 1 design patent search has been carried out. The Council received 38 patent applications out of which 15 were forwarded to DST-TIFAC; 6 patents have been filed and 3 granted. Further, 2 Women Scientists have been trained to empower them to take up careers in IP.

B. Activities to Strengthen R&D Ecosystem in Punjab:

1. The Council has engaged extensively with research institutions & universities of the state to map their research competence & strength. Simultaneously, it is identifying

unmet technological needs of industry. The unmet technological needs of Secondary Agriculture sector have been identified and to address the same, 5 industry-institutional clusters developed.

2. The Council is also identifying grand challenges of the State. It is working closely with Directorate of Environment & Climate Change for providing research & technology support for State Action Plans for Clean Water, Clean Air and Solid Waste Management by leveraging research strengths of universities and institutions in Punjab. Some specific programmes taken up include IoT based solutions for river water quality monitoring in the state; integrated dashboard for real time data monitoring & analytics of emissions, ambient air, effluent & river water quality; development of monitoring and management plan for generation of industrial effluents.
3. Further, paddy straw being a major challenge for Punjab, the Council is exploring options for its ex-situ management. It has taken the arduous task of setting up of two demonstration plants for production of briquettes from paddy straw in public private partnership at Moga and Patiala. The commissioning of both the demonstration units would result in utilization of about 8000 tonnes paddy straw annually from 10-12 villages in their vicinity. This will help in reduction of GHG emissions to the tune of 8800 tonnes per annum.

C. Activities to Strengthen State S&T Landscape viz. awareness, capacity building etc.:

1. S&T for Women Empowerment .
2. Green Skills Development Programme
3. Innovation and Technology Summit Punjab
4. Regional Conference on Environment

(B) Some of the achievements of the major location specific technology developed and demonstrated under the programme at various States:

1. “Development of Hill Agricultural Tools and Equipment’s” at Nagaland Science & Technology Council (NASTEC), Kohima, Nagaland

Under the project the traditional tools were improvised by changing design and material. Certain tools were identified to improve the service life by plasma nitriding process. Based upon above outcome a suitable plasma nitriding system was designed, developed and commissioned at Dimapur, Nagaland successfully.



Plasma Nitriding system installed and commissioned at NASTEC, Dimapur, Nagaland.

2. **“Genetic susceptibility to mastitis in cows, reared in temperate region of Kashmir” at Sher-e-Kashmir University of Agriculture Science & Technology of Kashmir (SKUAST-K), Srinagar, J&K**

The study was based on bovine mastitis in the temperate region of J&K. Bovine mastitis is complex disease with wide range of bacterial, viral, fungal pathogens associated with it. Screening and diagnosis of Bovine mastitis in the field was based on milk sample testing followed by blood sampling from screened cows. Diagnosis of mastitis was based on Somatic cell count using portable Somatic cell counter. Blood samples were subjected to immunological analysis using ELISA tests for finding any possible variation in designated Acute phase proteins (APPs) associated with udder infection of dairy cattle. Molecular analysis was also carried out for finding any single nucleotide polymorphism in various immune system related genes after extraction of genomic DNA from blood samples. The mutated alleles of these genes may be removed from population so that only productive and disease resistant dairy cows may be retained which directly benefits the dairy farmers.

3. **“Development of Low Cost Cold Storage using Appropriate Green Technologies for Nongmydro Village, WK hills, Meghalaya” at Meghalaya State Council for Science & Technology, Shilong, Meghalaya**

The most Innovative part of this Cold Storage unit is the use of green building technologies using Stabilised Mud Block (SMB) technology and Treated Bamboo technology where all raw materials were available locally. Capacity building was imparted to the villagers where 17 villagers were trained in SMB technology and 5 villagers in Bamboo technology. Moreover, the cold storage unit will be running on solar power or green energy with all electrical requirements such as running of the cold storage dehumidifier to maintain the humidity within the cold storage .



Photographs of Nongmyndo Cold Storage

4. “Uplifting hilly livelihood through the eco-friendly utilization of Lantana weed” at Indian Institute of Technology Mandi, Himachal Pradesh

Under the Project IIT Mandi has been successfully produced the bio-fuel out of lantana bio mass. The initial studies indicate that it can be a good substitute to be used in any industry which requires burning of coal/wood. Its use as domestic fuel is yet to be evaluated. It seems that making bio-fuel in the form of briquettes/pellets of lantana can be a viable solution. The figure below shows the chopping tool we found highly suitable and the bio-fuel samples IIT Mandi has made. The calorific value of briquettes of lantana is 5700 Kcal/kg which is quite good.

5. Development of eco-friendly artificial Ice Reservoir (Ice Stupa) at Thangu Valley, North Sikkim

Ice Stupa is an innovative technique for making artificial Ice reservoir, which resemble the Stupa, a Buddhist monument in cone shape. In this technique, the water from height brings down to a specific location through pipes and it makes sprinkles from the top of the cones. A model Ice stupa has been developed and demonstrated in 2019 winter season artificially. The success of this prototype in Sikkim has encouraged us to go to the next higher level with bigger mandate of reglaciation of glacier. Likewise in other areas, glacier retreat being a major issue in Sikkim Himalaya, an effort has been made to take the Ice stupa to a next level for the reglaciation of some portion of the selected glacier which is a prime need of the present times.



A seven days Ice reservoir at Thangu Valley, North Sikkim

1.3 Policy Research Cell

The Department is mandated to develop and deliver public policy support for the promotion of R&D in the country. Science, Technology, and Innovation (STI) are recognized to play a significant role in advancing human, social, and economic development to meet the aspirations of people. To understand STI processes for making effective policies, strengthen them and link these evidences to policy making, five DST-Centers for Policy Research (CPRs) established in academic institutions across the country were given continued support. The Centres undertake research in number of key areas relevant to the country, train young scholars in STI policy research, and contribute towards better STI policy making by providing inputs to Government agencies/departments. The DST-CPRs are also engaging itself with stakeholders, national and international experts to develop policy related papers. Apart from this, STI Fellowships at post-doctoral level was also initiated to generate critical mass of policy researchers. It has provided an opportunity to develop the skills of young-scientists and engineers who are interested in engagement with the STI policy domain as STI policy researchers. This year, four new STI Fellows at post-doctoral level were selected.

During the year, all the DST-CPRs continued their ongoing work in their identified thematic areas. Apart from that, the CPRs continued to engage actively with both policy makers as well as the broad community of academics engaged in STI policy research and other stakeholders including scientists engaged in industry oriented research, societal sectors etc. through seminars, conferences, workshops and other interactions with a view to enhance public dialogue on emerging S&T issues. A discussion cum review meeting of the above Centres was organised at IIT Delhi (Oct 21, 2019). During the meeting, discussions were made on the progress in the various research activities that have been entrusted with the five DST-Centres for Policy Research. The Review Committee under the Chairmanship of Prof.

A. K Sood, President INSA, New Delhi also discussed further strengthening and making future roadmap in STI sector in the country. The committee suggested some new initiatives/ modalities to be taken for science policy research. Secretary, DST also participated in the Review meeting.



Photo 1: Review meeting of the Centre for Policy Research at IIT Delhi.

DST-CPR at IIT Delhi submitted a draft report on 'Expansion of MNE R&D Centres in India and their linkages with the Indian Innovation System' which reviewed the expansion of MNE R&D landscape in India and explored the dynamics of a broad of linkages between MNE R&D centres in India and other actors in the Indian innovation system – India's higher education and research institutions, businesses, start-ups and policy makers. The report focused on the details of the linkages, how they influence the technology innovation capabilities across the innovation system, and the role for Indian policy makers and university administrators to expand and strengthen these linkages and enhance the innovation capabilities across the country.

DST-CPR at EDII, Ahmedabad submitted three draft reports; *viz.* (i) Women Entrepreneurship in India: Key Challenges & Critical Success Factors, (ii) Role of Innovation in Making MSMEs Global Competitive, and (iii) Role of Existing Mechanism in Technology Transfer and Assessing the Need for Setting up National Technology Transfer Centres in India.

DST-CPR at Panjab University, Chandigarh submitted two draft study reports on (i) Comprehensive Roadmap for Strengthening R&D Ecosystem of India via PPP Model' and (ii) A Study on 'Stimulation of Private Sector Investments in R&D: A Global Comparison'.

STI Fellowships at three levels *viz.* (i) young professional, post-doctoral fellow and (iii) Senior Fellow was announced to generate a critical mass of policy researchers and their engagement in the STI policy domain. To review the progress of existing STI Fellow's research output in science policy area, an annual review meeting was organised at DST, Technology Bhawan, on Dec. 21, 2019.



Photo 2: Review meeting of the STI Fellows at DST New Delhi.

In order to revisit the present STI Policy-2013 and to work for a new policy document/framework as per changing demands of present as well future scenarios, Policy Research Cell prepared a draft framework for initiating consultations on a new STI policy involving of O/o Principal Scientific Adviser to the Government of India.

Policy Research Cell constituted 6 consultative core groups viz. (i) Scientific Ministries, Industry and Academia (ii) Socio-economic & other line Ministries (iii) State Governments (iv) Global Partners (v) Young Scientists and technologists including women, and (vi) Science & Innovation Attaches of Indian and Foreign Missions. Consultative groups (i), (ii), (iv) & (v) have been constituted under the Chairmanship of Prof. K VijayRaghavan, Principal Scientific Adviser to GoI, with Member (Science), NITI Aayog and Secretary, DST as Co-Chair. Consultative groups (iii) and (vi) have been constituted under the Chairmanship of Dr. V. K. Saraswat Member (Science), NITI Aayog with PSA to GoI, and Secretary, DST as Co-Chair. A policy drafting committee also constituted under the Chairmanship of Scientific Secretary, O/o PSA with co-chair as Head, Policy Research, DST. Discussion meetings of the policy drafting committee and apex group on Scientific Ministries, Industry and Academia were organised. The Core Committee would review and assess the effectiveness of STI Policy 2013 in attaining the goals and national priorities set by the Government post 2013 like SDGs, Swachh Bharat etc and formulate the Vision, Mission and Objectives of a New STI Policy for New India. The above Committees would examine the policy instruments and resources available with the Government and the Private Sector to harness technology for New India.



Photo 3: Policy Drafting Committee meeting at DST New Delhi.

Policy Research Cell engaged along with O/o. Principal Scientific Advisor (O/o PSA) to Govt of India on India-OECD-CSTP ((Committee of Science and Technology Policy) engagement on STI policy and data. OECD-CSTP is a leading global platform on STI policy; and a standard setting body for R&D and Innovation measurement. India is recognized as one of the Key Partners by the OECD council. This provides various benefits and engagement opportunities. Formal engagement between India and OECD-CSTP initiated with the first meeting between Prof. VijayRaghavan and OECD-CSTP top officials on 26th March, 2019 during a conclave facilitated by DST-CPR at IISc Bangalore. As an outcome of this meeting, India received an official invitation from the Director, OECD-Directorate of Science, Technology & Innovation to join OECD-CSTP as a 'Participant Country'.

To understand UK's Science & Technology Landscape, Science & Diplomacy, a one week experiential visit for STI Postdoctoral fellows was organised to Science Policy Research Unit at University of Sussex. An interaction meeting with Economic and Social Research Council (ESRC), a part of UK Research and Innovation (UKRI) was also organised. On behalf of Policy Research Cell, Coordinator, DST-CPR at Punjab University, Chandigarh participated in ASIAN STI THINK TANKS NETWORK (ASTN) and 5th Asian Innovation Forum meeting during October 03-05, 2019, co-hosted by Korea Institute of S&T Evaluation and Planning (KISTEP) and Asian Society for Innovation and Policy at University of the Philippines Diliman, Manila. Policy Research Cell supported an International Conference on "Innovation driven economic growth in Asia focusing on India" organized by Zaheer Science Foundation during Nov. 27- 29, 2019 in collaboration with UNESCO, New Delhi and Goa University at Goa. Venue: Goa University, Taleigao Plateau, Goa

1.4 Centre for Human and Organizational Research Development (CHORD)

Centre for Human and Organisational Resource Development (CHORD) division formerly National Science & Technology Management Information System (NSTMIS) continued its efforts of generating and making available information on resources both manpower as well as financial devoted to scientific and technological (S&T) activities by conducting national surveys both through in-house as well as sponsored studies.

1.4.1 S&T Resource Studies

The data collection for National Survey 2017-18 on resources devoted to research and development activities (launched both in print and e-mode) has been completed. A response rate of more than 80% has been achieved so far with the target population of more than 6000 R&D organizations comprising of public sector, private sector, MNCs, higher education, SIROs and NGOs spread across the country. Checking of consistency of survey data and tabulation of S&T indicator tables is in progress. Based on the outcome of the survey, the new issue of national publication “**Research and Development Statistics**” along with the abridged version **R&D Statistics at a Glance** would be published which serves as an evidence base for the policy formulation in the S&T sector. Further, the latest set of S&T indicators thus developed is provided as a country input for the forthcoming UNESCO S&T Statistics and the Global Innovation Index reports.

Bibliometric Studies commissioned on India’s research output, collaboration and comparative performance based on the global databases SCI and SCOPUS were brought out by the agencies Clarivate Analytics and Elsevier respectively for the new set of Bibliometric Indicators for time period 2011-2016. The purpose of these reports is to provide an understanding of India’s volume of research activity, research quality and international collaboration across different research areas in an internationally comparative context through various bibliometric indicators. These reports would serve as an evidence base for the policy formulation in the S&T sector.

National Innovation Survey Considering the importance of Innovation in S&T sector, the Department of Science & Technology in collaboration with UNIDO, Austria has launched the 2nd National Innovation Survey entitled ‘**India Innovation and Systems Survey 2019**’. The survey attempts at understanding innovation from the systems perspective. It aims to develop innovation indicators so as to understand the role of innovation and knowledge creation activities with the growth and benchmark the performance of the national innovation system.

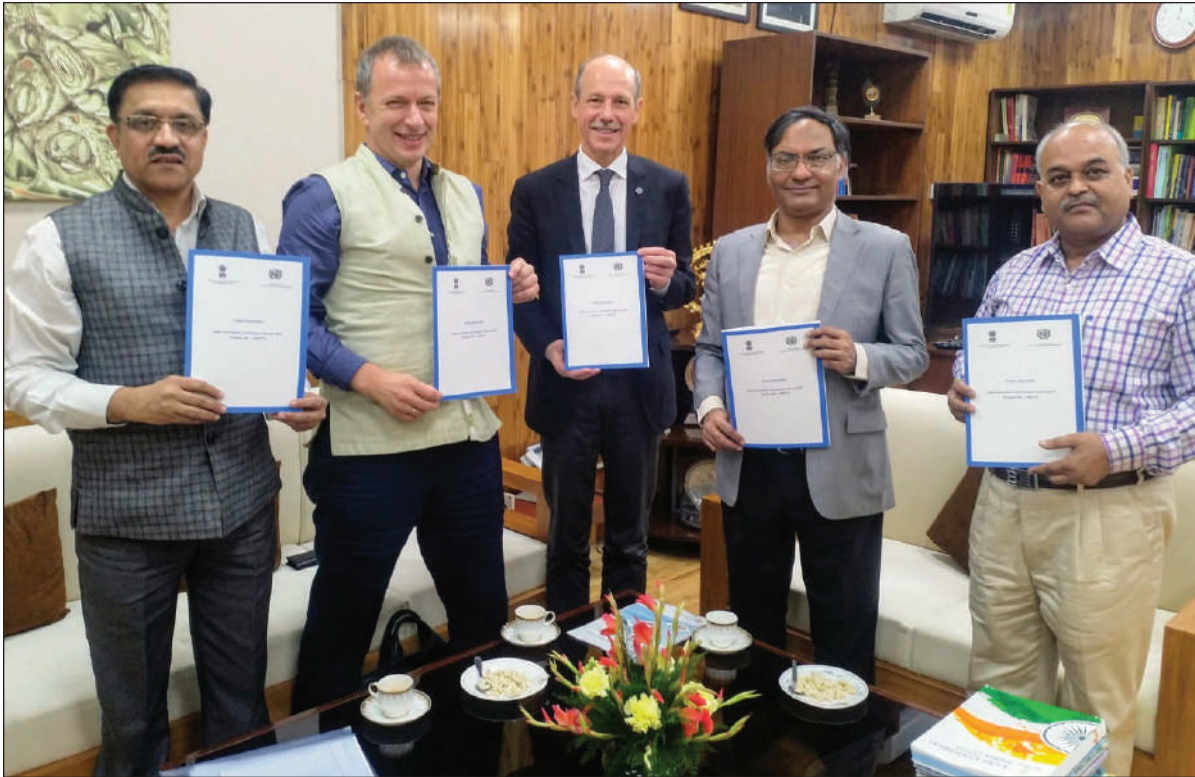


Fig. Prof. Ashutosh Sharma, Secretary, DST and UNIDO representatives at the launch of **India Innovation and Systems Survey 2019** in DST, New Delhi

The present National Innovation Survey, contrary to the first survey, which took place in 2011, provides a significant improvement in scope, methodology and quality, featuring several of UNIDO's tools and comparative advantages. It has three new dimensions over the previous survey and will cover (i) both manufacturing and associated services (ii) large enterprises and (iii) quantitatively map and measure the system of innovation 10 Indian States. It will follow the new addition of Oslo Manual as a standard guide for the firm-level innovation survey and UNIDO's tools tested successfully for the systems of innovation survey.

1.4.2 S&T Policy

The Division has framed two Draft Policy Documents: **Scientific Research Infrastructure Sharing Maintenance and Networks (SRIMAN)** and **Scientific Social Responsibility (SSR)** after detailed deliberations with experts and stakeholders in the S&T sector.

SRIMAN policy primarily focuses on access and sharing apart from addressing issues such as procurement, maintenance, disposal, capacity building etc., for effective utilization of public research infrastructure in all scientific departments and research organizations in the country.

SSR primarily involves the ethical obligation of knowledge workers in all fields of science and technology to voluntarily contribute their knowledge and resources to the widest spectrum of stakeholders in society, in a spirit of service and conscious reciprocity.

Posters on both the draft policies were released recently by Hon'ble Minister of Science & Technology at India International Science Festival (IISF) during November 2019 at Kolkata. Subsequently both the policies were also presented before the distinguished delegates at the IISF, Kolkata 2019. The two draft policies are now in the advanced stages of finalization.



Fig. Dr. Harsh Vardhan, Hon'ble Minister for S&T releasing the posters of SRIMAN and SSR policies at India International Science Festival (IISF) during November 2019 at Kolkata.

1.4.3 Information System/Database Activities

With a view to disseminate information on sponsored research and development (R&D) projects for the benefit of different stakeholders, NSTMIS since 1990-91, has been continuously engaged in compiling information on extramural R&D projects funded by various central S&T agencies and publishing an annual *Directory of Extramural R&D Projects*. The latest directories "**Directory of Extramural R&D Projects**" for the years **2017-18** and **2018-19** are being compiled and would be published together.

It may be seen from the below figure that Women participation in extramural R&D projects has increased significantly to 24% in 2016-17 from 13% in 2000-01 due to various initiatives

undertaken by the Government in S&T sector. In absolute terms, 1,301 women Principal Investigators (PIs) during 2014-15 availed extramural R&D support as against 232 in 2000-01.

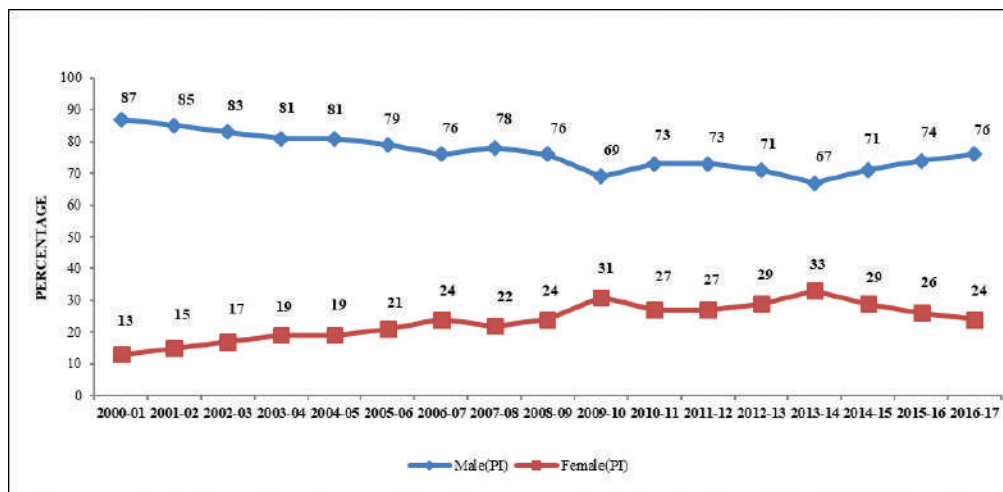


Fig. Gender Participation in Extramural R&D Support by Central S&T Agencies

1.4.4 NSTMIS Sponsored Studies

As a part of its outreach research programme, NSTMIS has sponsored several research studies/projects to various stakeholders' viz. research institutions, universities, colleges, NGOs and consultancy organizations spread across the country.

The **Program Advisory Committee (PAC)** of experts for implementation of NSTMIS Scheme met twice during the year to consider the projects submitted under the scheme for financial support. At present, there are 60 on-going projects out of which 17 new projects are initiated and 4 projects got completed during 2019-20. List of select projects approved by the PAC for support were in areas as below:

- Energy management strategies of lot on smart grid using scientometric analysis and socio-techno-economic survey
- Impact of Industrial collaborations in inducing the culture of scientific research among engineering students
- R&D and patenting by foreign firms in India
- Impact of Industry collaboration on innovation, Entrepreneurship and higher learning outcomes: A Study with reference to technical Institute in Karnataka
- Scientometric mapping of global research on cyber with special reference to India's status
- Assessing the factors responsible for mismatch between demand and supply of requisite skills in science and technology aspirants with special reference of Madhya Pradesh.

- Assessment the Impact of maker movement on Engineering Education
- S&T Research Impact and the Contributing factors: Analysis of Cross-National Data
- Design of a computational framework for discipline-wise and thematic mapping of research performance of Indian Higher Education Institutions (HEIs)

Some of the select sponsored studies completed during the year were:

- Implementation of Quality Management practices in performance improvement of Micro, Small and Medium Enterprises through Academic Intervention: A step towards Industry Institute Interaction
- An empirical study of B.Tech Student in Delhi & UP with special reference to their perception towards S&T
- Industrial Research, Development and Innovation in Public Sector Enterprises
- Data mining and analysis for Indian origin academicians in foreign university for exploring opportunities of academic interaction

The division further held review meetings of the on-going sponsored research projects at CEPT, Ahmedabad, ICRISAT, Hyderabad and Vardhman College of Engineering, Hyderabad. In addition, network projects involving multiple agencies on 'Impact of DST-FIST programme' and 'Impact of Government Policies on Improvement of Status of Women in Science' were also monitored periodically. The completed project reports/studies are available in public domain through a **web-based digital repository** (<http://www.nstmis-dst.org/NSTDRepository.aspx>).

1.4.5 International Collaboration

The Department actively participates and contribute in the UNESCO Institutes of Statistics (UIS) and Organization for Economic Cooperation and Development (OECD) meetings for the development and revision of standards/concepts/definitions used for collection of Science Statistics and development of Science, Technology and Innovation Indicators. The department also provided information for the country on Science & Technology Indicators to UNESCO Institute for Statistics for the Global database on S&T Indicators and other related publications such as UNESCO Science Report etc.

1.5 Training

Department of Science & Technology, in consultation with DoPT, other Scientific Departments and various organizations initiated an ambitious project of Human Resource Development namely "National Programme for Training of Scientists & Technologists

working in Government Sector” for scientific and technical personnel during the X Plan to meet the challenges of national development and international competitiveness in S&T area. Considering the efficacy of the Scheme, the Department decided to continue it in the XI, XII Plan and for financial years 2017-18,2018-19 & 2019-20 as well.

Training imparted to Scientists & Technologists strives to achieve better understanding of professional requirements, enhancing professional knowledge and skills needed for better performance of individuals and organisations in the profession of science and technology, creating awareness of latest technological, economic and social developments and infusion of scientific temper in the society, generating responsiveness to the challenging needs of the democratic system and expectations of the citizens from the scientific and technological developments, providing structured forum for peer to peer interaction, experience sharing and exchange of views among the scientific community for better networking and synergy.

Target groups for the training are “Scientists / Technologists holding scientific posts / working in scientific ministries / departments of Govt. of India and State Governments, Autonomous Institutions/ Public Sector Undertakings of Central / State Governments, Research and Development Institutions / Research Laboratories of Central / State Governments, Central / State Universities, State Science & Technology Councils.”

During the year 2019-20, 40 training programmes were approved under scheme “National Programme for Training of Scientists and Technologists working in the Government Sector” and about 800 scientists will be benefitted from these training programmes.

Women Component Plan:- Under Women Component Plan of the Training Programme 16 programmes were approved exclusively for women scientists during 2019-20 in which approximately 350 women scientists will be benefitted.



Training Programme conducted at Administrative Staff College of India, Hyderabad during 1-12 July, 2019

1.6 KIRAN

KIRAN (Knowledge Involvement in Research Advancement through Nurturing) embraces women-exclusive schemes of DST with the mandate to bring gender parity in S&T through various mechanisms. KIRAN paves the way to women scientists for building their career path by addressing crucial challenges (e.g. break in career primarily due to family responsibilities, self employment, part time career, relocation, etc.) faced by them. The achievements of various programs under KIRAN during the year 2019-20 are as follows:

1.6.1 Gender Mainstreaming

a. Women Scientist Scheme-A (WOS-A): WOS-A is aimed to provide opportunities to women scientists and technologists, who had a break in career, for pursuing research in basic or applied sciences in frontier areas of science and engineering. This year DST received 720 new proposals and after extensive as well as intensive scrutiny, 231 projects (Life Sciences–55 out of 216, Chemical Sciences–73 out of 184, Physical and Mathematical Sciences–33 out of 90, Earth and Atmospheric Sciences–48 out of 94, Engineering Sciences–22 out of 136) were recommended. During the year, progress of 175 ongoing projects, funded under WOS-A has also monitored.

Training Programme on Patent Search and Analysis in Research: A 5 days hands-on training programme on '*Patent Search and Analysis in Research*' was conducted especially for Principal Investigators of WOS-A projects under Life Sciences with aim to impart training on concepts of patent, patent databases, patent search and analysis, patent landscape analysis, white space analysis and patent filing procedures etc. at ICRISAT, Hyderabad with support from RICH.



Fig. Women Scientists during hands-on training on '*Patent search and analysis in research*' at ICRISAT, SciTech, T-hub and CCMB.

Twenty Three (23) women scientists participated in this training programme and they were not only exposed to theoretical knowledge about fundamentals of patent, patent database, prior

art search, drafting and related procedures but also they have been given hands on experience and training in patent search and analysis at ICRISAT and SciTech Patent Art. Participants also visited incubation centres at ICRISAT, CCMB, RICH and T-hub to get practical exposure and knowledge in IP commercialization and technology transfer. After the workshop participants are able to do patent search and analysis for their own research/inventions, identify similar technologies and refine their innovations to make them patentable.

b. Women Scientists Scheme-B (WOS-B): This fellowship focusses on S&T solutions of challenges/issues at the grassroots level for social benefit. Projects with specific location interventions addressing issues in rural/urban areas were invited from women scientists/technologists in three subject areas: Agriculture and Allied Sciences (AAS), Health, Food and Nutrition (HFN), and Engineering & Technology Development (ETD). Women scientists are required to work on development and adaptation of technology, transfer of technology from lab to field and its scaling up for improving quality of life and provide opportunities for income generation. Seventy Five (75) projects have been recommended by Subject Expert Committees during 2019-20 in these three areas. Budgetary support was also extended to Thirty Four (34) ongoing projects. Progress of 25 ongoing WOS-B projects was monitored in Group Monitoring Workshops.

Mentoring Workshop under WOS-B: KIRAN Division has taken a new initiative to mentor women scientists who are Principal Investigators (PIs) of projects sanctioned under WOS-B program as most of these women are returning to mainstream science after a break in career. The aim of the workshop was to provide guidance to women scientists in developing a clear roadmap with respect to concrete delivery/outcome for societal benefits. One to one interaction of PIs with subject experts in the beginning of new project is expected to bring more clarity about management of society based projects. 53 women scientists (PIs) and 25 mentors participated in the workshop held at Central Institute of Aromatic Plants (CIMAP), Lucknow.



Fig. Mentoring Workshop under WOS-B Programme

c. Women Scientists Scheme-C (WOS-C): This training and capacity building component of Women Scientist Scheme is one of the flagship programme of DST. WOS-C programme provides on-job training to the selected women scientists in the area of Intellectual Property Rights (IPRs) and prepares them towards self-employment. 114 women scientists and technologists joined 11th batch of WOS-C programme in 2019. One-month orientation for them was held at New Delhi in August 2019 followed by 11 months long on-the-job training at various agencies located throughout the country. The training of 10th batch concluded in 2019 and almost 60% of beneficiaries have been gainfully employed with IPR attorney law firms, government agencies, MNCs, KPOs, etc. A few have started their own freelancing of IPR work, IPR Consultancy and IPR firm.



Fig. Orientation Programme of 11th Batch under WOS-C at New Delhi

d. Mobility Scheme: Mobility Scheme is aimed to address the relocation issue of women scientists and academicians working in regular position in Government organizations. It endeavours to provide opportunities to women scientists who wish to relocate to different city to fulfill their family responsibilities. The Scheme provides 2-5 years R&D project support to sustain their research career at new place of their choice. Two women scientists are awarded with this fellowship during 2019-20. They are receiving a consolidated fellowship at new organization at par with their last salary from parent organization and Rs 5.00 lakh research grant per annum.

1.6.2 Overseas Opportunity for Women in STEMM

Indo-US Fellowship for Women in STEMM: DST in association with Indo-U.S. Science & Technology Forum (IUSSTF) is implementing “Indo-U.S. Fellowship for Women in STEMM (WISTEMM)” program to provide opportunities to Indian Women Scientists, Engineers & Technologists to undertake international collaborative research in premier institutions in U.S.A. During 2019, 20 women scientists (10 in each category) from IITs, Universities and national labs have been selected under the two categories of WISTEMM viz. student internship and fellowship. An interactive workshop was conducted with 20 WISTEMM awardees of the first batch after their return in order to know about their experiences gained (professional &

personal), research highlights, outcome of collaborative work, future plan carved etc.



Fig. Women Scientists & Technologists completed first batch of Indo-US Fellowship for Women in STEMM (WISTEMM)

1.6.3 Research Infrastructure and Facilities in Women Universities

CURIE (Consolidation of University Research for Innovation & Excellence in Women Universities): Since the inception of CURIE Programme in 2009, eight (8) women universities have been supported to strengthen R&D infrastructure & facilities. This year Rama Devi University for Women, Bhubaneswar has been supported under CURIE.

CURIE-AI Facility: Artificial Intelligence is new boom in technology field and has great scope for skilled human resource. To harness this opportunity in favour of women, Artificial Intelligence Facility has established in CURIE Beneficiary Universities in the year 2019. This support was given to Six (6) women universities where around 10,000 girl students are going to be benefitted with this component.

Faculty Development Programme (FDP) on Artificial Intelligence (AI): Two Faculty Development Programmes (FDPs) under CURIE-AI Component have been organized at Indira Gandhi Delhi Technical University for Women (IGDTUW), Delhi and Banasthali University, Banasthali in order to skilling and reskilling of faculty in the field of Artificial Intelligence. Fifty (50) faculties from all over India have participated in FDP at IGDTUW, Delhi and updated their understanding on fundamentals of AI and its applicability in research. In FDP at Banasthali University, 42 faculties of all the CURIE beneficiary universities and women faculties of other institutions from nearby areas have attended this programme and they have developed common course structure for certificate/diploma programme on 'Fundamentals of Artificial Intelligence' for adoption in all CURIE beneficiary universities.

1.6.4. New Initiatives for Gender Parity in STEM:

a. Vigyan Jyoti:

The DST took a big step in order to bring gender parity in STEM (Science Technology Engineering Mathematics) and launched Vigyan Jyoti Scheme to encourage girl students for STEM career especially in underrepresented areas for women. The scheme's aim is to bring more girl students from schools to prestigious academic institutions such as IITs, NITs, IISERs, central universities etc. The Navodaya Vidyalaya Samiti (NVS) is implementing partner of DST for this initiative. In the first phase 2500 meritorious girl students of class XI have been selected in 50 Districts in collaboration with NVS. Prestigious academic and research institutions such as IITs, NITs, CSIR/ICAR/ICMR labs etc. in the vicinity of each Jawahar Navodaya Vidyalayas (JNV) are also associated with this initiative as Knowledge Partners (KPs) and they will provide continuous mentoring, visit, project-based learning and so on to selected girl students.



Fig. Vigyan Jyoti Workshop with Principals of 50 Jawahar Navodaya Vidyalayas

b. Program for Gender Advancement in S&T Institutions:

This new program initiated in 2019, is expected to bring paradigm shift in institutional reforms to attract, recruit, retain and promote women into scientific laboratories and institutions of higher educations. It is based on initiatives in UK (Athena SWAN model), Australia (SAGE initiative) wherein a Charter for Gender Equality in STEMM for India will be developed, and institutions will be encouraged to adopt and bring transformational changes in facilities and policies to empower women. This aims to create a new ecosystem based on building competencies of institutions and provide them with ongoing mentoring support to achieve transformation. To implement the program in India, the DST has now signed Operational Alliance Agreement with British Council, which will help DST to select UK's best practices in this area and their customization in to Indian context. The program will not just assess, accredit and recognize institutions through Certification and Awards, it would also engage,

mentor, partner and support institutions as they work towards reaching the global best practices for gender equality.

1.6.5 Training and Capacity Building:

During 2019-20, Sixteen (16) training programmes have been organized under 'National Training Program for Women Scientists & Technologists working in Government' covering multifarious themes like managerial skills, leadership, Project management, internet of things, S&T for rural societies, entrepreneurship development, gender equality, work-life balance, etc. More than 350 Women Scientists participated in these training programmes conducted at 10 reputed institutions of the country.

1.6.6 Outreach Activities:

a. Gender Equity in Physics: KIRAN Division supported IPA National Conference towards Gender Equity in Physics held at University of Hyderabad, Hyderabad during 19-21 September, 2019. Over 200 physicists, social scientists and educationists gathered to cross disciplinary boundaries and debate on the vexed question of why there is a persistent gender gap in the physics profession in India. For the first time, physicists, educationists, social scientists and diversity experts shared a common platform to deliberate on Different Angles on Promoting Gender Equity. Moreover, all of them have participated in both immersive, process-based workshops that are designed to build capabilities in understanding gender inequity.

b. Sensitization Workshop: A sensitization workshop has been organized at Berhampur University, Odisha in December, 2019 with the aim to include underrepresented areas of the country in KIRAN programmes and encourage participation of women scientists under various programmes of KIRAN. In Berhampur workshop women scientists from aspirational districts of Odisha have also participated. These workshops not only give flairs of all the women centric programmes to the participants but also include lectures on thrust areas, location specific problems, how to write scientific proposals, communication part, etc.



Fig. Women scientists from different parts of Odisha including aspirational districts attending Sensitization workshop at Berhampur University

c. **Women Science Congress:** DST-KIRAN supported 9th Women Science Congress (WSC) held at University of Agricultural Sciences, Bangalore. Women Scientists from all over the country participated in WSC. Dr Tessy Thomas, Director General, Aeronautical Systems, DRDO gave key note address.



Fig. Dr Tessy Thomas during Inaugural Session of 9th Women Science Congress

1.7 INSPIRE

The “**Innovation in Science Pursuit for Inspired Research (INSPIRE)**” Scheme of the Department of Science and Technology, GOI is focused on the young population of the country. It aims to impart to them the excitements of creative pursuit of science, attract meritorious among them to study basic and natural sciences at the college and university level and to pursue research careers in both basic and applied science areas including engineering, medicine, agriculture and veterinary sciences. The ultimate aim is to expand the R&D base of the country. INSPIRE programme has 4 Components.

The **INSPIRE Internship** is the second component of the **Scheme for Early Attraction of Talent for Science (SEATS) branch of the INSPIRE Scheme**. It aims at providing exposure to the joys of creative science to young science students of 16-17 years of age by organizing Science Camps either in summer or winter days. About 98 INSPIRE Internship camps were organised during the year wherein about 20,000 students studying science in Class XI were provided an opportunity to interact with science icons from India and abroad including Nobel Laureates. The Science Camps were organized in different parts of the country.

The Scholarship for Higher Education (SHE), is the second branch of the INSPIRE Scheme.

It aims at encouraging meritorious students to study basic and natural sciences in B.Sc. and M.Sc. through attractive scholarship and mentorship opportunities. The scheme offers 12,000 scholarships to meritorious students in the age group 17-22 years every year @ Rs 0.80 lakh per year (10,000 Direct Mode + 2000 Institutional Mode). The main feature of the scheme is the mentorship support provided to every student to carry out research during vacation periods. During 2019-20, in the Direct Mode, 19,062 applications were received based on the results of the academic year 2018. Out of these, 10,220 candidates have been offered INSPIRE-SHE till date (Figure 1).

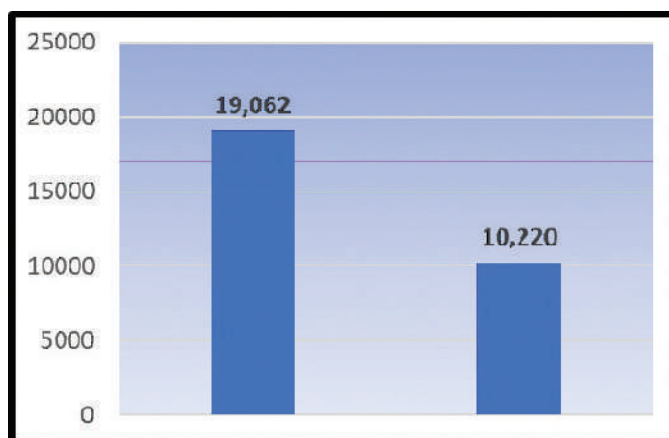


Figure 1: INSPIRE-SHE 2018 (Applications Vs Selection)

Under the Institutional Mode, 982 ongoing Scholars received their Scholarship for taking up undergraduate/integrated post-graduate degree courses in basic and natural sciences in various IIT's, IISER's, NISER's etc. The selections are based on performance (top 1%) in Class XII examinations of State/Central School Examination Boards and in various competitive examinations like IIT-JEE. The gender-wise distribution of the INSPIRE-SHE Scholars is given at Figure 2.

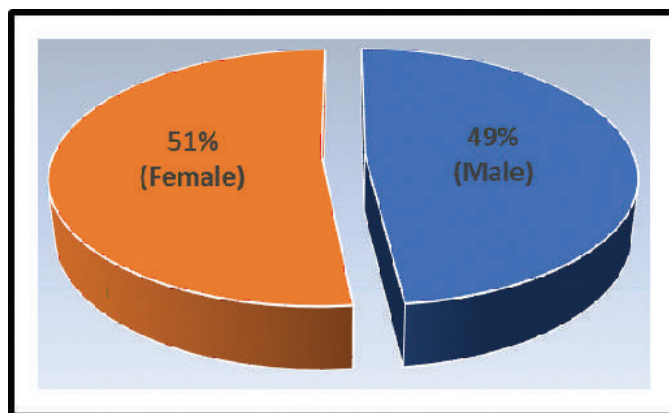


Figure 2: Gender Distribution of INSPIRE-SHE Scholars

The third branch of the INSPIRE Scheme is called **Opportunity for Research Careers (ORC)**. The aim is to attract and nurture meritorious young manpower for scientific research and help retain them in careers in R&D so as to enlarge the R&D base of the country. It has two components. The first component, viz. **the INSPIRE Fellowship**, offers 1000 Fellowships every year to bright students in the age group of 22-27 years to pursue Ph.D. in basic and applied sciences including engineering, medicine, agriculture and veterinary sciences. The second component under this branch, viz. **the INSPIRE Faculty Fellowship**, offers 100 attractive post-doctoral research fellowships for 5 years to bright candidates in the age group of 27-32 years in basic and applied sciences including engineering, medicine, agriculture and veterinary sciences.

INSPIRE Fellowship: This is offered to (i) students who secure 1st Rank in basic and applied sciences including engineering, medicine, agriculture and veterinary sciences in the University/National Institute level examinations; and (ii) INSPIRE-SHE Scholars who secure 70% marks in aggregate in their M.Sc. level examinations, and who are eligible for admission to a Ph.D. Program in any recognized University/Academic Institution of the country. The Fellowship is provided for a maximum of 5 years (2 years as JRF and 3 years as SRF) to pursue a full-time Ph.D. program. The Fellowship amount including contingency grant is equivalent to the CSIR-UGC NET Fellowship and is governed as per extant GOI norms and regulations. So far, about 8800 students have been awarded INSPIRE Fellowships for pursuing their Ph.D. Out of them, 65% are Female students (Figure 3). Nearly, 26 % of the INSPIRE-SHE Scholars have continued to pursue their doctoral degrees in science after availing 5 years of INSPIRE-SHE Scholarship. Out of the 8800 INSPIRE Fellowships awarded so far, 3705 INSPIRE Fellows received their fellowship (including 952 new fellows) during the year 2019-20. Besides this, 9 INSPIRE Senior Research Fellows were selected for participating in the 12th HOPE meeting in Tsukuba, Japan to engage in interdisciplinary discussions with Nobel laureates and other distinguished scientists and researchers. 25 INSPIRE Senior Research Fellows and 3 UK Fellows were selected for short-term Research Internship programmes in various laboratories/ universities in UK and India, respectively, as part of the Newton-Bhabha Ph.D. Placement Programme of DST and UK. Eight Group Monitoring Workshops/ Meetings were organised across the country to monitor the progress made by 1048 INSPIRE Fellows in their research work.

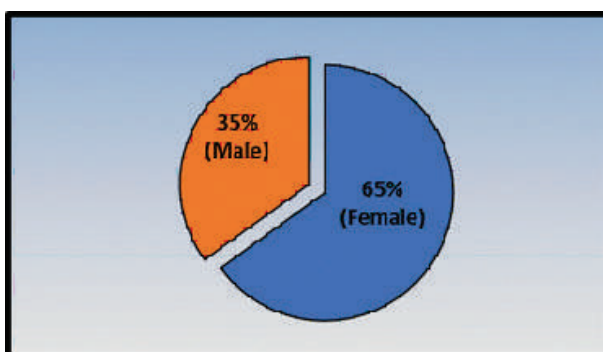


Figure 3: Gender Distribution of INSPIRE Fellows

The **INSPIRE FACULTY FELLOWSHIP** provides opportunities to person with Ph.D. qualification in the age group of 27-32 years to carry out post-doctoral research in both basic and applied science areas including engineering, medicine, agriculture and veterinary sciences. It aims at the following: (i) to provide attractive opportunities to young achievers for developing independent scientific profiles; (ii) to provide them opportunities for independent research, and not guaranteed jobs, so that they are able to effectively compete for long-terms positions that become available in various academic and research institutions of the country; (iii) to, thereby, augment the scientific manpower of scientific and educational institutions, specially the central and state universities.

So far, more than 1265 fellows have been awarded these fellowships. The gender-wise distribution of the INSPIRE Faculty Fellows is given in Figure 4. Among the INSPIRE Faculty Fellows who have got 5 years of support, 66% have obtained regular position in academic/ research institutions. During 2019-20, 562 INSPIRE Faculty Fellows received their Fellowship including 67 new INSPIRE Faculty Fellows. A Review Meeting to monitor the progress made by 235 INSPIRE Faculty Fellows in their research was organised during October 21-23, 2019 at Andhra University, Visakhapatnam.

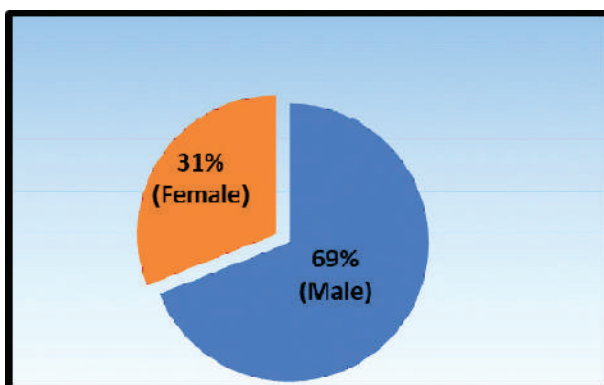


Figure 4: Gender Distribution of INSPIRE Faculty Fellows

1.8 Swarna Jayanti Fellowship

On the occasion of 50th year of India's Independence, 1997, the SwarnaJayanti Fellowship Scheme had been launched to support young scientist to enable them to pursue research in frontier areas of science and technology. The scheme offers Rs.25,000/- per month for 5 years along with a research grant of Rs 5.00 lakh each year international & domestic travel and grants for Consumables and Contingency if required. The main project is once again evaluated by SERB through an Empowered Committee and once approved the project is granted with monitoring after 3 years and at end of the project. This exercise is carried out for developing Young renowned Scientists capability and capacity to improve their Research Capacity.

The exposure through the SwarnaJayanthi Fellowship Scheme has enabled the fellows in achieving higher scientific recognition. Some of the advanced areas of S&T got recognized due to support to the Young Science Leaders as SwarnaJayanti Fellows like for the INO-India. During a survey, it was found that most of the SwarnaJayanti Fellows have received the prestigious Shanthi Swarup Bhatnagar Prize at a later stage.

During the year 2018-19, 14 Fellows have been selected for award of SwarnaJayanti Fellowships through a three-tier rigorous screening process from 443 applications. The following 14 applicants were selected for SwarnaJayanthi Fellowship for the year 2018-19: The first instalment of Fellowship along with Research Grant of Rs 3.00 lakh is being released during the remaining months of FY 2019-20.

The output from each Fellow is in the form of **2-3 PhDs, on average of 12 publications**, from the project in the best Journals including "Nature Group" and Science too and **2-3 patent, in few cases**. In few completed Fellowships project newer areas in Science Research has come up in which a leadership trend is being shown through publications with high Citations. Many leading Fellows are now heading the Institutes for Higher Learning of Department of Higher Education.

List of Awardees- SwarnaJayanti Fellowships Scheme- 2018-19

S. No	Fellows Detail	Discipline
1.	Dr. Sheetal Gandotra , CSIR- IGIB, Delhi	Life Science
2.	Dr. Jitender Giri , NIPGR, Delhi	Life Science
3.	Dr. Rakesh Singh Laishram , RGCB, T' drum	Life Science
4.	Dr. Vishal Rai , IISER-Bhopal	Chemical Science
5.	Dr. Kanishka Biswas , JNCASR, Bengaluru	Chemical Science
6.	Dr. Gopalan Rajaraman , IIT-Bombay, Mumbai	Chemical Science
7.	Dr. Apoorva Khare , IISc-Bengaluru	Mathematical Science
8.	Dr. Mahender Singh , IISER-Mohali	Mathematical Science
9.	Dr. Subimal Ghosh , IIT-Bombay, Mumbai	Earth & Atmospheric Science
10.	Dr. Smarajit Karmakar , TIFR, Hyderabad	Physical Science
11.	Dr. Arjun Bagchi , IIT-Kanpur	Physical Science
12.	Dr. Anindya Das , IISc-Bengaluru	Physical Science
13.	Dr. Yogesh Simmhan , IISc-Bengaluru	Engineering Science
14.	Dr. Shweta Agrawal , IIT-Madras, Chennai	Engineering Science

RESEARCH & DEVELOPMENT

2.1 International Cooperation -Bilateral

2.1.1 Salient Activities During the Year

Joint S&T Committee/ Council Meetings were held with Australia, Denmark, Israel, Myanmar, Netherlands, Oman, Sri Lanka and Uzbekistan. These meetings were led to the renewal of new Program of Cooperation (PoC) and Action Plans with various partner countries. Governing Body meetings of the bi-national Indo-U.S. S&T Forum (IUSSTF), Indo-French Centre for Promotion of Advanced Research (IFCPAR), and Indo-German S&T Centre (IGSTC) were also held during the year. New areas of S&T cooperation were also introduced for implemented through Programme of Cooperation (PoC), Memorandum of Understanding (MoU) and through joint declarations.

Bilateral Meetings were held with Australia, Brazil, Canada, Denmark, Finland, France, Germany, Israel, Italy, Mexico, Myanmar, Netherlands, Oman, Russia, Spain, Sweden, Switzerland, Sri Lanka, United Kingdom and Uzbekistan to discuss ways to take advantage of all linkages and networks supported in the previous years, including joint solicitation for scientific research and technological development and innovation proposals. The other considerations highlighted during these meetings included exploring possibilities of establishing joint centres of excellence and inter disciplinary cross cutting ideas to promote futuristic bilateral cooperation.

Ministerial meetings were held with Afghanistan, Bhutan, Brazil, Germany, Maldives, Myanmar and Netherlands to discuss ways to rejuvenate ongoing bilateral S&T cooperation.

New Science & Technology Agreement was concluded with United States of America.

New Program of Cooperation in Science & Technology were initiated with Brazil, Mexico, Philippines, Slovenia, Sri Lanka, Sweden, Switzerland and Uzbekistan

About 340 new joint projects and over 100 Joint Workshop/ Seminars were supported during the years.

Technology Summit: The 25th DST-CII Technology Summit with Netherlands as partner country was held in New Delhi during 15-16 October 2019. The flagship event was inaugurated by Union Minister of Science & Technology, Health and Earth Sciences Dr. Harsh Vardhan and H.M. Mr Willem-Alexander, King of the Netherlands. The Summit focussed on water, agriculture and health involving all stakeholders-government, academia,

industry, start-ups, etc. In the two days programme, 40 MoUs were signed between Indian & Dutch companies and Institutes, 511 business to business meetings were held, around 25 Indo-Dutch collaborative projects showcased. Digital exposition by 60+ organisations in agriculture, health care, water and hi-tech areas were displayed. More than 250 speakers and over 1400 delegates were participated. Some of the key recommendations emerged from the Summit included to incentivize to encourage R&D by industry, innovate to reduce the cost of technology and capital equipment, usher transparent regulatory framework on non-tariff barriers, initiate a focussed collaboration on waste water treatment, Initiate capacity building in whole value chain in water management, make the vaccines available at the most affordable way, support tech collaborations in digital transformation to make it affordable for smaller companies, launch exchange of R&D professionals, start-ups and tech-talents between India & Netherlands, and Launch an Indo-Dutch Campaign - WAH! (Water-Agriculture-Healthcare).



Photo 1: 25th DST-CII Technology Summit with Netherlands

2.1.2 S & T Ministers and Diplomats Conclave (OMDC)

As a part of our foreign policy initiatives of the present government like “Neighbours First”, India has now embarked upon a visible path of developmental diplomacy using science, technology and innovation that will not only help towards capacity building in R&D but also address the needs of the people through the application of science technology and innovation. The Overseas S & T Ministers and Diplomats Conclave (OMDC) on the theme ‘S & T policy as a driver for Social change/Socio-economic development’ was organized as a part of the 2019-India International Science Festival (IISF) in Kolkata on November 5, 2019. S & T/ Education Minister from Afghanistan, Bhutan, Maldives and Myanmar participated in the event along with UK Chief Scientific Advisor and other senior diplomats from various countries. The ministers and the diplomats from the key-partner countries stressed on collaboration with India in the field of Science and Technology and suggested mutually beneficial avenues for a cohesive socio-economic growth.

Germany: A Joint Declaration of Intent (JDI) for Joint Cooperation in Research and Development on Artificial Intelligence between the Federal Ministry of Education and Research of the Government of the Federal Republic of Germany and the Ministry of Science & Technology of the Government of the Republic of India was signed during the bilateral meeting between S&T Minister of India and the Federal Minister of Education & Research of Germany on November 1, 2019 and exchanged in presence of Prime Minister of India & German Chancellor. The JDI is to identify areas of mutual interest in basic and applied research in Artificial Intelligence (AI) through a workshop in 2020 in Berlin including relevant stakeholders from research institutions, universities and industry.



Photo 2: A Joint Declaration of Intent (JDI) with Germany

India-Ethiopia Innovation & Technology Commercialization Programme (IEITCP): Under India Ethiopia S & T Cooperation, a new programme i.e. India-Ethiopia Innovation & Technology Commercialization (IEITCP) was initiated towards technology transfer in African countries. The objective of the programme is to match the socio-economic needs of Ethiopia by linking the Ethiopian industry with leading edge Indian technologies and innovations. The programme will deploy 30 Indian technologies in Ethiopia over a period of 3 years. The joint programs/ventures created with Ethiopian partners will deliver at least 30 sustainable enterprises that will stimulate economic impact in Ethiopia.



Photo 3: India-Ethiopia Innovation & Technology Commercialization Programme

New program with Oman: The first India-Oman Joint Committee meeting was held on September 24-25, 2019. The discussion was held on area of mutual interest like biotechnology, information technology, petroleum, technologies and science education. Both sides decided to propose a Programme of Cooperation for joint science and technology activities.



Photo 4: India-Oman First Joint Committee meeting

2.1.3 Bilateral Research Projects and Programs

Africa: An Indian stakeholder discussion meeting was held to review the progress of DST-World Bank collaboration towards strengthen India Africa Science and Technology Initiative

at Hyderabad on November 15, 2019. The representatives from all 10 Indian institutions have participated in the meeting. 25 African researchers spent 1-6 months in Indian institutions for capacity building in identified themes towards the program for development of African Centres of Excellence.

Australia: The 9th India-Australia Joint Science and Technology Committee meeting of AISRF was held at Canberra on 6th September 2019. Ongoing programs were reviewed, and it was agreed to enhance the allocation of Australia India Strategic Research Fund to invite new proposals in Climate change: Mitigation and Adaptation, Food processing and Storage and Mine Safety and Efficiency. It was agreed to work together on Athena Swan model on gender equality program in STEMM, participation of Indian and Australian scientists in mega science projects like Square Kilometer Array (SKA), Laser Interferometer in Gravitational wave Observatory (LIGO). Development of joint collaborative programs in incubation, entrepreneurship was also agreed. Australian side informed that they have announced fellowship program for their young researchers to India and requested Indian side to initiate call for Indian researchers to work in Australia.

A joint call was issued by DST and Australia under Australia-India Strategic Research Fund (AISRF)-Round 11 in the areas of (i) Energy Storage (Batteries) and (ii) Marine Science. In response to the call, 20 project proposals were received by both sides. After judicious assessment based on scientific strength, technical aspects, project objectives and national priorities of both the countries DST and Department of Industry, Innovation and Science (DIIS) of the Australian Government have jointly decided to support the one project.

Austria: 32 new joint projects were approved for implementation in 2018-19. In the year 2019, a joint call was launched and both sides received 29 joint projects, which are under evaluation process.

Belarus: Under the India-Belarus S&T Cooperation, a joint Seminar on “Nanomaterials and Advanced Materials” was held at OV Roman Powder Metallurgy Institute, Minsk during September 25 – 27, 2019. Eight-member Indian expert team was led by Dr. G Padmanabhan, Director, International Advanced Research Centre for Powder Metallurgy and New Materials Hyderabad. During the Seminar experts made presentation covering areas such as (i) Additive Manufacturing (AM) (ii) Powder production for AM and Powder Metallurgy Components (iii) Nanostructured Materials (iv) Ceramic Materials (v) Functional coatings and thin films for various applications (vi) Sputtering targets. During the three days visit, experts from India and Belarus had in depth discussion in the entire range of possible technology-oriented collaborations, especially in powder metallurgy.

Support extended to 8 joint research proposals selected in the areas of (i) Energy; (ii) Information and Communications Technologies; (iii) Biotechnology, Medicine and Pharmacy; (iv) Agro technology and Food Security; (v) Clean Technology for Environment and (vi) Materials Sciences & Metallurgy, against the call for proposals launched in July 2018.

Bulgaria: 16 new joint R&D India Bulgaria projects are being implemented in the areas of information and communication technologies; materials and material Sciences; physics, including laser science and technology, nuclear physics, astronomy and space and technology research; chemical sciences; renewable energy; earth science, geophysics, climate studies, oceanology and environmental protection, including waste management; biotechnology, agriculture and food technology; healthcare, biomedical appliances, bioethics, pharmacy and traditional medicine and social studies related to science and technology.

Canada: Six new joint projects on Cyber Physical Systems to support Green Buildings in Smart Cities were approved for implementation for support under India-Canada IC-IMPACTS programme in the areas of large area microbolometer; uncooled focal plane arrays for thermal imaging; carbon neutrality through combined carbon dioxide capture and novel hydrogen technology with production of non-conventional fuels for smart cities; meta-material based lightweight panel wall for enhanced building acoustic and seismic resistance; metal material walls for improved acoustic performance in green buildings; improving building energy demand predictions in smart cities through sensor observations and considerations of landscape characteristics; harnessing the potential of renewable energy for sustainable building energy management through compressed air energy storage.

Czech: 20 new projects have been approved for support under India-Czech joint R&D collaborative program in the areas of information and communication technologies; natural sciences and biotechnology; new materials and nanotechnology; medical sciences (including pharmaceutical sciences) and food safety; research of climate change, environment and energy.

Denmark: The Second meeting of the India-Denmark Joint S&T Committee was held on 22nd November 2019. The Joint Committee confirmed support to 3 ongoing joint research proposals against the 1st joint call in the areas of Energy. Also second joint call for proposals in the area of “Cyber Physical System” was launched.

Egypt: 131 joint research proposals have been received in Biotechnology, Nanotechnology and Information & Communication Technologies. The proposals are under review.

Ethiopia: A call for proposal was announced under the India Ethiopia Innovation & Technology Commercialization Programme (IEITCP) in the following thematic areas: Agriculture & Animal Husbandry; Food Processing; Health; Water & Sanitation; Renewable Energy; ICT & IT; Trade & Industry; Mines & Minerals; Petroleum & Natural Gas; Environment & Forestry and Infrastructure. The Programme will identify and utilize validated Indian technologies/innovations culled through a unique and rigorous evaluation process to create sustainable joint projects/ventures in Ethiopia. About 30 technologies are shortlisted for collaboration with Ethiopian enterprises. Strengthening of 4 Ethiopian Centres of Excellences continued to be supported in the areas of Water Management, GIS, Energy and Food Technology.

Finland: A meeting with Business Finland was held in Delhi and it was agreed to initiate joint research collaboration (Academia-Academia) and Industrial R&D programme between the two countries.

10 Indian researchers visited Finland and Three Finnish researchers visited India for duration of 1 to 3 months during the year.

France: Meeting with President CNRS (National Centre for Scientific Research) was held with Secretary DST. It was agreed to initiate joint research programs in Cyber Physical System, Quantum Computing, Electric Vehicles, Gender equality, and Clean fuel (methanol).

Targeted programs in focused areas enabling research funding agencies of both the nations were supported. These include (i) Indo-French Centre for Applied Mathematics (IFCAM), between DST and Centre National de la Recherche Scientifique (CNRS); (ii) DST-Inria program in Information and Communication Science & Technology; (iii) DST-CNRS joint projects in the areas of (i) Engineering & Systems Sciences (ii) ICT (iii) Detector & Theory Developments in Nuclear & Particle Physics and (iv) Biodiversity, Ecosystems & Human-Environment Interactions. One joint project against the fifth DST-Inria joint call and four joint research projects between DST-CNRS call were agreed for support during this period. The Indo-French Centre for Applied Mathematics (IFCAM) proactively facilitated cross-disciplinary interactions between mathematicians, engineers and other scientists of the two countries. An active short-term visitors' program and exchange of post-doctoral fellows/research students were the important components of this Centre's activities.

Under the Raman-Charpak Fellowship, visit of 25 Indian PhD students were supported for the duration of 3 to 6 months. Visit of 5 French PhD and Master Students to India were also supported during the reported period.

Germany: Multiple scientific agencies cooperation with Germany was pursued, besides the joint activities through Indo-German Science & Technology Centre (IGSTC).

The German Federal Minister for Education and Research Ms. AnjaKarliczek called on Hon'ble Minister for Science & Technology, Earth Sciences and Minister for Health Dr Harsh Vardhan and discussed on various activities under Science and Technology and research co-operations between India and Germany. Both Ministers expressed happiness on signing a Joint Declaration of Intent to launch dedicated research cooperation on Artificial Intelligence addressing several societal issues pertinent to cyber security etc. Both Ministers expressed satisfaction on research cooperation between two countries for the past few decades through which more than 2000 scientists, scholars and students from both countries have exchanged their knowledge through networking visits supported by Department of Science & Technology (DST) of India and Ministry of Education & Research (BMBF) of Germany.

Both Ministers also acknowledged the progress of the Indo-German Science and Technology Center established both Governments since 2010 onwards. Indian and Germany are also co-

operating with other International community on Facility for Antiproton and Ion Research (FAIR) Facility at Darmstadt, Germany. The FAIR facility is under construction at present.

A New call for proposals under DST DAAD program was launched and received 63 joint proposals on all areas of S&T. These projects are under evaluation by the respective expert committees.

A joint call between DST and DFG was launched under physical and chemical sciences and received 65 joint projects. These projects are under evaluation by subject expert committees.

Israel: The 9th meeting of the India-Israel Joint Committee on Science and Technology was Co-chaired by Secretary DST with Prof. Alexander Bligh, Chief Scientist, Ministry of Science and Technology, Israel. The Committee reviewed and appreciated the India-Israel Scientific Cooperation in the areas of Big Data Analytics in Health Care and Security Cyber Space. The Committee decided to organise a joint 'Women in STEM' workshop, which is scheduled to be held in India. The aim of this workshop will be to highlight the issues related to policies for women empowerment in science and technology, especially in areas under-represented by women researchers such as mathematics, engineering, artificial intelligence etc.

Italy: Visit of 49 Indian scientists to Trieste, Italy was supported for conducting experiments on Elettra beam lines allotted 294 shifts.

An Italian Workshop was held at Haveli of Shahjahanabad, Delhi to showcase outcome of the joint research programme on conservation techniques and processes for heritage buildings.

23 ongoing R&D projects were continued to be supported for implementation in the areas of MEMS, renewable energy, telecommunication, cognitive neuro sciences, healthcare, etc.

Japan: Joint Council meeting was held in Tokyo to promote bilateral scientific collaboration between Indian and Japanese scientists. A joint call for proposals was launched in the areas of Fundamental Sciences: Physical and Chemical Systems, Materials and System Engineering: Man-made Systems, Natural Systems: Life Sciences and Bioengineering, Astronomy, Space, Earth System and Sciences, and Mathematics and Computational Science. 137 Joint Research Projects and Joint Workshops/Seminars under IJCSP received against this call, are being assessed.

Midterm Evaluation of the India-Japan Science & Technology laboratories for International Research Program in ICT field was held at Hyderabad. Joint mid-course comments were given to the respective Principal Investigators from India & Japan.

A DST-ICMR-AMED joint workshop was organised at ICMR. Experts from India and Japan gathered to deliberate on the potential areas in health research, to identify priority research areas that are of mutual interest for India and Japan for future collaborations.

Mexico: An India-Mexico Dialogue on 'Innovation and Social Development' was organised at

Delhi. The target of this workshop was to bring together business, academic and government leaders to exchange perspectives on how technology and innovation can improve the lives of citizens and explore opportunities for collaboration in areas such as innovation and social development, integrating SMEs into high-value global productive networks, and entrepreneurship with social inclusion.

Myanmar: An India-Myanmar Joint Committee Meeting was held at Delhi. It was agreed to cooperate in the area of Cyber security, disaster mitigation, food technology, virtual reality and GIS.

Indian and Myanmar Ministers had a meeting at Kolkata to discuss initiation of bilateral cooperation and endorsed the recommendation of Joint Committee meeting.

Poland: A joint call for research proposals in areas including Natural Sciences, Engineering and Technology, Medical and Health Sciences, and Agricultural Sciences was made. A total 220 projects received against this call, are being assessed.

Russia: Under the DST-RFBR program, ninety-six joint R&D projects are currently under implementation. Against a new call for proposals launched in February 2019, 43 research proposals approved during the year. Under the joint research programme with Russian Science Foundation, support was extended to 17 ongoing and 20 new projects in areas of Physics, Chemistry, Mathematics, Life Sciences, Information & Communication Technologies, and Earth Sciences.

Singapore: Participation of Start-ups in emerging technology domains like Artificial Intelligence, cybersecurity, fintech, healthcare, Innovation and Social Impact (Energy) was supported in the Business and Innovation Summit organized by the High Commission of India in Singapore. The Exhibition was inaugurated by Dr. S. Jaishankar, External Affairs Minister, India and Dr. Vivian Balakrishnan, Minister for Foreign Affairs, Singapore followed by walkthrough and an interaction with exhibitors who were representing start-ups from India and Singapore.

Slovenia: A new Programme of Cooperation for the year 2020-22 was concluded at Ljubljana, Slovenia during the visit of President of India to Slovenia. The program would promote cooperation in areas of health, biomedicine and biotechnology; new materials, including polymers; information and communication technologies; renewable energy sources; urban areas (smart cities) and artificial intelligence.

Sri Lanka: The 4th Joint Committee Meeting (JCM) on Science and Technology Cooperation was held at New Delhi, in which a new Program of Cooperation was concluded. 20 ongoing projects were continued to support. Both sides agreed to initiate cooperation in the area of Renewable energy, Information and Communication technology, waste management, Science popularization and Technology incubation and acceleration and further strengthen the cooperation in the area of Food Technology and biofertilizers. A Call for proposal is

announced in September 2019 and 211 proposals are received which are under assessment.

Sweden: The joint committee meeting (JCM) highlighted the importance of India-Sweden collaboration with their priority areas such as artificial intelligence and smart cities and clean technologies. The JCM recommended the following activities with detailed sub themes: Sustainable Development: Waste to wealth, circular economy, e-waste processing and recycling, toxicity etc.; Life Sciences: Bio medical devices, social media presence, AI mission for healthcare; New technologies: Smart grids, micro grids, Water Splitting for hydrogen, energy storage, new batteries / battery recycling, artificial intelligence drones. The Committee also reviewed the ongoing activity under DST VR programme, and recommended 20 joint projects in the themes of Computer sciences and Nano sciences. The projects are being processed for funding. The JCM also recommended 3 industrial R&D projects under DST-Vinnova cooperation on the themes of Digitalization, IoT and Clean Technologies.

The India delegation also participated in the roundtable discussion at Sweden India Business Council (SIBC) and Swedish Aerospace and Defence Company (SAAB). Secretary, DST deliberated on academia, industry and business cooperation between Indian and Swedish entrepreneurs and also briefed about the recent initiatives by the Government of India for promoting entrepreneurs and business incubators supported the Ministry of Science & Technology, NITI Ayog etc.

Switzerland: The fifth joint committee meeting between India and Sweden was held on April 29-30, 2019 at Zurich. Extensive discussions were held on promoting scientific cooperation between the Swiss National Institutes by presenting the various avenues and opportunities and national institutes in India. During the Joint Committee meeting, both the delegations have discussed elaborately on the possible themes for the next joint call and identify the themes of joint call for inviting proposals in the areas of Hydrogen Generation through Water Splitting, Smart grids, artificial intelligence, Machine Learning etc.

South Africa: 25 ongoing joint R&D projects were continued to be supported. A new call for proposals was made in the areas of advanced materials including manufacturing, biotechnology and renewable energy. 85 project proposals have been received which are being assessed.

India-South Africa Stakeholders consultation meeting to develop implementation plan for technology localization program was organised at Ahmedabad.

South Korea: Necessary support extended to two joint R&D Networked Centres focused on 'Robotics' and 'Computational Materials'. These Centres are leveraging complimentary R&D strengths of both countries through convergence of competencies in design, simulation and development of advanced manufacturing techniques in these areas. Support continued to the 12 ongoing joint Research projects in the areas of (i) Engineering Sciences (ii) Health & Medical Sciences and (iii) ICT Convergence.

Two new projects entitled (i) Next-generation robust reconfigurable fixed-wing UAV with wing morphing concept for shipdeck operations and (ii) Development Of Metallo-Mechanical Prediction Module of Magnesium Forging and its Application to Automotive Components were approved under the India Korea Applied R&D Programme being supported through GITA.

United Kingdom: 46 ongoing joint R&D projects were continued to be supported. 16 India-UKIERI joint workshop proposals were recommended in various scientific areas towards generation of new scientific programs. An India UK Round Table meeting on development of bilateral cooperation in Artificial Intelligence was organised at New Delhi. Chief Science Adviser of UK visited Kolkata and held meetings on various issues pertaining to enhancement of scientific cooperation.

United States of America: Agreement on Science and Technology Cooperation (STA) between the Government of the United States of America and The Government of the Republic of India for a period of 10 years was signed on 23rd September 2019.

The 3rd India-US Health Dialogue was held in Washington DC in which representatives from both the sides presented ongoing activities, future prospects and exchanged the thoughts and ideas to strengthen collaborations in a wide range of areas of common interest such as digital health, skilling human resource, reproductive, maternal and new born child health, health policy, global health security agenda, environment and occupational health and climate change, food and drug safety. Both the sides expressed their interest to synergize and leverage knowledge resource of both the countries for further strengthening the collaboration and address health care issues of mutual interests.

Uzbekistan: India and Uzbekistan signed Programme of Cooperation (PoC) in Science, Technology and Innovation for next 3 years on 11th October 2019. As a follow-up to signing of the PoC, a joint call for research proposals was launched in areas such as (i) Agriculture and Food Science and Technology; (ii) Engineering Sciences; (iii) Information and Communication Technology, Applied Mathematics and Data Science and Technology; (iv) Health and Medical Technology; (v) Materials Sciences; (vi) Life Sciences and Biotechnology; (vii) Physics and Astrophysics; and (viii) Energy, water, climate and natural resources.

2.1.4 Industrial-R&D Programs

Industrial R&D programs are being implemented with Canada, Ethiopia, Finland, France, Germany, Israel, Italy, Rwanda, Spain, South Korea, Sweden, United Kingdom and United States. 30 joint industrial R&D projects are presently being implemented in areas of Affordable Healthcare, Clean Technologies, Energy, Cyber Physical System, Water etc.

Under the India-Korea Applied R&D Programme, prototype of a robotic arm clapping fixture with Electro Permanent Magnet System (EPMS) and real time flux sensing technology to safely handle Ferrous and Ferro alloy items has been developed. This innovation enables

safe and secure material handling by dynamically assessing clamping power requirement, resulting in 97 % more efficiency.

To address sustainable water management system to solve water crisis, a prototype of an automated amphibious and aerial vehicle for real time water quality testing with on board water analysing sensors for immediate actions on water quality has been developed under the India-Korea Applied R&D Programme. This led to the development of a unique water quality assessment solution in remote area and inaccessible water bodies, enabling digital image processing.

2.1.5 Other Activities

India hosted 70th sitting of the Committee of Plenipotentiary Representatives (CPR) of the International Centre for Scientific and Technical Information (ICSTI), a Moscow based Inter Governmental organization with membership from 22 nations. Activities of this Centre include conclusion, processing and exchange of scientific and technological information, organization of thematic exhibition/seminars, publication of analytical review & other information and training of scientists and specialists amongst member states. The meeting was attended by the representatives of Belarus, Hungary, Kazakhstan, Korea, Moldova, Poland, and Russia. Various administrative issues like results of ICSTI financial and economic performance, technical programme for the year 2019-20 and budget for the year 2020 were discussed and approved the CPR.

As part of the International Centre for Scientific and Technical Information (ICSTI) 70th CPR meeting, an International conference on «Digital Economy: The Space for Science and Technology Information» was also organized. Over 20 speakers delivered talk on themes such as (i) Science and Technology Information in the Digital Age: A Global View (ii) Information Literacy and Information Revolution (iii) Regulating Information Flow (iv) Scientific Journals in the Open Digital Environment (v) Scientific Ethics and Open Access (vi) Infrastructure for the Digital Economy (vii) S&T Information Literacy: The Role of Intermediaries.

Participation of Indian students in the 69th Nobel Laureates meeting: 21 Indian scholars under three categories namely; Master Students, Doctoral Students and Post-Doctoral Researchers to participate in the 69th Nobel Laureates meeting from June 30 - July 5, 2019 at Lindau, Germany. A total 580 young scientists from 89 countries along with 39 Nobel Laureates in Physics have participated in this meet.

Asian Science Camp: Indian team consisting of 18 undergraduate students participated in 11th Asian Science Camp, held in Shantou, China. The camp provided them an opportunity to meet Nobel laureates and Asian luminaries, interact & exchange scientific ideas with international scientific community and won 06 medals in different events. The camp was attended by over 300 students from all over Asian countries including Japan, Russia, China, Pakistan, Bangladesh, Israel and Australia.

8th GITA Foundation Day: The 8th foundation day of Global Innovation and Technology Alliance (GITA) was inaugurated by Dr. Harsh Vardhan, Hon'ble Minister of Health & Family Welfare, Science & Technology, Earth Sciences. Fifteen successful projects supported by GITA were recognized and felicitated. The projects were from a range of areas including smart transport management to biomedical technologies and smart water quality monitoring solutions. The Minister also launched the 2nd Call for Proposal for Joint Applied Research under the India-Korea Future Strategy Group.

Global Indian Scientists and Technocrats (GIST): Global Indian Scientists and Technocrats (GIST) Meet was held on 6th November at Kolkata under IISF 2019 on 'Disruptive technologies and opportunities of artificial intelligence and its applications'. About 10 Indian scientists from various parts of world participated in the event and shared their experience. This forum provided opportunity to connect and contribute in India's growth through knowledge of exchange.

The India Science and Research Fellowship (ISRF) Programme: As a part of our initiatives to engage with our neighboring countries to develop S & T partnerships, DST announced 6th Call of India Science and Research Fellowship (ISRF) Programme for the Afghanistan, Bangladesh, Bhutan, Maldives, Myanmar, Nepal, Sri Lanka and Thailand researchers to work in Indian Universities and Research Institutions. Awarded fellows would be visiting India for 3-6 month to undertake reserach in various areas of S & T.

A total 43 fellows from 6 countries (Afghanistan, Bangladesh, Bhutan, Myanmar, Nepal and Sri Lanka) are awarded ISRF fellowship against the 5th Call. These fellows are availing fellowship during FY 2019-20.

2.2 International Multilateral and Regional S&T Cooperation

DST continued to coordinate and promote international STI cooperation activities with various regional and multilateral STI related entities, UN associated agencies, International Organizations; and Global S&T Platforms. This role was fulfilled in close consultation with Ministry of External Affairs, Government of India and included activities such as joint R&D projects, technology development, S&T infrastructure development, exchange of human Resource, research and training fellowships, hosting tech summits, forum and workshops etc. The significant achievements during the year are briefly described below.

2.2.1 BRICS Science Technology and Innovation Cooperation

Science, technology and innovation cooperation under BRICS MoU signed in 2015 has been matured over the period. The stable funding commitments (~ US\$ 10 million annually) from eight funders from five BRICS countries for funding BRICS R&D projects has allowed funding support to 92 multilateral projects in ten thematic areas with most sought-after themes Material Science including nanotechnology, Biotechnology and Biomedicine Energy, Water Resources and Pollution Treatment. Russia-India-china combination has maximum

projects and about 20 percent projects have partners from all five BRICS countries. This indicates strong interest among the researchers to collaborate in multilateral form

BRICS S&T Ministerial Meeting

The 7th Meeting of the BRICS Science, Technology and Innovation Ministers, 9th Meeting of the BRICS STI SOM and 5th Meeting of the BRICS STI Funding Agencies were held in Campinas, Brazil during 16-20 September 2019. A 4-member Indian delegation was led by Hon'ble Minister of Science & Technology. The Campinas Declaration of BRICS STI Ministers adopted the: The BRICS Action Plan 2019-2022; The BRICS Calendar of Activities 2019-2020; The new BRICS STI Architecture and the Enabling Framework for innovation BRICS Network.



Fig. Signing of STI Ministerial Brasilia Declaration at Campinas, Brazil on 19th September 2019

BRICS Sectoral S&T Engagements

The Concept of **BRICS Science, Technology and Innovation driven Entrepreneurship Partnership (STIEP)** emerged during the 4th BRICS STI Ministerial Meeting hosted by India in Jaipur, in 2016. BRICS STIEP was thereafter agreed as one of the agreed areas of cooperation among the BRICS countries with India in lead. The BRICS S&T Ministerial has adopted a 'BRICS Action Plan for Innovation Cooperation' which among others encourages cooperation among Science Parks, supporting transnational establishment of BRICS high-tech enterprises in Science Parks, exchange mechanism of science parks and expanding cooperation in these domains including Technology Transfer among BRICS countries. To

begin with under BRICS STIEP a network of Science Parks, Technology Business Incubators and SMEs following are planned. Creation of cross-cultural talent pool in domains of ICT, Health, energy, natural disaster risk reduction and resilience is also envisaged. A Steering Committee of iBRICS Network has since been set up to take the cooperation further.

Information Technology and High Performance Computing (ICT and HPC) is also an identified area of cooperation among the BRICS countries. A two-member Indian delegation attended the 3rd Meeting of the BRICS Working Group on ICT and HPC hosted by the Ministry of Science & Technology of the Govt. of Brazil during 13-15 May 2019. A Task Force to prepare a report on the structure, governance and funding mechanisms of the BRICS integrated Hub on ICT and HPC was recommended by the WG. 8 topics have been identified for the next call of proposals.

With a view to developing an innovative mechanism to engage, network and connect BRICS youth a **BRICS Young Scientist Forum (BRICS-YSF)** was created by DST India, with the aims of providing a platform to young talented scientists from BRICS countries. In this background, India hosted the BRICS young Scientist Conclave in 2016 The 4th BRICS Young Scientist Conclave was hosted by Brazil Rio de Janeiro during November 7-9,2019. More than 100 young scientists and innovators from BRICS countries including 21 participants from India participated in the conclave.

A Young Innovator Prize Competition was also held to recognize and reward the best results related to research, development and innovation projects. Indian Ph.d student from National Dairy Research Institute (NDRI), Bangalore Mr. Ravi Prakash won the First Prize worth US\$ 25000 for inventing an affordable indigenously designed milk chilling unit for small to marginal rural dairy farmers. ICAR-NDRI and National Dairy Development Board, India is collaborating to translate this technology to the grass root level.

2.2.2 India European Union (EU) S&T Collaboration

India hosted 12th India-EU Joint Steering Committee Meeting on 1st March 2019 under the co-chairmanship of Secretary, Department of Science and Technology and DG Research and Innovation of European Commission. Both sides agreed to collaborate in different thematic areas such as smart grids; cyber physical system; ICT; bio-economy; health research including brain research; polar science. Further, to promote networking of innovators and entrepreneurs, both sides considered creation of India-EU Joint Innovation Centre. The India-EU Agreement for Scientific and Technological Cooperation originally signed in 2001 and renewed two times, in 2007 & 2015 is valid till May 2020. Both sides agreed to further renew the agreement The joint Call on Smart Grid was launched seeking project proposals in this area with joint co-investment of 18 million euro.



Fig. 12th India-EU Joint Steering Committee Meeting on 1st March 2019 in New Delhi

India (DST and DBT) and European Commission Directorate for Research and Innovation have agreed to co-invest about 15 million euro each for supporting joint research and demonstration projects in the areas of wastewater treatment, drinking water purification and real time water quality monitoring in Indian field conditions. As a part of this initiative, a meeting of the representatives of Funders from EU and Government of India (DST & DBT) and project Consortium from India and Europe was held in New Delhi on 14-15 February 2019 to structure and execute the activities of seven water projects being jointly supported by India and EU. The deliberations have culminated in listing the major European technologies to be implemented and adopted in India and enhancement of their treatment capacities. The European side will provide the details of technology and also supports in testing, validation and replication while the Indian consortia will work out modifications to adopt and integration to local conditions and replication in India. The technologies will emerge as low O & M systems embedded with automation and real time monitoring and decision support for an effective management of water resources both from quantity and quality perceptions.

Government funding for implementation of three India EU Water Projects namely PAVITRA led by Aligarh Muslim University, PANIWATER led by CSIR-NEERI and LOTUS led by IIT Bombay was released. The focus of these projects is design, development and deployment of water and wastewater treatment technology and real time water quality monitoring suited to Indian conditions.

2.2.3 India ASEAN S&T Collaboration

The 12th Meeting of ASEAN-India Working Group on Science & Technology (AIWGST) and 6th Meeting of the Governing Council of ASEAN-India Science & Technology Development Fund (AISTDF) were held in Bangkok, Thailand during 18-19 February 2019 led from India by Prof Ashutosh Sharma, Secretary DST. 17 new collaborative R&D projects, 7 Research & Training Fellowships and various other STI activities/ events to be organised during 2019

under the over-all aegis of ASEAN-India S&T cooperation were approved. The priority areas of collaboration in 3 topics namely Bio-medical devices; Agriculture and Food Science & Technology; ICT and Cyber Physical systems were finalized. In addition, the thematic ASEAN Network and Centres would open for Indian collaboration. The AIWGST also agreed for early conclusion of the ASEAN-India MoU for Cooperation in the fields of Science & Technology.



Fig : The 12th Meeting of ASEAN-India Working Group on Science & Technology (AIWGST) and 6th Meeting of the GC of AISTDF in Bangkok, during 18-19 February 2019

21 collaborative R&D projects in the broad areas of Physical, Chemical and biological sciences, Electronics, ICT and computer sciences and Advance Material were supported under ASEAN-India STI Cooperation program. 47 Researchers /professional from ASEAN countries were awarded fellowship under ASEAN-India Research Training Fellowship for carrying out up to 6 month's research training at Indian University/ Institute/ R&D lab etc.

The 2nd editions of ASEAN-India Grass-root Innovation Forum and ASEAN-India InnoTech Summit were held in Davo, Philippines during 20-22 Nov 2019. A total of about 500 Innovators/ Academicians/ Scientists/ Technologist/ Start-ups etc from India and ASEAN Member States participated in the event which was supported through ASEAN-India Science & Technology Development Fund (AISTDF) of Govt. of India. The events included technology/Innovation exhibitions, Grassroots innovation competition, B2B meetings, panel discussions, lectures etc for promotion of ASEAN-India Innovation Platform for pooling and

sharing the technologies and Innovations between ASEAN member states and India.

Research and Training Fellowship for Developing Country Researchers (RTF-DCS)

53 Researchers/ Scientists/ Students from developing countries were awarded Fellowships under RTF-DCS scheme of DST for carrying out 6 month's research training at Indian University/ Institute/ R&D lab etc.

2.2.4 India- G20 S&T Collaboration

DST participated in the meeting convened by the Department of Economic Affairs, to discuss various agenda items of G20 in 2019 and provided inputs on India's position and priorities in Science Technology and Innovation (STI) for discussion during the First G20 Sherpa Meeting in Tokyo.

DST also participated in the Inter-Ministerial Meetings chaired by Additional Secretary (IER), Dept of Economic Affairs, to discuss India's position/priorities on various agenda items in the G20 Japanese Presidency during 2019 and to deliberate on the future interventions/positions and concerns, for the forthcoming G20 Working Groups and Task Force Meetings. Department of Science and Technology (DST) was included in the G20 Digital Economy Task Force (DETF). DST shared with the Task Force its recently launched mission on "Inter-disciplinary Cyber Physical Systems (ICPS)" to foster and promote R&D in this area. On the Theme on Society 5.0, DST emphasized more on 'inclusivity'. A study on 'Society 5.0' will be undertaken jointly by NITI Aayog, DST and MEITY.

2.2.5 India -Shanghai Cooperation Organization (SCO) STI Cooperation

After becoming a full member of SCO by signing a Memorandum of Obligation (MoO) on 24th June 2017 at Tashkent, Uzbekistan, India is obliged to join 18 International Treaties under SCO Framework which includes S&T cooperation.

The fifth session of Heads of Ministries and Department of Science & Technology the SCO member states was held at Moscow during 20-21 November 2019. This was preceded by SCO Science, Technology and Innovation (STI) Working Group Meeting 19-20 November. Meeting was attended by all eight member states of the SCO, representatives of the SCO observer states as well as representatives from the SCO dialogue partners. In order to promote scientific, technical and innovative cooperation a Protocol was signed by Heads of Ministries and Departments of science and technology of the Shanghai Cooperation Organization Member States to implement the STI activities among SCO member states. Key decisions, actionable points and Roadmap include:



Fig. The fifth session of Heads of Ministries and Department of Science & Technology of the SCO member states in Moscow during 20-21 November 2019 (right): SCO Science, Technology and Innovation (STI) Working Group Meeting 19-20 November (Left)

1. Supporting Joint R&D Projects at SCO multilateral forum

All sides unanimously decided to collaborate in thematic areas such as environmental technologies, biotechnology, bio-engineering, energy efficiency and energy saving; innovative technologies in agriculture, including the food sector, Life Sciences, Earth Science

The first “Pilot Call” for seeking joint R&D Project Proposals may be may be launched in first half of 2020 when at least three countries agree for this. Simultaneously, the scoping of details of SCO STI framework program and “Implementation Plan” will be carried out in consultation with SCO member countries. The first full-fledged Call Competition for joint R&D and innovation project proposals likely to be will be announced by the end of 2020. Russia and India will jointly develop SCO STI Framework Program and “Implementation Plan” for supporting multilateral interdisciplinary research and innovation projects.

2. Young Scientist and Innovators networking.

India proposed to host the first SCO Young Scientist & Innovators Forum meeting in 2020.

India will host the young scientist forum meeting before the meeting of Council of heads of States (Prime Ministers) of SCO member states to be hosted by India in 2020. The details concept note on SCO Young Scientist and Innovators networking will be developed by India (DST, IMRCD) in consultation with different stakeholders and shared with other SCO member states in due course of time (February 2020).

3. Sharing and access of Research Infrastructures and mega Science projects among SCO countries.

The SCO member states have agreed to create a SCO Research Infrastructure Database. India will consult different scientific agencies under Ministry of Science and Technology to identify the research Infrastructure which may be shared with SCO countries based on reciprocity.

2.2.6 Collaboration in STI with the Indian Ocean Rim Association (IORA)

India (DST) chaired the Indian Ocean Rim Association (IORA)- 1st Expert Group Meeting on Academics, Science & Technology Cooperation (EGMASTC) held in New Delhi on 12th December 2019. Prof Ashutosh Sharma, Secretary DST delivered the Key-note address at the inaugural session of the Meeting attended by 22 IORA member countries.

Secretary DST announced the launch of 100 IORA-India Fellowships for scientists/researchers from India and IORA countries. He also called upon IORA to work towards developing Grand Challenges R&D projects. The EGMASTC finalized the draft Terms of Reference (ToR) for creation of an IORA-Working Group for cooperation in the fields of Science, Technology and Innovation and also its draft Work Plan 2019-2022.



Fig. 1st Expert Group Meeting on Academics, Science & Technology Cooperation (EGMASTC) in New Delhi on 12th December 2019.

2.2.7 India- Japan Collaboration on Multilateral platform

4th Science and Technology in Society Forum (STS Forum) Japan- India Workshop held on 27th February 2019 in New Delhi, attended by the Japanese ambassador, Deputy Minister for S&T in Japan, Policy makers, heads of organisations, academicians, researchers, industry leaders and entrepreneurs from India and Japan. The Workshop dwelled upon two Sessions: 1: “Start UP and Innovation Ecosystem driven by Science and Technology” and 2: “Society changed by IoT and IoE”. CEO NITI Ayog Delivered the Key Note address and offered India’s size and scale for collaboration with Japan. Secretary DST chaired Session 1 and shared the start up scenario in India and various initiatives taken by the government in developing an enabling start-up ecosystem in India.



Fig. Secretary DST (extreme right) chairing session I during 4th India-STST forum Japan workshop in New Delhi- 27 February 2019

The Workshop recommended exploring India-Japan partnerships in Tech-based innovation, commercialization of open innovations, joint innovations in natural disaster resilience, education in entrepreneurship, and establishing market plan connecting innovations targeted around TRL7. Japanese strength could be leveraged in heavy engineering, automobiles, precision engineering, sensors, robotics, product quality and linked with Indian competitiveness in IT systems. Joint start-up hubs, annual entrepreneurship summits, engineering design conclaves were recommended, Best practices exchange and mentoring of technopreneurs, connecting ideas to the investors and business world, were other significant recommendations.

2.2.8 DST support on international award of Ramanujan Prize for excellence in Mathematics

The ICTP 'Ramanujan Prize of US\$ 15000, for outstanding contributions by Young Mathematician from the developing countries, was instituted in 2005 by ICTP for the outstanding work of the mathematicians, undertaken in challenging circumstances in developing countries. The prize is currently being funded by DST through an MoU originally signed in 2014 with International Centre for Theoretical Physics (ICTP), International Mathematical Union (IMU) and DST and renewed for a further period of five years from the 2019 prize.



Fig. Prof Hoàng Hiệp Pham (Second from right) being awarded the Ramanujan Prize 2019)

Prof. Hoàng Hiệp Pham, from Vietnam was selected for the 2019 Ramanujan prize for his outstanding contributions in the field of complex analysis, and in particular to pluripotential theory, having important applications in algebra and geometry, and for his important organizational role in the advancement of mathematics in Vietnam. Dr Pham was awarded the 2019 Ramanujan Prize in a ceremony held in Trieste, Italy on 10th December 2019, attended by the India's Ambassador to Italy.

2.3 National Mission on Nano Science & Nano Technology

The tenure of the Nano Mission has been extended till 31.03.2020 through an SFC in which the focus of the Nano Mission will now be more on Nano Technology Development. The third-party review was undertaken recently and they have recommended to convert this Mission into a regular Scheme of DST.

Nano Mission is an umbrella programme, which promote basic research and focuses on Nano Technology adaptation and transfer to industry for use by masses. The Department had joined hands with other Ministries and is likely to develop a Nano S&T portal for submitting all projects online to be taken up for processing by respective Ministry/ Department/ S&T Agency in consultation with one another. This is due to the fact that R&D in this emerging and active area of research should be optimally provided support either by an individual funding body and projects of higher costs ie. above Rs 300 crore should be funded by various S&T agencies coming together for optimal utilisation of the output.

The Nano Mission has the following objectives. To scrutinize the proposals in either Nano S&T there are several committees that have been reconstituted:

- **Basic Research Promotion {Nano Science Advisory Group (NSAG)}**
- **Infrastructure Development for Nano Science & Technology Research {Nano Mission Council}**
- **Nano Applications & Technology Development Programmes (NAT Advisory Group (NATAG))**
- **Human Resource Development**
- **International Collaborations**
- **Nano Regulatory Aspects**

During this year we gave Call for Proposals in three areas along with number of proposals received as mentioned below:

- **Nanotechnology for Agriculture - 116 proposals received**
- **Nano for Energy and Environment - 199 proposals received**
- **Quantum Materials with novel properties and applications - 59 proposals received**

We have shortlisted the proposals and the Expert Group meetings have now been scheduled in the recent future. Finally, we will seek the final recommendations of Nano Mission Council in March, 2020 on the proposals which will be funded next financial year ie. 2020-21.

This year we have sanctioned a Technology Business Incubator at one of the DST Aided Institutes namely Centre for Nano and Soft Matter Sciences (CeNS) at Bengaluru.

We have also supported the PETRA-Phase II keeping in view the excellent use of the PETRA-III facility of DESY at Hamburg, Germany.

Thus Nano Mission during this year has supported the following new projects:

Nano Science	- 15
Nano Technology	- 25
International Collaboration	- 01 (Phase II of PETRA-III)
National & International Conferences	- 04
Technology Business Incubator	- 01

2.3.1 Basic Research New Projects

During this year, so far:

1) Under NSAG (Nano Science Advisory Group), 2 meetings were held. A total of 22 new individual scientist-centric R&D projects have been recommended and supported through release of grants. A few cases where only General Grants was released last year but the Capital grants could not be released, the Capital grants have been released this year.

Some important achievements from the ongoing projects are summarized below:

- Under the project “Ferromagnetic-semiconductor heterostructures for magnetic field sensing and optoelectronics applications” new observations reported include:
 - o CFB ($\text{Co}_{40}\text{Fe}_{40}\text{B}_{20}$)- MoS_2 as ferromagnetic layer and MoS_2 -CFB as semiconductor layer for fabricating the heterostructures bilayer thin films were successfully fabricated.
 - o Observation of hysteresis loops and domain structure in these bilayer samples by Kerr microscope in longitudinal mode were recorded.
 - o Observation of anomalous Hall effect in transport measurement on bilayer sample were seen.

The group reported approach to prepare MoS_2 via sputtering is a novel approach. With preparation of good quality thin films, it will be a unique approach to fabricate large area MoS_2 thin films.

- CSIR, NIIST- developed a robust diagnostic platform for breast cancer diagnosis in clinical samples using multiplexing SERS, which is non-invasive, cheap and ultrasensitive

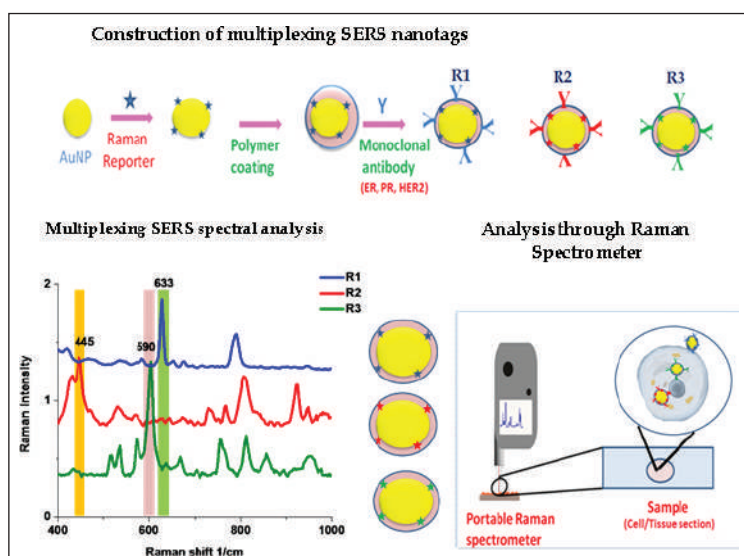
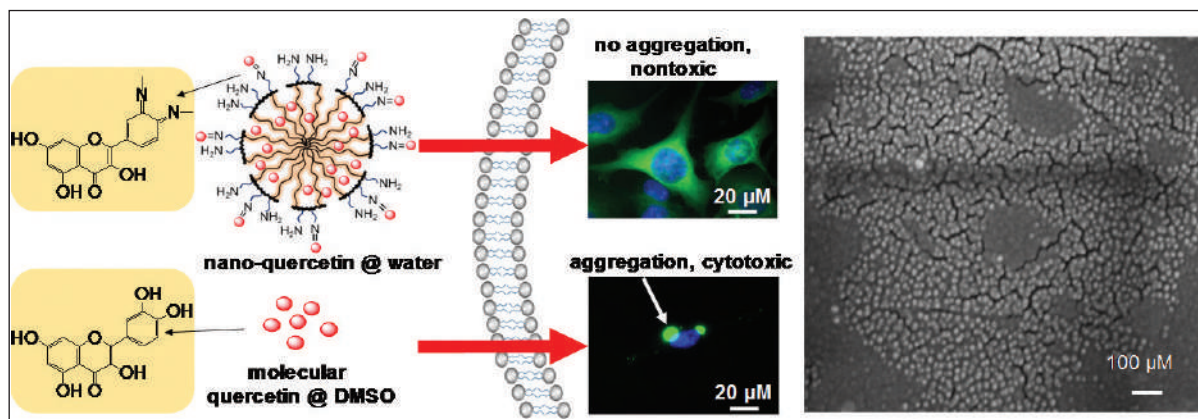


Fig. Thematic representation of the multiplexing detection platform using SERS in breast cell lines/tissues.

- New observations from IACS, Kolkata for curing of Huntington's disease was reported: Conventional anti-amyloidogenic molecules are shown to enhance their performance in inhibiting the protein aggregation if they are used in nanoparticle form & (b) Nanoparticle can be designed to clear protein aggregate from live cells.



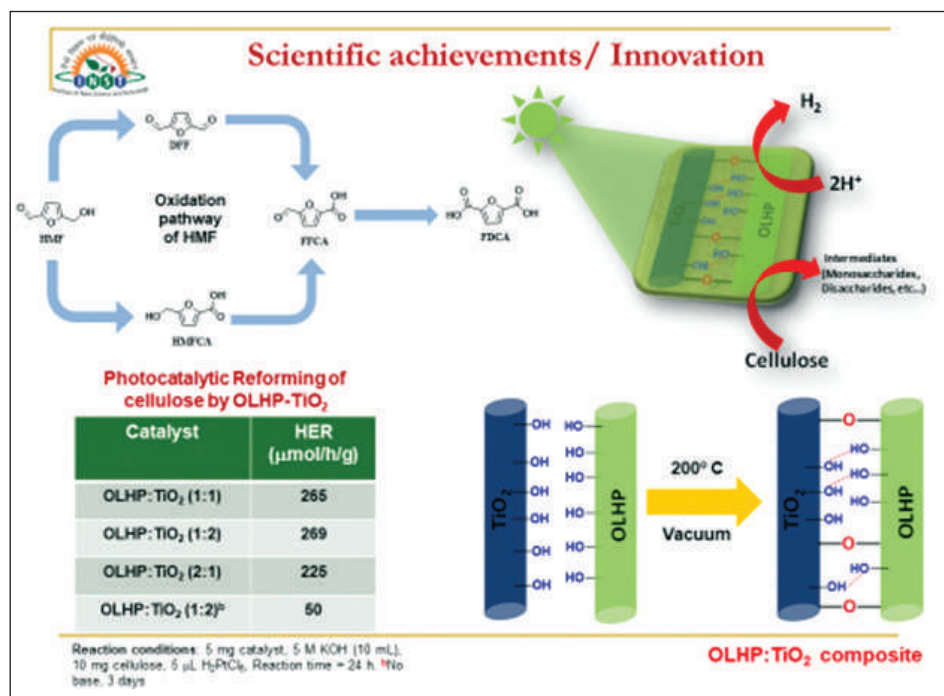
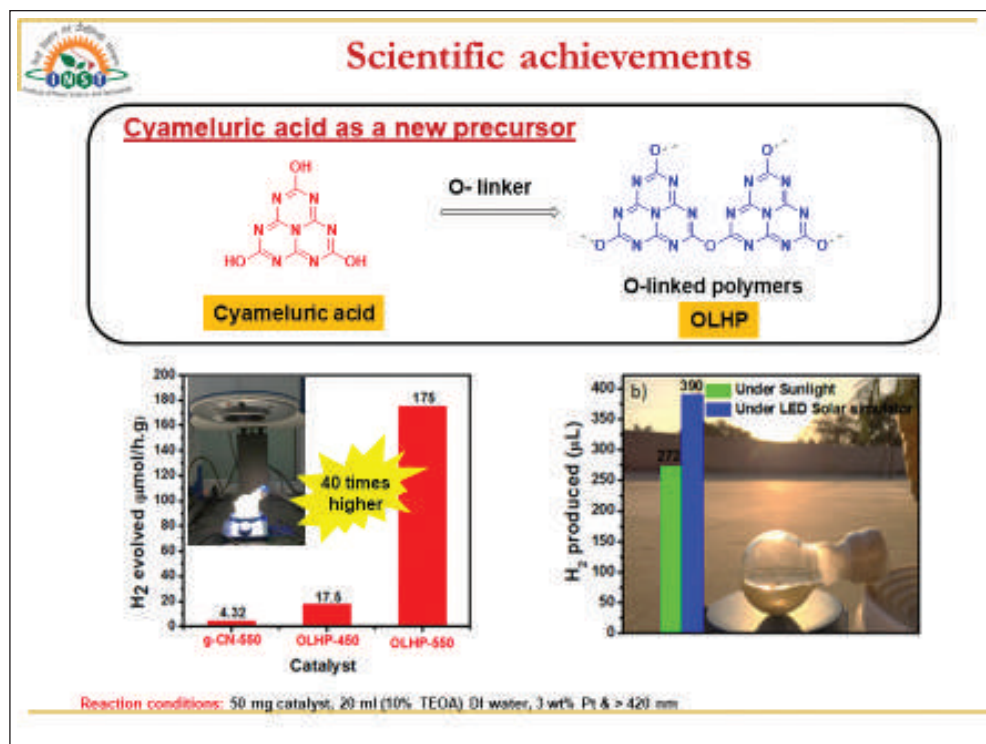
2.3.2 NANO Applications and Technology Development

Under NATAG (Nano Applications and Technology Advisory Group) this Year, a total of 26 projects were recommended in 2 meetings and all except one has been issued sanctions along with 6 projects recommended last year whose sanctions were issued this year.

We had reviewed 22 projects in the mid-way period of their implementation and few patents have been filed under few projects of Application Development. Most of the projects were rated **Very Good** or **Excellent** for their progress.

Scientific highlights from Nanotechnology & its thematic projects

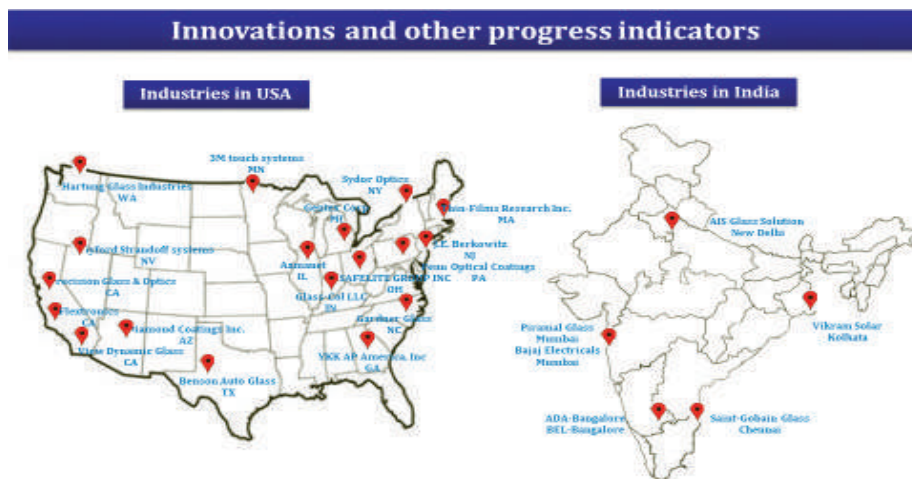
- 1. Prototype Large-scale Reactor for Simultaneous Production of H₂ and Fine Chemicals under Natural Sunlight:** Upon completion, this facility will be the first of its kind that can be used for industrial chemical waste separation and large scale hydrogen production for futuristic fuel need.



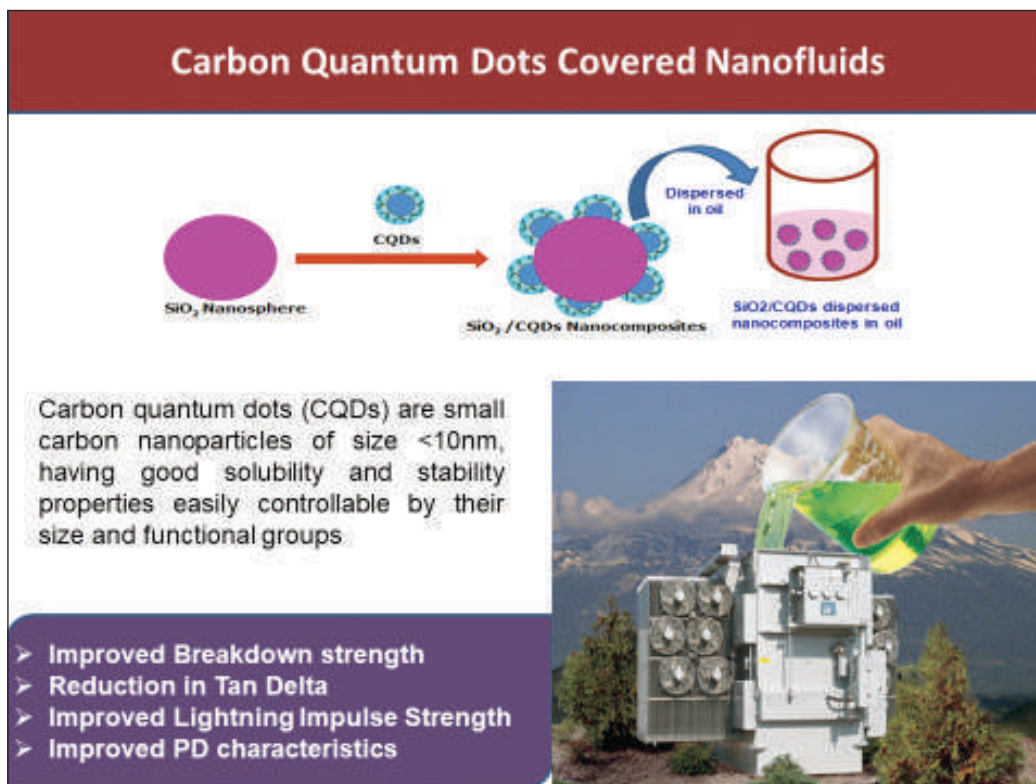
2. Smart window glass demonstrated via thematic project fund



Figure shows the industries under exploration for possible technology transfer



3. **Development of nanofluid insulation with carbon quantum dots covered insulative/semiconductive/magnetite nanoparticles and investigation of its partial discharge characteristics for power transformers:** Nano based fluid for low loss and efficient power transfer in the power grids.



2.3.3 Human Resource Development

During the year following activities with major focus on Human Resources were supported:

- Support was also continued for Post-doctoral Fellowships to attract talented young researchers towards advanced research in Nano Science & Technology through the Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore. 8 students completed their research work under the PDF programme.
- Similarly, support also continued for the NanoS&T Overseas Fellowship during this year. Currently, 3 fellows are continuing their Fellowship.
- Ongoing PG Programmes:

Support to 5 ongoing Post Graduate programmes [M.Sc./M.Tech in Nano Science & Technology] continued this year too at several institutions across the country. However this programme would be discontinued from year 2020 onwards.

- New Faculty Associateship programme 2019-20:

Nano Science & Nanotechnology Visiting Associate-ship (NS& T-VA) (14 Institutions Pan-India had been chosen): Institutions with established research profile in Nano Science & Technology in the country would implement this programme in a proactive fashion. Each such institution would be provided funds for managing the programme, with provisions of travel support, fellowship, board and lodging expenses and research expenses for Visiting Associates.

2.3.4 Development of R&D Infrastructure

Thematic Unit of Excellence on Supercomputing were continued to be supported. Some important achievements from them are summarized below:

Project entitled “Computational Studies on Novel Materials and Nanoscale Transport”

The group investigated the photocatalytic efficiency and corresponding hydrogen and oxygen evolution reactions (HER and OER) through different functionalization (done by replacing the anion (S) site with P, N and C atoms and also by creating a mono-vacancy defect at the same site) of stable 1T palladium disulfide (PdS₂) monolayer. They have not only envisaged the photocatalytic activity, but also the specific reaction coordinates for HER and OER based on the adsorption energies of the intermediates of the individual reaction, stability of the functionalized 1T PdS₂ monolayer (phonon dispersion calculations) and the respective work function of the individual systems. The steady optical response in the visible range is in favour of the photocatalytic activity of the monolayer, while the corresponding reaction coordinates predict the suitability of the functionalized and defected monolayer for HER and OER mechanism through the bifunctional catalytic activity. They have computationally synthesized CdS bilayer assembled with strategic placement of Cd₆Se₆ clusters. Studies about their stability and electronic structure are followed by Bardeen, Tersoff and Hamann formalism for their tunneling properties. Our calculations show that the hexagonal arrangement of these clusters prevails as the most stable geometry showing all real phonon modes. First-principles molecular dynamics studies on this 2D structure show that it remains intact even at room temperature. We functionalized this bilayer using transition metal atoms, Co and Cr. Co functionalization brings ferromagnetic ordering in the bilayer which turns near half-metallic upon increasing the concentration. On the other hand, Cr functionalization shows a transition from antiferro- to ferromagnetic ordering upon increasing the concentration. I-V characteristics of pristine and functionalized bilayers show negative differential conductance like a tunnel diode.

A new class of tetragonally symmetric 2D octagonal family of monolayers (o-MLs) of metal nitride and carbide family (BN, AlN, GaN, GeC, SiC) along with C and BP are computationally designed and their stability and electronic structure are investigated. Geometric and structural similarity of o-C and o-BN has been exploited to form patterned hybrid o-MLs ranging from

metallic to insulating phases. Stacking of zigzag buckled o-MLs results in stable body centered tetragonal (bct)-bulk phase that is suitable for most materials from group IV, III-V and II-VI. Vertically cut chunks of o-BN and o-C bulk or stacking of orings, unlike rolling of hexagonal (h)-ML, provide a plausible way to form very thin onanotubes (o-NT). Confined and bulk structures formed with an octagonal motif are of fundamental importance to understand the underlying science and for technological applications. The calculations involved are very heavy and the problem could not be taken up without and hpc facility like SAHASRAR.

Systematic investigations of the electronic structure of the fluorite type cubic phase of Bi₁₁VO₁₉ nanoparticles are reported for the first time using size confinement for tailoring of electronic structures for photocatalytic properties. The valence band is found to comprise mainly of O 2p states, whereas the conduction band arises from V 3d states giving rise to a band gap value of 2.26 eV. Absence of excess O in δ -Bi₂O₃ results in shrinking of the band gap because of O 2p, Bi 6s and 6p states from the surrounding atoms at doping sites. Bi₁₁VO₁₉ nanoparticles show an efficient visible light absorption. To explore the possibility of cluster assembly resulting in a two-dimensional (2D) stable monolayer of ZnO, a systematic study of structural evolution of bare and passivated stoichiometric Zn_nO_n, (n = 1–8) clusters is undertaken. Changes in hybridization are investigated using site-projected partial density of states and partial charge density, while the effect of passivation and size on the ionicity of the clusters is studied using Bader charge analysis. The structural and chemical properties are found to be influenced by the coordination number of atoms in the clusters irrespective of the coordinating species. The physical parameters and hybridization of the states for the clusters on passivation resemble those of the bulk. Passivation thus provides an environment that leads to the stability of the clusters. Cluster assembly using stable cluster geometries of passivated clusters (without the passivating atoms) has been shown to lead to stable 2D structures - a new octagonal 2D monolayer geometry of ZnO. Electronic structure and stability of nearly stoichiometric and nonstoichiometric clusters of ZnO having bulk-like wurtzite geometry passivated with fictitious hydrogen atoms are comparatively analyzed for structural evolution. A parameter, average binding energy per atomic number (ABE-number), is introduced for better insight of structural evolution. The overall structural evolution is mapped for bare and passivated ZnO clusters to site projected partial density of states (I-DOS) and a correlation is established. O_{excess} and O_{-surfaced} clusters are found to be more stable. Present results reported for clusters of sizes up to 1 nm can pave a path for formulating strategies for experimental \square synthesis of ZnO nanoparticles for tuning the HOMO–LUMO gap.

Magnetic nanocarbon offers unique opportunities for future molecular spintronic applications. Computational studies have been carried out for pristine graphene nanoribbons (GNRs), both armchair and zigzag and GNR with monovacancy with and without passivation. Unpassivated zigzag GNR exhibits magnetic moments at the edges but the magnetic moment is quenched at the edge atoms on adsorption of the molecule.

Density functional theory-based electronic structure calculations are carried out to obtain the geometries corresponding to the lowest three energy values for Tey ($y = 2-20$) clusters. A comparison of the stability from binding energy curve of these clusters with exchange correlation energy functional approximated within the local density approximation (LDA), generalized gradient approximation (GGA) and hybrid functional (PBE0) indicates the structures to be most stable within the LDA, and these results are also found to be closer to those obtained from the experiments. Clusters form arm-chair and crown-like structures for small sizes and ring-like geometries for larger sizes. Partial charge density and eigenvalue spectrum reveal that there is no s-p hybridization and the highest occupied states are mostly π non-bonding orbitals. Clusters with even number of atoms show a charge distribution approximately uniformly localized around each atom similar to the σ_s anti-bonding orbital in Te₂. Spin-polarized electronic structure calculations for helical chains of Tey ($y=3-8$) reveal a behaviour similar to that predicted for Se chains by Pal et al. namely ferromagnetic behaviour for chains with odd number of atoms and antiferromagnetic behaviour for chains with even number of atoms. Also it is found that the magnetic moments are localized and are on fine to the end atoms of the chains.

A combined experimental and theoretical study was undertaken for lead-free ferroelectrics, Ba_{1-x}Ca_xTiO₃ ($x=0.0-0.3$) and BaTi_{1-y}Zr_yO₃ ($y=0.0-0.2$). First principles density functional calculations are used to investigate the electronic structure, dynamical charges, and spontaneous polarization of these compounds. Calculation of Born effective charges indicates that doping with Ca or Zr increases the dynamical charges on Ti as well as on O and decreases the dynamical charge on Ba. An increase in the dynamical charges on Ti and O is ascribed to the increase in covalency of Ti-O bond that reduces the polarizability of the crystal.

Coupled with nudged elastic band method and kinetic Monte Carlo simulations, to the best of our knowledge, our work is the first report of providing microscopic understanding of growth of small clusters on MgO support. To achieve these, we have build up a model that involves 170 mechanistic pathways. We had to perform about 250 odd computationally expensive nudged elastic band calculations along with phonons for the transition and the initial state. These calculations would not have been possible without the computational facility "SAHASRAR" set up from the nano-mission fund.

Using computed X-ray photoemission spectra of the C 1s state of semihydrogenated graphene on lattice matched transition metal substrates, we showed that the adsorbed H does not form a uniform adsorption pattern on these surfaces. Achieving visible photoluminescence (PL) from hexagonal boron nitride nanosheets (hBN-ns) is synthetically very much challenging due to its intrinsically high electronic band gap. Recently our experimental colleagues at IISER Pune have explored the concept of molecular doping in turning on PL from hBN-ns in the red region of the visible spectrum. Solution of organic electrophile, tetracyanoquinodimethane (TCNQ), was mixed with the dispersion of exfoliated hBN-ns and molecularly doped hBN nanosheets (md-hBN-ns) were isolated. Detailed mechanistic investigations evidenced the

presence of dicyanotoluoylcyanide (DCTC) anion – an oxidative decay product of TCNQ – as the dopant species. Density functional theory calculations revealed a selective and strong bonding scenario between the negatively charged DCTC moiety with the positively charged boron vacancy (VB) in hBN, giving rise to optically active electronic states within the hBN forbidden gap, which were assigned to be the primary source of such an unusual emission from chemically derived md-hBN-ns.

Dynamics in Nano-structured Ionic Liquid environment: Effect of anions and temperature: The effect of water on various properties of ionic liquids (ILs) has been a subject of several investigations due to its applications in electrochemistry, CO₂ absorption, oil recovery and biomass treatment. While several studies so far have characterized dynamical properties on several ILs, there has been no computational investigation to systematically probe the effect of various water concentration and temperature in imidazolium ILs which differ in hydrophilic and hydrophobic anions. The effect of water shows that diffusion coefficients of Hmim⁺ cations is higher in [Hmim][Cl] IL compared to [Hmim][NTf₂] IL, and Cl⁻ anions diffuse faster compared to NTf₂⁻ anions with an opposite behavior of diffusion coefficients seen in neat ILs. The diffusion coefficients of Hmim⁺ cations and NTf₂⁻ anions are similar in hydrated [Hmim][NTf₂] IL. At very low water concentration of [Hmim][Cl] ILs, multi-bridged structures formed between Cl⁻ anions and water molecules are observed (see Figure below showing snapshots from [Hmim][Cl] IL at very low water concentration at T = 303 K). With increasing water concentration, decreasing Ion-Pair lifetimes and Interaction energies between the hydrogen atoms of the Hmim⁺ cations and Cl⁻ /NTf₂⁻ anions with increasing water-water interaction energies supports the trends seen in translational diffusion coefficients. The insights from dynamical properties in this investigation will serve as a benchmark for prediction of dynamical properties in a family of imidazolium ILs in similar hydrated environments.

Mechanism of CO₂-Lys⁻ reaction and role of an explicit water molecule: Amino acid anions are important constituent of Ionic Liquids and salts used for carbon capture. In this study, we explore the molecular mechanism of CO₂ with amine sites of Lysinate anion (to examine the chemistry of interactions responsible for absorption) using Density Functional Theory (DFT). The calculations predict that participation of carboxylate group in the reaction between the CO₂ and the amine group makes the process thermodynamically favorable to form a stable carbamate product. In the far-amine site which is tethered to the butyl chain of the cation, the reaction barrier suggests an extremely low probability of chemical reaction, though a stable non-bonded complex suggests its formation via physisorption. This study will motivate and support the synthetic design and development of ILs for efficient carbon capture. Classical molecular dynamics simulations were employed to characterize structure and dynamics of ion transport in Ionic Liquid doped polymer membranes for application in fuel cells. The system sizes up to 140, 000 atoms were investigated with 140 cores (long simulations time 75 ns and several systems). These calculations were done on “SAHASRAR” and were not possible without this facility.

Using first-principles density functional theory based electronic structure calculations, we have investigated the geometric, electronic and optical properties of passivated CsSnX₃ (X=Cl, Br) quantum dots. We have studied the effect of quantum confinement, variation in quantum dot-size, different passivation ligands and the halide composition on the energy gaps and optical-absorption behavior. The calculations on Cesium-Tin-Halide quantum dots involved 156 valence electrons in the smallest and 1268 valence electrons in the largest dot studied. The calculations on the ceramic materials had 350 valence electrons. Such large valence electron systems were possible to handle only because of the HPC set up of SAHASRAR.

They have performed a comprehensive study of the pressure dependent polarization in PbTiO₃, PbZrO₃ and BaTiO₃ and Zr-rich PbZrTiO₃ ceramic materials. The pressure dependent phase transitions, piezoelectric and elastic properties have been studied and correlated with the structural and electronic changes under compressive and tensile strains. The mechanical stability of the different phases with pressure has been characterized using piezoelectric strain constants. The antiferroelectric to ferroelectric phase transition is investigated in the Zr-rich PbZrTiO₃ ceramics.

They have investigated the electronic and optical properties of pure, Se and S doped GaNbO₄. Crystallographically different O-sites were chosen for substitutional doping. GaNbO₄ is a wide bandgap semiconductor with an indirect bandgap > 3.0 eV, similar to the widely studied photocatalytic material TiO₂. Our studies show that the optical properties exhibit a site dependent behavior with a broadening of the absorbance spectra in the UV region and an appearance of absorption peak in the visible region. The results are compared with the pure and doped TiO₂.

Project titled “Computational Material Science” at IISc., Bangaluru. The brief of the achievements of the project are:

1. Dendrimer-Graphene Composite

The adsorption of PAMAM dendrimers at solid/water interfaces has been extensively studied. However, the pH effects of the adsorption driven via van der Waals interactions is not explored enough. To address this lacuna and also to investigate the surface applications of dendrimers, we have studied the adsorption behavior of PAMAM dendrimers of generations 2 (G2) to 5 (G5) with pH and salt concentration variation, on a charge neutral graphene substrate, using fully atomistic molecular dynamics simulations. The instantaneous snapshots from our simulations illustrate that the dendrimers deform significantly from their bulk structures. Based on these snapshots and the parallel, perpendicular components of the radius of gyration and the eigenvalues of the gyration tensor calculations, we could classify the adsorbed dendrimer morphologies into five categories and map them to a phase diagram. Interestingly, the morphologies we report here have striking analogies with those reported in star-polymer adsorption studies. From the fractional contacts and other structural

property analyses we find that the deformations are more pronounced at neutral pH as compared to high and low pH. Higher generation dendrimers resist deformation following the deformation trend, $G2 > G3 > G4 > G5$ at any given pH level. As the adsorption here is mainly driven by van der Waals interactions, we observe no desorption of the dendrimers as the salt molarity is increased, unlike that reported in the electrostatically driven adsorption studies.

To address the non-monotonic nature of the adsorption of the dendrimer on to graphene with pH variation, we further investigated the thermodynamics of its binding. We have used umbrella sampling simulations and a mean-field theory for this purpose. We find that the dendrimer strongly binds to the graphene sheet ($O(100)$ kcal/mol) from our potential of mean force (PMF) calculations. In specific, we find that the dendrimer binds the most at neutral pH (~ 7) and the least at low pH (~ 4). To understand the origin of this nonmonotonicity, we studied the interactions contributing to the PMF, i.e., the dendrimer-graphene, dendrimer-water, and dendrimer-ion interactions. We find that the van der Waals interactions between the dendrimer and the graphene alone cannot capture the accurate trends in the binding free energies (BEs) as a function of pH. The solvent and the counterions present in the system are also found to have a major influence on these trends. We demonstrate that the dendrimer-graphene and dendrimer-water interactions become favorable, whereas the dendrimer-ion interaction becomes unfavorable, as the dendrimer binds to graphene. These opposing effects lead to the observed nonmonotonicity in the BE trends. Our theoretical model also reproduces these trends in the sub-interactions contributing to the PMF. To the best of our knowledge, this is a novel attempt where an equivalence between theory and simulations is made in the context of the dendrimer's adsorption.

2. Nucleic Acid Nanotechnology

In this study, they have revealed the microscopic origin of several biophysical phenomena involving DNA using all-atom molecular dynamics simulation. We report the enhancement of the structural stability of a DNA nanotube (DNT) by changing the salt concentrations for three different salt species, namely, NaCl, KCl, and MgCl₂. Using fully atomistic molecular dynamics simulations, we find that, with the gradual increment in the NaCl salt concentration, the DNT becomes compact and rigid. We explain how the DNT-ion interactions play a vital role in the conformational fluctuation of the DNT. To understand the salt dependence of the mechanical properties of the DNTs, we have calculated the stretch modulus (γ) and persistence length (LP) as a function of salt concentration. The calculated stretch moduli of the DNTs change from 8.3 to 13 nN, and the persistence length of the DNT varies from 6 to 10 μm when the NaCl salt concentration is varied from 0 to 1 M. Both the stretch modulus and the persistence length calculations reaffirm the structural stability of the DNT at higher salt concentrations. We find similar trends for another monovalent salt (KCl). However, for a divalent salt (MgCl₂), we find minimal variation in the structural properties with an increase in the salt concentration. They then take one step further and prepare synthetic nanopores

made of RNA. We present a computational framework to model RNA based nanostructures and study their microscopic structures. We model hexagonal nanotubes made of 6 dsRNA (RNTs) connected by double crossover (DX) at different positions. Using several hundred nano-second (ns) long all-atom molecular dynamics simulations, we study the atomic structure, conformational change and elastic properties of RNTs in the presence of explicit water and ions. Based on several structural quantities such as root mean square deviation (RMSD) and root mean square fluctuation (RMSF), we find that the RNTs are almost as stable as DNA nanotubes (DNTs).

3. Fusion Mechanism of HIV with Cell Membrane

In this study, the post-fusion (PoF) trimeric structure of ecto-domain including transmembrane domain of gp41 was modeled using multiple homologous templates of Simian immunodeficiency virus (SIV) and HIV-1. In order to validate the gp41 model, interactions of three peptide inhibitors: T20, C37 and C34; were studied using all-atom molecular dynamics (MD) simulations, binding free-energy calculation and per-residue energy decomposition analysis. The binding free energy predicts maximum affinity for C34 and minimum by T20 for gp41, which is in good agreement with the available computational and experimental studies. The van der Waals interaction is a dominant contributor for the peptide-gp41 complexes. The per-residue decomposition of energy confirmed the role of Trp117, Trp120 and Ile124, present in C34 and C37, for the strong hydrophobic interactions with the deep pocket localized around the N-terminal of gp41, which is lacking in T20. The HIV-1 gp41 structure developed in this work can be used in future study to gain insight into the mechanism of virus invasion and probing potent inhibitor to eliminate AIDS.

4. Phase Separation of Active Lennard-Jones

In this study in collaboration with Prof. Chandan Dasgupta, the group reported scalar activity induced phase separation and crystallization in a system of 3-d Lennard-Jones particles taken at state points spanning from the gas to the liquid regime using molecular dynamics simulation. Scalar activity was introduced by increasing the temperature of half of the particles (labeled 'hot') while keeping the temperature of the other half constant at a lower value (labeled 'cold'). The relative temperature difference between the two subsystems is considered as a measure of the activity. From our simulations we observe that the two species tend to phase separate at sufficiently high activity ratio. The extent of separation is quantified by the defined order parameter and the entropy production during this process is determined by employing the two-phase thermodynamic (2PT) model and the standard modified Benedict-Webb-Rubin (MBWR) equation of state for a LJ fluid. We observe that the extent of the phase separation and entropy production increases with the density of the system. From a cluster analysis, we obtain the mean number of clusters, and the mean size of the largest cluster in the system, complementing each other. Bond orientation order

parameters reveal that the so formed largest cluster also develops solid-like order consisting of both FCC and HCP packing. The presence of such crystalline order is also supported by a common neighbor analysis.

5. Osmolyte Effects on Protein Aggregation

The deviation from optimum folding conditions can lead to protein misfolding and aggregation. The effect of osmolytes on protein aggregation is important because these molecules have the potential to act as drugs for diseases related to amyloid formation. Osmolytes broadly can either denature the protein folded state (denaturants) or stabilize the folded state (protecting osmolytes). They have studied the effect of denaturants (urea and guanidinium chloride) and protecting osmolytes (trimethylamine N-oxide, sucrose, sorbitol and sarcosine) on the growth step of the aggregation of intrinsically disordered proteins (IDPs) and globular proteins.

They have shown that the protective osmolytes stabilize the compact aggregates, while denaturants destabilize them. However, protective osmolytes increase the effective energy barrier for the multi-step domain swapped dimerization, which is critical to the growth of protein aggregates by globular proteins, thus slowing down overall aggregation rate. Contrastingly, denaturants decrease the effective barrier height for dimerization, and hence enhances the aggregation rate in globular proteins. The simulations further show that globular proteins have to unfold before dimerization and the barrier to monomer unfolding regulates the effective rate of aggregation. In the case of IDPs, protective osmolytes decrease and denaturants increase the effective barriers in the dock-lock mechanism of fibril growth, leading to faster and slower growth kinetics, respectively. We have further show that globular proteins sample sparsely populated intermediates, which play an important role in domain-swapping during aggregation. Increasing or decreasing the probability of sampling these intermediates through mutations can drastically effect the aggregation of globular proteins.

2.3.5 Output Indicators

Research papers from Nano Mission Projects, Thematic Units, Thematic Projects in frontiers of Nano S&T, R&D projects and other major projects.	550
Patents filed	10
Phd's produced	17
Manpower trained (MSc dissertation produced)	60

Assorted SCI articles published in 2019 from the Thematic projects of Nanotechnology

SCI Journals	Number of articles	Impact Factor
ACS Appl. Mater. Interfaces	2	8.456
Chem. Mater.	1	10.159

ACS Energy Lett.	1	16.331
ACS Appl. Energy Mater	2	N/A
Carbon	1	7.466
Chem Comm.	1	6.164
Sustainable Energy & Fuels	2	4.912
Nanoscale	2	6.970
Chem. Mater.	1	10.159
ChemElectroChem	1	3.975
Inorg. Chim. Acta,	1	2.433
J. Mater. Chem.	1	6.641
Dalton Trans.	3	4.052
ACS Appl. Nano Mater.	1	N/A
J. Phys. D: Appl. Phys.	1	2.829
Eur. Phys. J. E	1	1.8
J. Chem.Phys.	2	2.997
Solid State Commun.	1	1.433
Adv. Opt. Mater	1	7.125
J. Optics	1	2.753
ACS Photonics	1	7.143
J. Phys. Chem	2	4.309
J. App. Phys	1	2.328
ACS Materials Letters	1	N/A
Polymer	1	3.483
ACS Applied Nanomaterials	1	N/A
	Total : 34	

Nano India 2019:

2019 Nano India was hosted at M.G. University, Kottayam. Two young scientist award and two senior scientist award was granted for the outstanding personnel's who have contributed in the field of Nano Science and Technology. Nearly 1000 participation were there from all over India. A large number of research scholar and post-doctoral fellows attended the meeting along with the eminent scientists and academicians from all over India

NNetRA Collaboration with Ministry of Electronics and IT (MeitY)

DST has supported *Nanoelectronics Network for Research and Applications (NNetRA)* under

1) **Cooperation with MEITY:** Technical Review and Advisory Committees

(TRACs) for the Project “*Nanoelectronics Network for Research and Applications (NNetRA)*” discussing technical aspects and review procedure of projects related to Safety, Energy & Environment, Agriculture, Healthcare & Nano devices & Systems and Others have been set up and two Nano Mission officers have been deputed on these TRACs as members from DST.

Nano- Regulatory Aspects

- 2) **Cooperation with DBT** on Nanobiotechnology Regulatory Aspects (*with focus on Nano Medicines/ Nano-Pharmaceuticals*) – The guidelines on Nano Pharmaceuticals have been recently released by the Hon’ble Minister.
- 3) **Cooperation with BIS (Bureau of Indian Standards)** towards Review of Standards as per the scope of Medical Biotechnology and Nanotechnology Sectional Committee, MHD 20

2.4 Mega Facility for Basic Research

This programme is aimed to create Mega Science facilities and launch Mega Science projects in and out of the country to improve access to such state-of-the-art facilities for the Indian scientific community, especially from the academic sector. Because of technical complexities and requirement of large resources, such projects are manifestly multi-agency, multi-institutional and, most often, international in character. The Department of Science and Technology (DST) and the Department of Atomic Energy (DAE) have been jointly promoting most of such projects in the country. Under this programme, several important developments took place during the year, which are described project-wise below.

2.4.1 Experiments at the Large Hadron Collider (LHC) at CERN, Geneva

Compact Muon Solenoid (CMS): Upgrade, Operation & Utilization

Indian scientists and research students continued their participation in the CMS experiment. Indian research groups successfully completed design, development and prototyping of Gas Electron Multiplier (GEM) GE 1/1 read-out boards and 17 boards were sent to CERN. Work on GEM GE 2/1 read-out boards with indigenously developed GEM foils progressed further.

During the year, Indian researchers were joint authors of 75 collaborative research publications. The project also resulted in 16 Ph.Ds during the year. Out of these, 14 Ph.D. students have found post-doctoral positions in prestigious institutions across the world, including one each at Princeton and Stanford. Another 60 Ph.D. students continued their research work on the CMS experiment.

A Large Ion Collider Experiment (ALICE): Upgrade, Operation & Utilization

Indian scientists and research students continued to participate in the ALICE experiment.

The hardware upgrade activities for Muon Station and R&D for the FOCAL detector also continued during the year.

During the year, Indian researchers were joint authors of about 30 collaborative research publications. The project also resulted in 10 Ph.Ds. during the year.

Upgrade and Operation of the Worldwide Large Hadron Collider Computing Grid (WLCG) Grid system

Support to this project continued during the year and the WLCG Grid continued enabling the scientists and research students to process the voluminous data obtained from the CMS and ALICE experiments.

Associate Membership of CERN

Vigorous efforts were made to connect Indian Industry with the CERN procurement processes including the Market Surveys and Tenders. 10 Indian companies participated in CERN Tenders and Market Surveys. 3 Indian Companies received orders as per details given in Figs. below, thus marking a beginning.

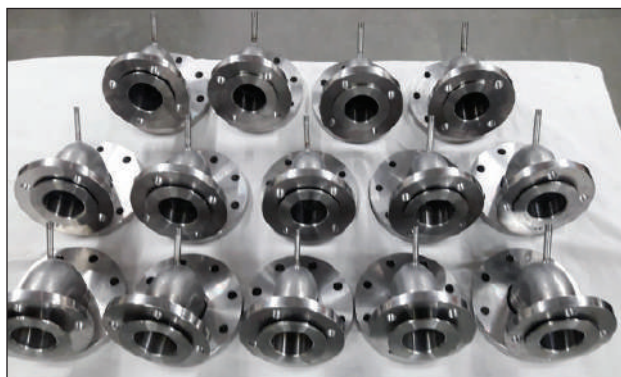


Fig. 1a: Elbow with flange for Super-proton synchrotron (SPS) cavities (IDEMI, Mumbai)



Fig 1b: Sleeve Outlet for SPS cavities (IDEMI, Mumbai)

2.4.2 Facility for Antiproton and Ion Research (FAIR), Darmstadt, Germany

Support towards construction of the facility continued during the year and implementation of the project gained further momentum. While the civil construction work moved ahead at the project site in Germany, the work on building in-kind accelerator and detector items, viz., power converters, vacuum chambers, beam stoppers, superconducting magnets and advanced detector systems in the country also proceeded forward further. Some notable achievements are mentioned below.

Power converters: 67 Power Converters made in India by the Electronics Corporation of

India Limited (ECIL), Hyderabad cleared Factory Acceptance Tests by FAIR, Germany. These power converters were shipped to Germany in the presence of Dr. Uday Bandyopadhyay, Director, Bose Institute, Kolkata and Mr. Jorg Blaurock, Technical Managing Director, FAIR. Prof. Ashutosh Sharma, Secretary, DST and Shri KN Vyas, Chairman, Atomic Energy Commission and Secretary, DAE also joined through video conferencing.



Fig.2: Power Converters shipped to FAIR

Vacuum Chambers: The work on prototyping of 71 ultra-high vacuum (UHV) chambers for FAIR beamlines continued. These vacuum chambers demand extreme mechanical tolerances and need to withstand ultra-high vacuum and, thus, are highly challenging to fabricate. During the year, two such prototype vacuum chambers were shipped to FAIR, Germany after successful mechanical and vacuum tests at the factory in India. Final tests are being performed at FAIR, Germany.

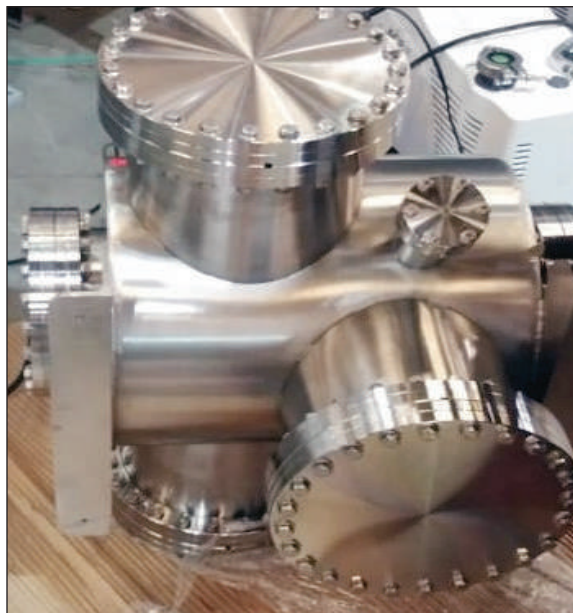
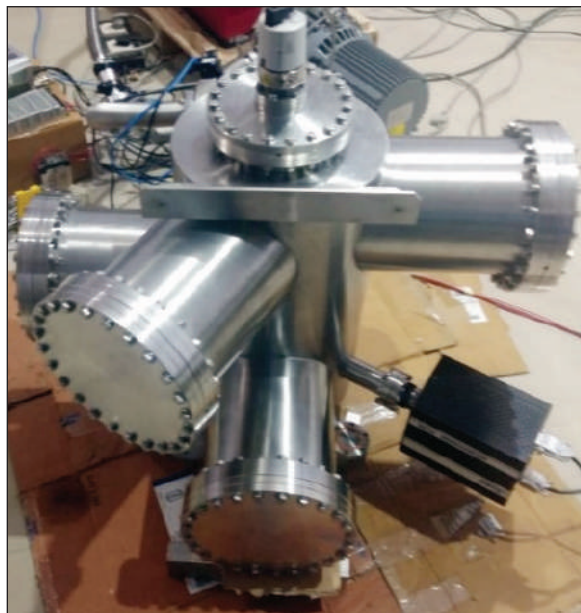


Fig.3. Prototype UHV chambers shipped to FAIR



Fig. 4. UHV chambers being inspected at FAIR

Advanced Detector Systems: Two large-size Gas Electron Multiplier (GEM) chambers made in India successfully took data at the SIS18 beamline at FAIR during the year.

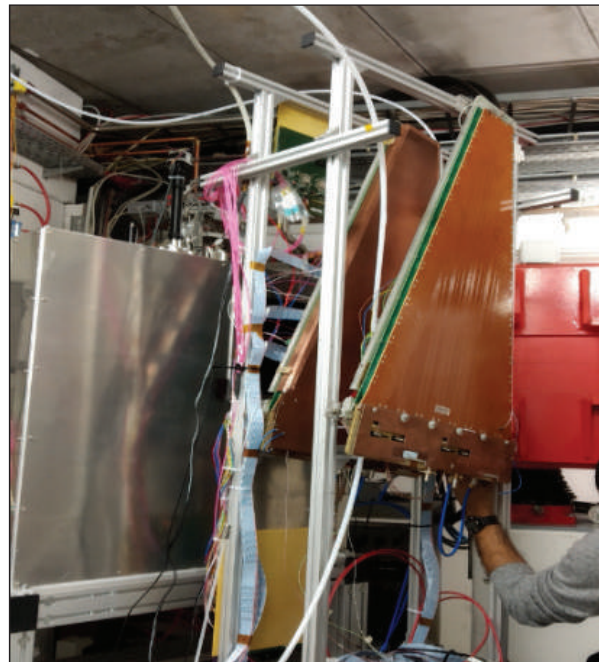


Fig.5: GEM chambers being installed in the SIS18 beamline at FAIR

India also received a credit of 0.5 M Euro (2005 prices) for the design work done by Indian scientists and engineers for superconducting magnets.

An International Collaboration meeting on Compressed Baryonic Matter (CBM) Experiment was organized at Bose Institute, Kolkata during 27 September-3 October, 2019 with participation of about 60 participants including 30 participants from abroad. Another meeting on “Physics of CBM Experiment” was organized at Gauhati University, Guwahati on 28th September, 2019 with participation of about 30 participants including 6 participants from abroad.

The project also resulted in 3 research papers in journals and 10 papers in conferences during the year.

2.4.3 Thirty Metre Telescope (TMT) Project

Support to this project continued during the year. All legal hurdles regarding construction at the project site at Mauna Kea, Hawaii were cleared. However, civil construction at Mauna Kea could not start due to blockage of road access and continued protests by native Hawaiians. Efforts were made to resolve the issue. For the identified alternate site, La Palma, Canary Islands, Spain, all necessary permits were obtained. All partners of the project continued their deliberations to decide on change in the project site and the way forward.

In parallel, R&D and prototyping activities for supply of various in-kind items from India – Segment Support Assemblies, Actuators, Edge Sensors, Segment Polishing and Segment Coating, First Light Instruments, Observatory Software and Telescope Control Systems Software – continued in full swing.

Civil construction of a state-of-the-art Optics Fabrication Facility at the CREST Campus of Indian Institute of Astrophysics (IIA), Bengaluru for fabricating TMT mirror segments was completed during the year and its commissioning was initiated.

A Global Tender for supply, installation and commissioning of equipment and transfer of technology for polishing primary mirror segments of TMT was floated and the contract was finalized during the year. 20 Actuators made in India by four Indian companies were shipped to the TMT Project Office, USA and these actuators successfully completed performance and life-cycle tests, paving the way for their production in India.



Fig. 6: Actuators made in India undergoing life-cycle tests

Development of prototype Central Diaphragm was successfully completed and few vendors were qualified. 21 Leaf Springs, an important component of Segment Support Assembly successfully completed life-cycle tests. Cutting and polishing of 8 edge sensor glass blocks were completed successfully by an Indian Company. Laser etching on 4-edge and 5-edge sensor blocks were also completed successfully by two Indian companies.

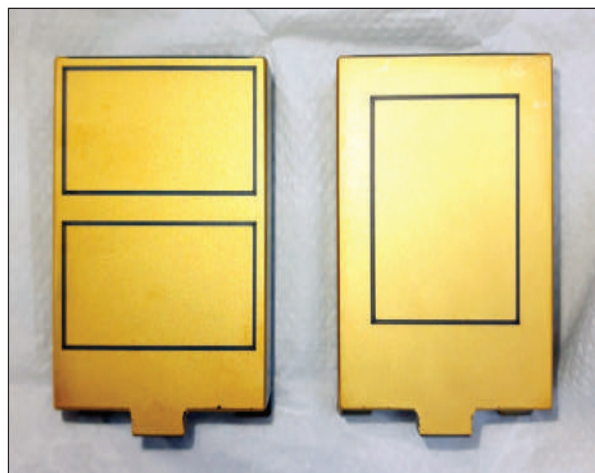


Fig. 7: Laser-etched Edge Sensor blocks (by ARCI, Hyderabad)

Preliminary design phase of the Telescope Control System (TCS) Software was completed and the work progressed further.

India is leading the design and development of TMT Wide Field Optical Spectrograph (WFOS). Work progressed on designing two major mechanical subsystems for TMT-WFOS. Work on development of Instrument Control Software and Calibration system for WFOS also progressed further.

Work on design and development of TMT-HROS - a second-generation High Resolution Optical Spectrograph - also progressed further, led by India.

On outreach front, a National Workshop on India-TMT Science and Instruments was organized at ARIES, Nainital during October 17-19, 2019 with participation of about 130 persons from 17 institutions. An International meeting on TMT-HROS was organized in China on 3rd November 2019 in which Indian scientists participated. Annual TMT Science Forum meeting was organized in China during November 4-6, 2019 in which Indian scientists participated. India-TMT continued its very active involvement in the Vigyan Samagam Exhibition at Mumbai, Bengaluru and Kolkata and geared up for the New Delhi event. The Hon'ble Minister for Science & Technology visited Vigyan Samagam including the TMT stall at Kolkata.

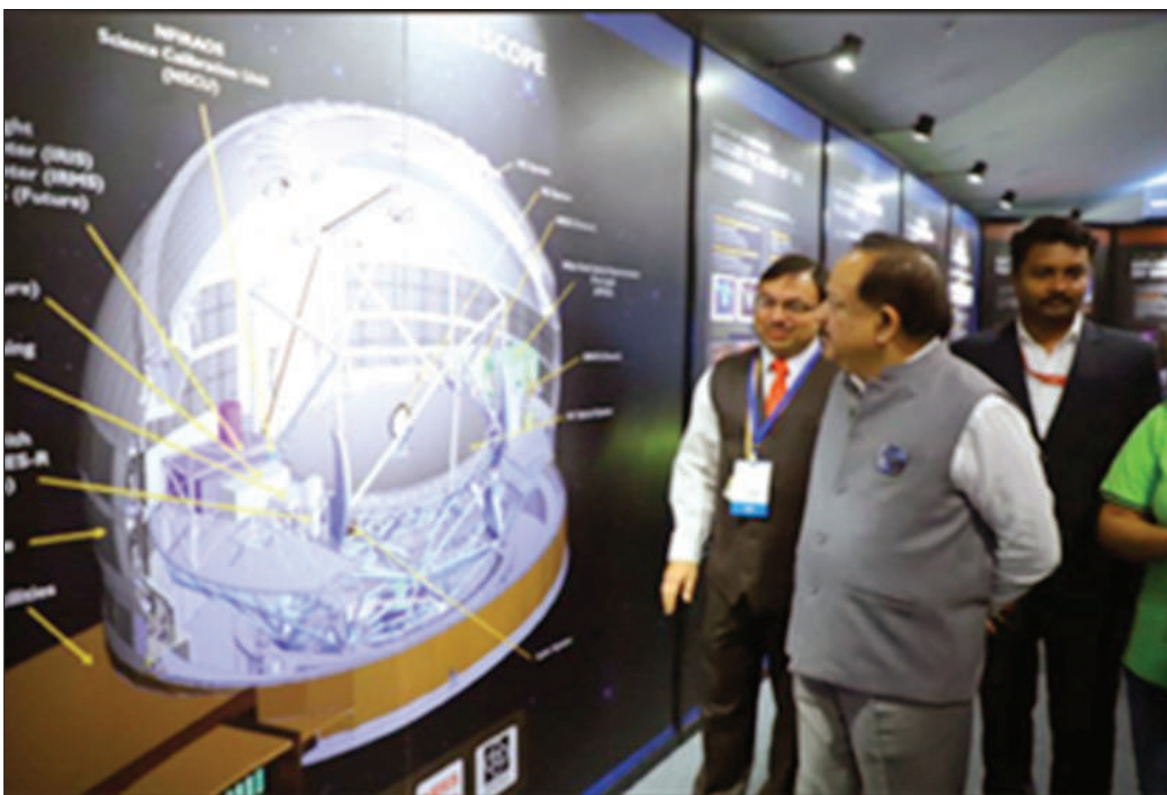


Fig. 8: Hon'ble Minister for Science & Technology at TMT stall at Kolkata

2.4.4 Utilization of Twin Beamlines for Macromolecular Crystallography (XRD2) and High Pressure Physics (XPRESS) at the Elettra Synchrotron Facility, Trieste, Italy.

Utilization of the twin beamlines, XRD2 and XPRESS, for carrying out frontline research in macromolecular crystallography and high pressure physics by the Indian scientific community continued during the year.

XRD2 Beamline: It was in full operation and was accessed by Indian scientists and research students. For enhancing its utilization, a scheme for remote access to the beamline including its control and data collection was also implemented. A close-up picture of the end-station of this beamline is shown below.

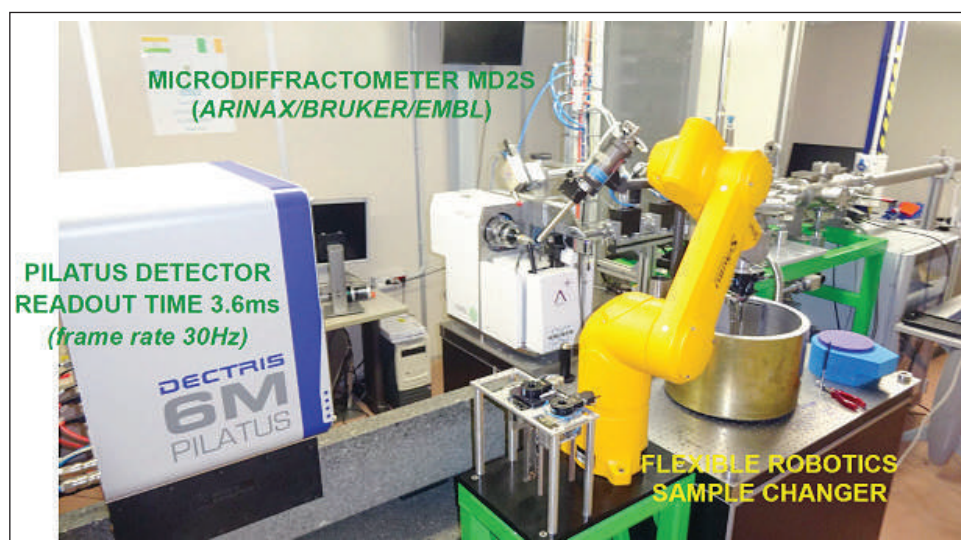


Fig. 9: XRD2 Beamline

36 research proposals from 18 institutions across the country were received for carrying out research using this beamline. Out of these, 27 experiments were carried out during 2019. This number is expected to increase significantly in coming years. In 2019, 2363 crystals were shipped from India to XRD2 and out of those, 1623 were screened. Out of these, 683 in total and 435 in 2019 were investigated in detail and high-quality data was collected. More than 30 Ph.D. students benefited from this facility in their research work. Two Ph.D. theses have been submitted based on the work done using this beamline. From the high-quality data obtained at this beamline, six entries were made into the Bio Sync Database.

XPRESS Beamline: It is fully functional and Indian scientists are regularly using this for their research work. In fact, Indian scientists have availed more than India's share of the beam time due to the excellent quality of proposals received from the Indian scientific community for this beamline. The work on augmenting the beamline to allow for temperature variation of the sample is in progress.

During the year, 19 experiments were performed by Indian users on this beamline and 8 Ph.D. theses are expected from usage of this facility. More than 20 Ph.D. students are utilizing the facility for their research work. 7 research publications in high impact factor journals have resulted so far and this number is expected to grow sharply in the coming years. A close-up view of the end-station of this beamline is given below.

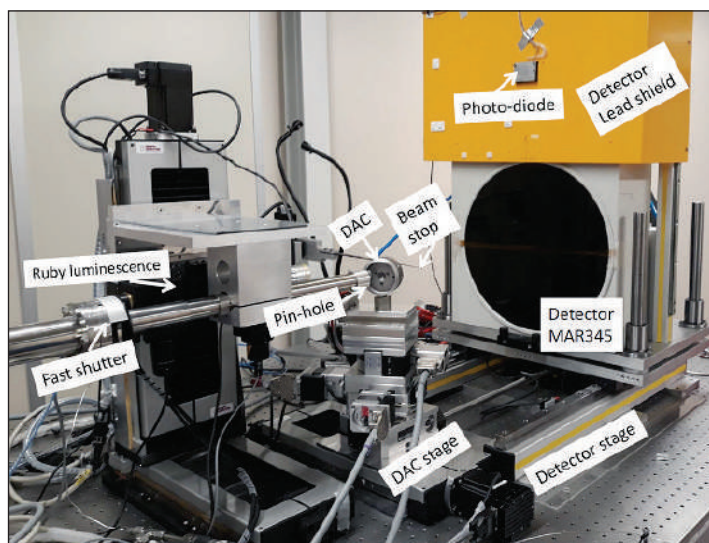


Fig. 10: Xpress Beamline

A User Meeting and Outreach Program to disseminate information about the research facilities at these two beamlines was organized at AIIMS, New Delhi during November 11-12, 2019 in which about 120 persons participated. The event was inaugurated by Prof. Ashutosh Sharma, Secretary, DST. Dr. Shekhar Mande, DG, CSIR also graced the occasion.



Fig.11: User Meeting and Outreach Program at AIIMS, New Delhi

2.4.5 Accelerator-based Research Facilities

Low-Energy Ion Beam Facility at Kurukshetra University

Support to the 200 KV ion beam facility at Kurukshetra University continued during the year and the facility was also utilized by users from neighboring institutions. During the year, 13 research groups carried out 31 experiments utilizing the facility with a variety of gaseous and solid ions.



Fig.12: Ion Beam Facility at Kurukshetra University

The project also resulted in 16 research publications and 8 conference papers during the year. Two Ph.D. theses were submitted based on the work done at the facility. 29 university teachers and 448 B.Sc./M.Sc. students from neighboring institutions were given demonstration of the facility during the year.

High-Fluence Ion Beam Facility at Allahabad University

Support to the facility at Allahabad University continued during the year.

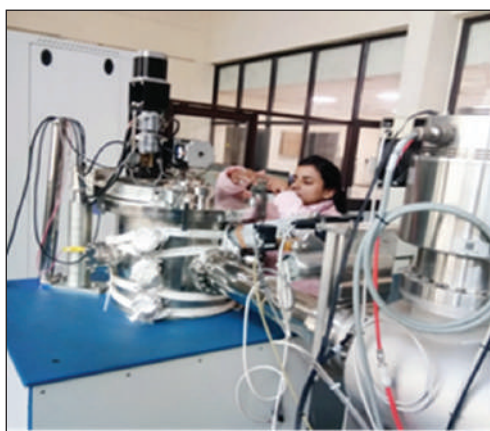


Fig.13: High-Fluence Ion Beam Facility at Allahabad University

During the year, 5 research groups from 4 institutions carried out 7 experiments utilizing the facility. The project also resulted in 1 research publication and 1 conference paper during the year.

2.4.6 India-based Neutrino Observatory (INO) project.

Support to 6 research groups for INO-detector-related R&D and simulation studies continued during the year. The projects resulted in 6 research publications and 2 Ph.Ds. during the year.

Indian Institutions-Fermilab Collaboration in Neutrino Physics.

Study of neutrinos is important for unraveling some of the deepest mysteries of the Universe. Groups from universities and academic institutions in India have been supported to participate in ongoing front-ranking neutrino experiments at Fermilab, USA.

Support to these 10 research groups continued during the year. 10 papers were published and 3 students completed their Ph.Ds. 16 other students continued with their research work.

2.4.7 Laser Interferometer Gravitational-Wave Observatory (LIGO) project.

LIGO in India will join the other two observatories in USA in gravitational wave research. The LIGO laboratory in India will help determine the location of gravitational wave sources more precisely. This will be a major facility in the world. Acquisition of land for locating the project in Hingoli district in Maharashtra was completed during the year. The project site-specific activities progressed further. The Detailed Project Report for the full project was formulated and submitted for funding. Civil construction for the prototype facility at RRCAT, Indore continued in full swing. The projects on LIGO-related R&D in some IITs and other institutions gained momentum during the year.

2.4.8 Square Kilometre Array (SKA) Project in South Africa and Australia.

The Square Kilometre Array will be the next-generation and largest radio telescope in the world. It will come up at two sites, in South Africa and Australia. India has been participating in this project from the beginning. After successfully participating in the Design Phase, the proposal for India's participation in the Construction Phase has been formulated and its approval process advanced further during the year.

2.4.9 National Large Solar Telescope (NLST) project.

It is planned to establish a 2-metre solar telescope at Merak in Ladakh. Land for locating the telescope at Merak was acquired by the Indian Institute of Astrophysics (IIA), Bengaluru during the year as a pre-project activity. The process of financial approval for the full project advanced further during the year.

Vigyan Samagam: Mega Science Exhibition.

Vigyan Samagam, a traveling, multi-venue, Mega Science exhibition was successfully organized during the year at Mumbai, Bengaluru, Kolkata and New Delhi. The exhibition is showcasing India's engagement in eight Mega Science projects – Indian participation in the Large Hadron Collider (LHC) at the European Organization for Nuclear Research (CERN), Facility for Antiproton and Ion Research (FAIR), India-based Neutrino Observatory (INO), International Thermonuclear Experimental Reactor (ITER), Laser Interferometer Gravitational-wave Observatory (LIGO), Thirty Meter Telescope (TMT), Square Kilometre Array (SKA) and Major Atmospheric Cerenkov Experiment (MACE) Telescope. These projects throw light on crucial questions related to the evolution of Universe through its various stages since the Big Bang that happened about 13.7 billion years ago.

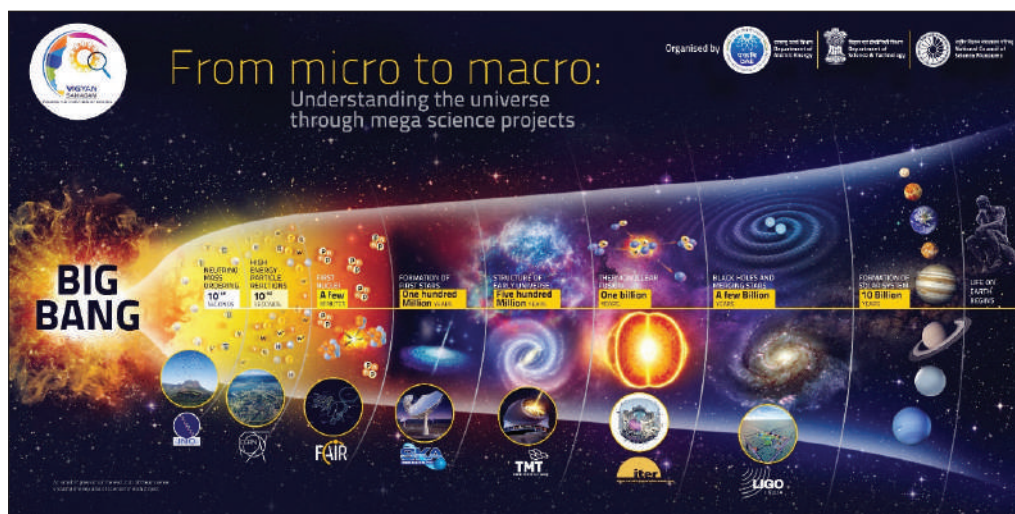


Fig 14: All mega science projects on single time diagram since the Big Bang



Fig. 15a: Secretary, DST and others at Vigyan Samagam



Fig. 15b. Curious minds at Vigyan Samagam

The events at Mumbai, Bengaluru and Kolkata witnessed a footfall of more than 5.5 lakh persons. Each event included talks by eminent speakers, industrial exhibition, live demos, quizzes etc. Dr. Fabiola Gianotti, Director-General, CERN, Geneva visited the exhibition on 30th August 2019. Foreign Ministers of Afghanistan, Maldives and Myanmar visited the event on 6th November, 2019.



Fig. 16: Foreign Ministers of Afghanistan, Maldives & Myanmar at Vigyan Samagam

Vigyan Samagam ended its journey after its New Delhi stop from 21st January, 2020 to 20th March, 2020.

2.5 Climate Change Programme (NMSHE & NMSKCC)

As part of National Action on Climate Change (NAPCC), DST has been entrusted with the responsibility of coordinating and implementing two national missions on climate change. These are: (i) National Mission for Sustaining the Himalayan Ecosystem [NMSHE] and (ii) National Mission on Strategic Knowledge for Climate Change [NMSKCC]. The Climate Change Programme (CCP) of Strategic Programmes, Large Initiatives and Coordinated Action Enabler (SPLICE), Division is implementing these national missions.

2.5.1 Major achievements and progress made during 2019-20

A. New Programmes initiated/launched during the year:

As part of implementation of two national missions on climate change i.e. NMSKCC and NMSHE, following new programmes were initiated during the year 2019-2020:-

i) Human and Institutional Capacity Building Programme (HICAB)

The new programme **Human and Institutional Capacity Building Programme (HICAB)** was launched during the year. The programme has broad sub themes such as Climate change vulnerability and impact, Meteorology, Glaciology and Hydrology, Bio-diversity and flora/faun, Health and Livelihood. The programme is comprised of three major components likely to be positioned both in the western and eastern Himalayan regions:

- (a) Centres of Excellence (CoEs) established in some key universities/Institutions of national importance having potential and capacity to undertake studies in areas of Glaciology, Bio-diversity and flora/fauna and Climate Change Impacts and Adaptation etc. The total duration of a CoE project will be 5 years.
- (b) Major R&D Programmes (MRDPs) in a few select areas positioned in some universities /Institutions of national importance. The total duration of a MRDP project will be 3 years.
- (c) Network Programmes (NPs) in some identified thematic areas being addressed under NMSHE. The total duration of a NNP project will be 3 years.

14 new programme/projects were initiated viz. 3 Centres of Excellence (CoEs), 8 Major R&D Programmes (MRDPs), 2 projects under the State Network Programmes and one project for the Vulnerability profile for India: State and District level have been initiated in this year.

ii. State CC Cell/Centre(SCCC)

During the year, second phase of the State Climate Change Cell in the State of Madhya Pradesh- has been initiated. The State Climate Change cells to implement State Action Plan on Climate Change. These centers have been assigned to undertake following major tasks:

- Vulnerability and risk assessment at district/sub-district levels
- Institutional Capacity building and R&D for data base/ Information generation
- Training programmes for stakeholders, and.
- Public awareness as per the requirements of state and national action plan on climate change.

2.5.2 Major outcomes from the ongoing programmes

a. Centres of Excellence (CoEs)

Centre for Climate Change, IIT Delhi: As a part of the efforts under the DST Centre

of Excellence in Climate Modeling at IIT Delhi, significant improvements have been made to the base model (NCAR Community Earth System Model), especially the convection parameterization, cloud parameterization, gravity wave drag parameterization, and the surface flux parameterization schemes, with an objective to develop an India Centric Climate Model (ICCM). The current version of ICCM shows significant improvement in simulated precipitation, temperature, and large-scale circulation features over the south Asian region, both in terms of mean features and extremes. Some of the findings have already been published, and others are in the pipeline. In addition to core model development, significant progress has been made in conducting process studies, comprehensive validation of latest climate models, and making climate change projections using unprocessed as well as bias-corrected and downscaled (both dynamical and statistical) model outputs under various global warming scenarios. In the process, around 30 young students and research staff have been trained in climate modeling as a part of capacity building, and thus preparing the next generation of climate modelers in the country. The efforts so far have led to a total of 33 publications in highly reputed international journals (e.g., Bulletin of the American Meteorological Society, Geophysical Research Letters, Environmental Research Letters, Climatic Change, Climate Dynamics, Scientific Reports, etc.), with a cumulative impact factor of ~118, and an average impact factor of ~3.6 (highest IF of ~9.5).

DST-Mahamana Centre of Excellence in Climate Change Research: The Centre aims to assess the impacts and vulnerability in water, agriculture and health sectors due to climate variability and change and building long term capacity in the areas of climate research and multi-disciplinary fields in the region. The Inter-annual variability over India and its sub-region have been studied using the simulated values of climate variability, precipitation and surface temperature. To understand the uncertainty in temperature pattern over different agro-climatic zones, the performance of six Conformal-Cubic Atmospheric Model (CCAM) at 50 km simulation forced by six global climate models has been analyzed. Vertical distribution of smoke aerosols were analyzed over Indo-Gangetic Plain between 2008 and 2016 using space-borne Lidar. A time series analysis of impact of individual and multi air pollutants on all-cause mortality special emphasis on Black Carbon (BC) conducted.

DST-ICMR Centre of Excellence for Climate Change and Vector-borne Diseases, National Institute of Malaria Research, New Delhi: The main focus of the centre is to determine the temperature thresholds for survival of vectors of major Vector-borne diseases (VBDs), modelling of projected scenarios of the VBDs and to set up a system for early warning of outbreaks for malaria and dengue. The impact of temperature on development and survival of vector of dengue (*Aedes aegypti*), Malaria (*An. stephensi*, *An. culicifacies*) on immature stages, i.e. eggs, larvae, pupae and adults was studied during the year. Study was undertaken to determine the effect of differences in indoor

and outdoor temperature on the Extrinsic Incubation Period (EIP) of the Dengue virus in *Ae. Aegypti*. Studies also conducted to identify the most preferred breeding habitats of Japanese Encephalitis vectors in Gorakhpur. Climate data (Temperature and Relative Humidity) has been generated by installing the HOBO data loggers and entomological data by carrying out the monthly field visits in three field sites i.e. Uttarakhand, Delhi and Coimbatore. In Delhi, 3 cycles of transmission in a month (8-12 days each) take place in monsoon month while 2 in winter. Whereas in Coimbatore, transmission continued for whole year due to upper limits of temperature suitability for more EIP cycles. The efforts so far have led to a total of 2 publications in highly reputed journals.

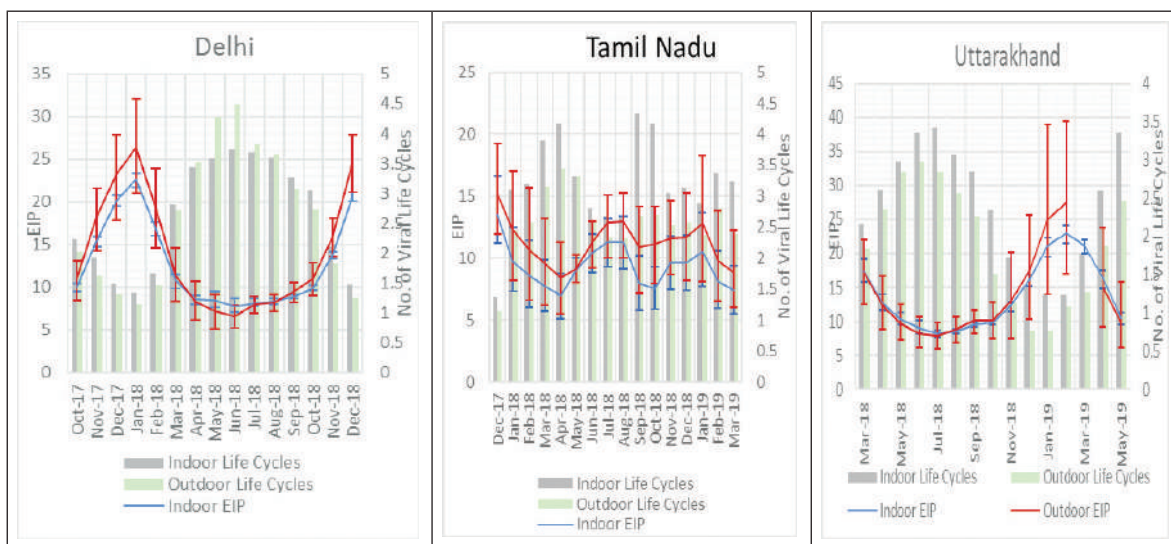


Figure 1: Determination of Extrinsic Incubation Period (EIP) for dengue transmission at three field sites.

DST Centre for Excellence in Climate Studies, IIT Bombay: DST-CoECS, IIT Bombay is established for steering high-impact research in the field of climate science and policy. One of the major efforts developed so far has been experimental demonstration of sensitivity of monsoon precipitation towards the choice of irrigation practices in South Asia. An open-access irrigation module has been developed specifically for India, as it was a first-of-its-kind discovery - stressing the need for accurate representation of irrigation practices to improve the reliability of earth system modelling over South Asia. Another recent effort discovered the region-specific information for dynamic vegetation modelling in the Indian monsoon region that may further be used in understanding global vegetation-land-atmosphere interactions. These studies helped to understand farmers' behaviour in terms of irrigation which further motivated to develop Agricultural Vulnerability Maps at national-scale, exclusively utilizing available observed data. A novel unified country-level framework to quantify and map the decadal agricultural vulnerability and risks for entire India has been derived. Fig 2 shows a

demonstrative Agricultural Bivariate Risk Map (considering both Hazard and Vulnerability components) developed for India. A similar effort as agricultural risk assessment has been made for the first time ever for developing social vulnerability (SoV) and risk maps, utilizing district-level India census data. In this study, a first analysis of the social vulnerability to disasters at a national-scale for the past two decades using a robust data envelopment analysis framework has been provided, which completely eliminates subjectivity associated with conventional indicator weighting (Fig 3). The efforts so far have led to a total of 6 publications in highly reputed international with a total impact factor of ~17.5.

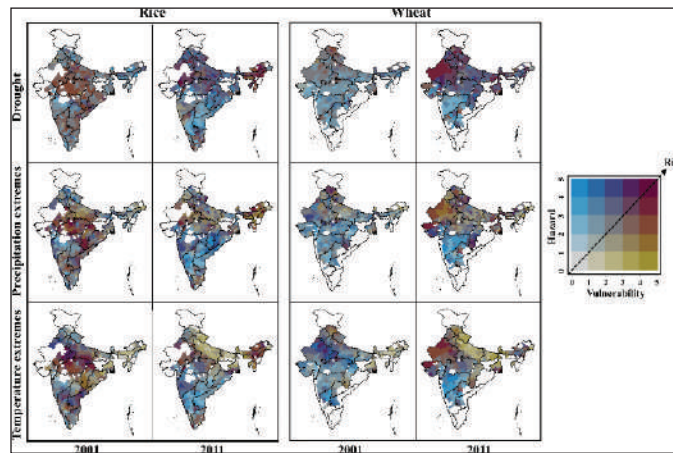


Fig 2: A representative agricultural risk map to drought, precipitation extremes and temperature extremes for rice and wheat in 2001 & 2011.

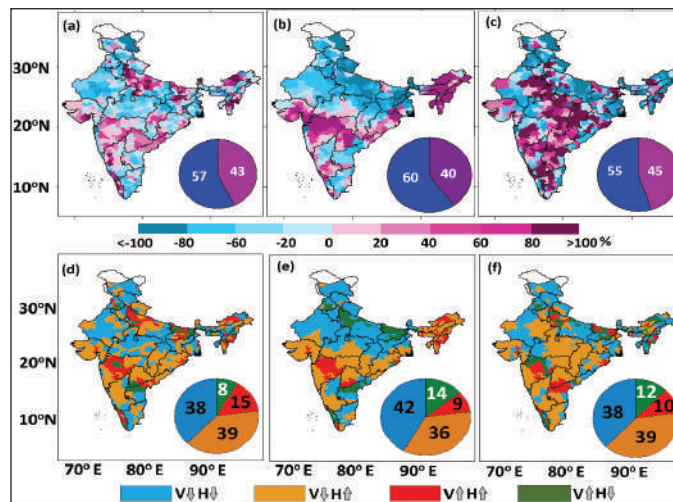


Fig 3: A demonstrative Disaster Risk maps (Risk as a product of Social Vulnerability and Hazard) for extreme precipitation, heatwaves, and droughts, for different categories of risks (Low Vulnerability and Low Hazard; Low Vulnerability and High Hazard; High Vulnerability and High Hazard; High Vulnerability and Low Hazard).

DST Centre for Excellence in Climate Change Impact on Coastal Infrastructure and the Adaptation strategies, IIT Madras: The main objective of the center is to develop suitable climate change adaptation measures for coastal infrastructure and utilization of water resources.

The study shows that extremely severe cyclonic storms such as Hudhud (2014) will intensify into Super Cyclonic Storm in both Near-Future (2035) and Far-Future (2075) for all RCP scenarios. There will be a delay in land fall and a drastic increase in cyclone damage potential index; (ii) deepening of tanks in catchment area can reduce the urban flooding in Chennai in future for moderate storms (1 in 50 year storms); (iii) A wind-wave model has been successfully adapted and validated for projection of wave climate into the future due to climate change (Fig. 4); (iv) Crucial data on shore line changes due to an extreme weather event obtain during GAJA cyclone (Fig. 5); (v) Important primary data on structural health of berth structures in Paradip and Cochi ports obtained using non-destructive testing (Fig. 6); (vi) A new numerical model for wave-vegetation interaction has been developed; (vii) A climate-resilient in-vessel co-composting technology is developed for solid waste management (Fig. 7) and (viii) BASIEC: A coastal climate service framework for community-based adaptation to sea-level rise has been developed.

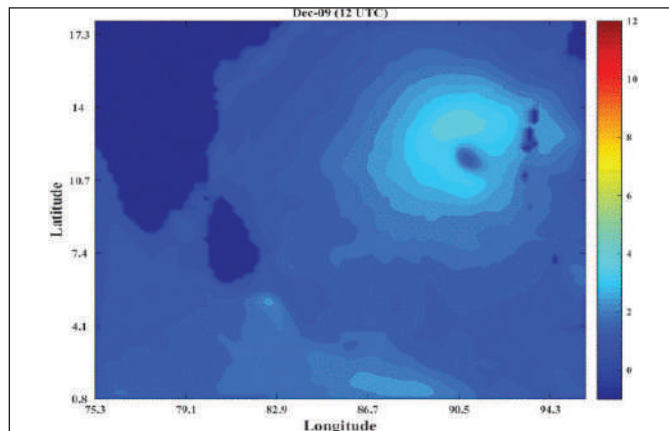


Fig. 4: Wave Climate

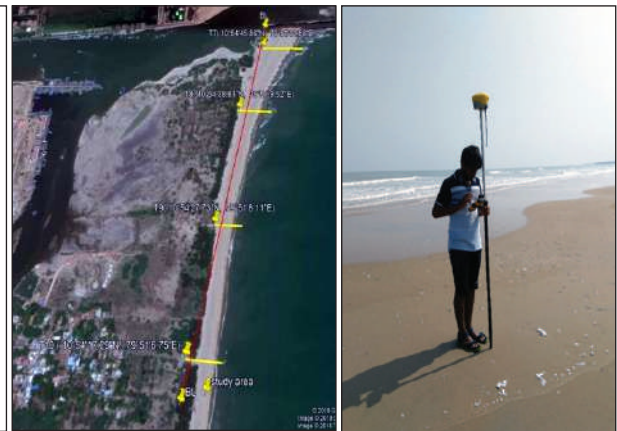


Fig. 5: Beach Monitoring



Fig. 6: Damaged Pile at berth at Paradip

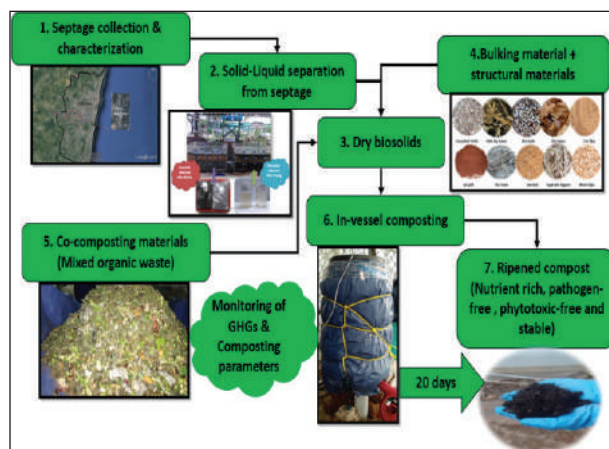


Fig. 7: In-vessel Co-Composting

Center of Excellence (CoE)- IIT Kharagpur: A comprehensive analysis of CMIP5 historical climate data under different RCPs for the Indian Ocean region has been carried out where a comprehensive inter-comparison exercise was performed to understand the temporal variability of domain averaged significant wave height (SWH) over the Bay of Bengal (BoB) region for the period 1997-2015. The study was carried out using the past 60 years (1951 – 2010) SST data analysed to segregate different types of El Nino events from a reconstructed sea surface data set. A comprehensive inter-comparison exercise was performed to understand the temporal variability of domain averaged significant wave height (SWH) over the Bay of Bengal (BoB) region using ERA-Interim and third generation WAVEWATCH-III model output for the period 1997-2015. The spatio-temporal consistency of datasets was examined using error analysis and probability density functions. Important findings include a negative bias in SWH over deeper oceans and positive bias over the shallow waters. There is an over-estimation in SWH seen in ERA-I dataset as compared to WIII for most of the time with an exception during the period 2007-2011. Probability density function showed wave heights ranging between 1.0 to 1.5 m were most dominant in both these datasets. The probability on wave height occurrence less than 0.5 m and between 3.0 to 3.5 m was found to be less.

A comparison was made on CMIP5 future simulations performed under four contrasting RCP scenarios: RCP8.5, a high emission scenario with radiative forcing reaching 8.5 Wm⁻² by 2100, intermediate scenario RCP6 with radiative forcing reaching 6 Wm⁻² by 2100, a midrange mitigated emission scenario RCP4.5, with radiative forcing reaching 4.5 Wm⁻² by 2100 and a low emission scenario RCP2.6, in which radiative forcing reaches a maximum of 3 Wm⁻² near the middle of the 2100 and then declines. The efforts so far have led to a total of 39 publications in highly reputed international and national journals.

DST-ICRISAT Center of Excellence on Climate Change Research for Plant Protection (CoE-CCRPP): Pest and disease management for climate change adaptation: The center developed to identify risk areas for mapping the spatial and temporal distribution of diseases and insect-pests under changing climate scenario and study host-insect-pest/pathogens interactions in relation to simulated climate variables to develop adaptation strategies to minimize crop losses. To develop weather-based plant protection advisory tools for the timely management of diseases and insect-pests. Historical pest and disease, insect-trap and weather data were collected, curated and uploaded to server. Targeted crops biology, pest and disease, hotspots and epidemiological information was collected and used in development of forewarning models. Roving and fixed survey and surveillance studies during 2018-19 and 2019-20 indicated that unseasonal-high density rainfall and prolonged moisture stress increased intensity of insect and disease in targeted crops. Increased incidence of chickpea dry root rot; Pigeonpea Maruca and Phytophthora blight, Cotton pink bollworm infestation (Raichur, Kalaburgi, Ballari, Koppala, Chitradurga, Gadag & Dharwad districts Karnataka. Increased sheath blight incidence (20-30%) and severity (10-25%) in all three surveyed mandals, blast incidence (10-15%) and severity (40-50%) and Incidence of BPH and WPBH was recorded about 30% in Ragadapa, Trippuraram mandal. The efforts so far have led to a total of 15 publications in highly reputed international and national journals.

b. Thematic Task(TF) Forces under NMSHE:

TF on Status of geo- resources and impact assessment of geological (exogenic) processes in NW Himalayan Ecosystem: This taskforce aims to establish database and information system about different geological resources and to study the changes in geological resources and processes (incidence of mass movements, ground water availability, spring discharges, and snow cover) under various climate change scenarios and to analyze its consequences. Major achievements during the year include Landslide susceptibility mapping along some of the Himalayan rivers like Satluj, Yamuna, Bhagirathi, and Goriganga valleys and hilly township of Mussoorie carried out using different bivariate and multivariate techniques. It has been observed that along all the river valleys, there is a high positive relation with the geological and tectonic set up of the area and the landslide susceptibility (Fig. 8). Very high and high landslide susceptible zones are mainly observed near the MCT zones and the barren land. The following figures present some of the landslide susceptibility zones map prepared for the Goriganga valley (Kumaun Himalaya) using various techniques like Yule Coefficient (Yc), Frequency ratio (FR), Information Value (IV), and Weight of Evidence (WoE).

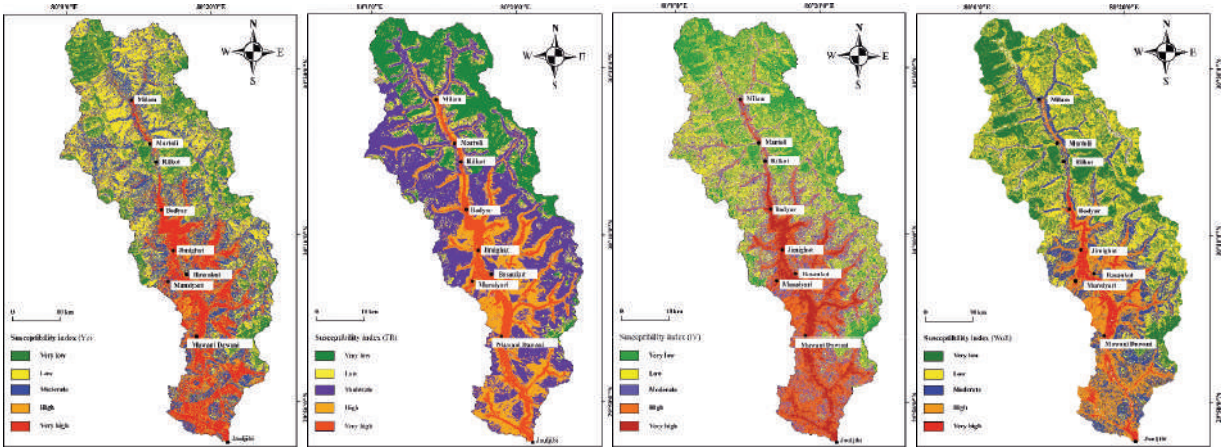


Fig. 8 Landslide susceptibility mapping of the Goriganga valley (Kumaun Himalaya) using various techniques like Yule Coefficient (Yc), Frequency ratio (FR), Information Value (IV), and Weight of Evidence (WoE)

TF on Integrated Hydrological Studies for Upper Ganga Basin up to Rishikesh: The TF is engaged with development of hydrological database in Upper Ganga basin, observation and modeling of various hydrological processes in a small watershed in the basin, generating real-time snow cover information and understanding of hydrological processes in study basin by using isotopic techniques. Major achievements during the year include a webpage linked with the advanced Web-GIS tool for display of snow cover information in the study basin since the year 2000. In the metadata section, options have been included for the visual display of data availability at a station. It helps in locating the gaps in the available data at a station.

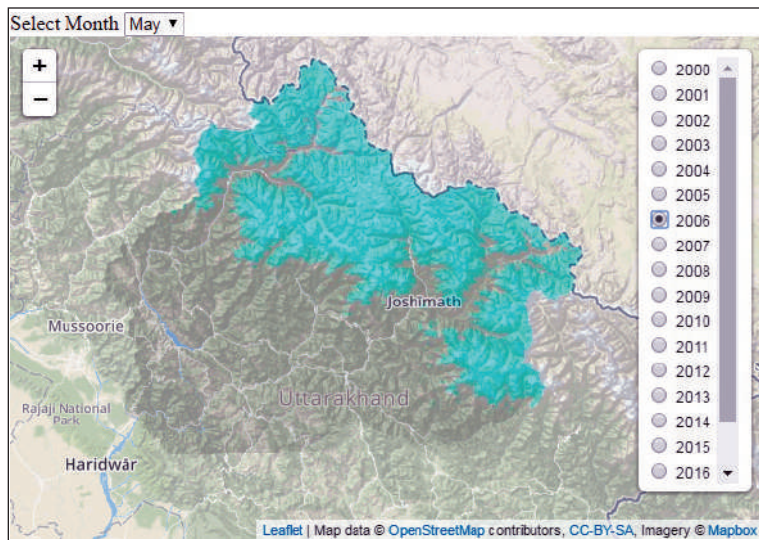


Fig.9 : Web-GIS application for month-wise snow cover extent in UGB

Lake inventory has been prepared using various datasets for four basins (Sutlej, Beas, Chenab and Ganga up to Rishikesh) and type of lakes have been defined. Area of all lakes have been computed and vulnerable lakes have been identified in all the basins. For hydrodynamic modelling for few vulnerable glacial lakes, preparation of database like cross sections etc. have been completed (Fig. 9). A semi-automated procedure for altitude-based masking of NSIDC MODIS snow extent maps has been developed and implemented in R software (Fig. 10).

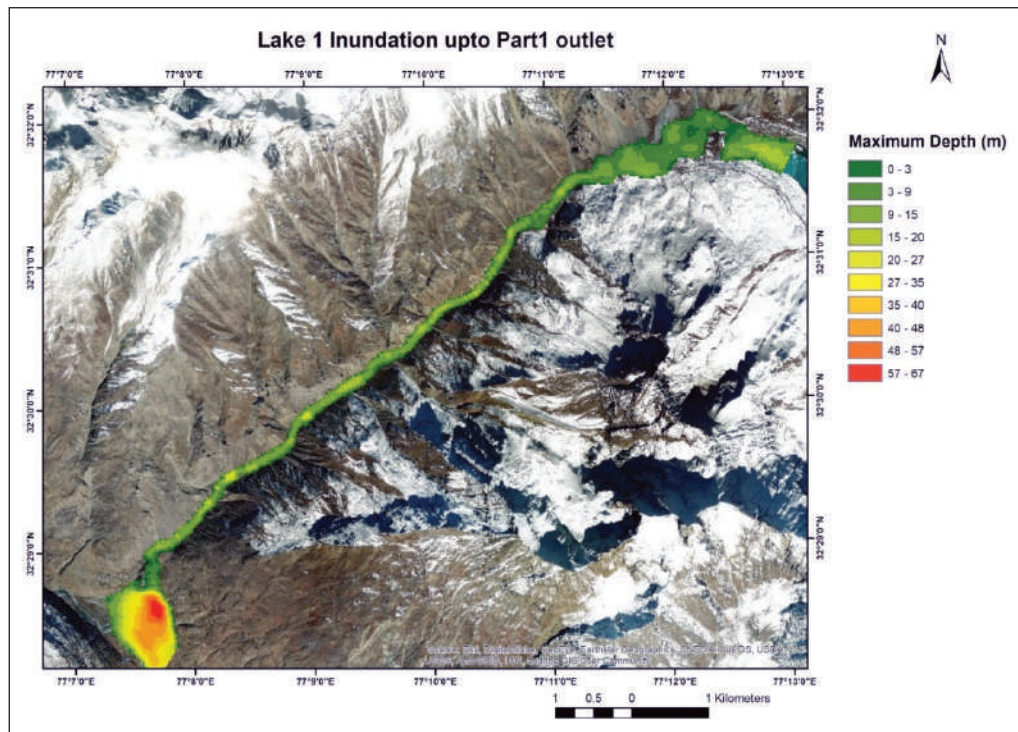


Fig. 10 : Inundation at the outlet of a potentially dangerous lake using GLOF modeling

TF on Forest Resources & Plant Biodiversity: This task force is engaged in developing a database of forest resource and plant diversity in the IHR under a standard format. An inventory of trees species of Indian Himalayan Region (IHR) have been prepared. A total of 1464 species belonging to 1384 angiosperms and 84 gymnosperm have been documented. Forest vulnerability index (FVI) was developed to assess the inherent vulnerability of 31 community forests. The results of the pilot study provided high vulnerability of low altitude forests as compared to high altitude forests, attributed to high density of alien species ($R^2=0.18$, $p=0.015$), low moisture content ($R^2=0.40$, $p<0.0001$) and high anthropogenic disturbance ($R^2=0.49$, $p<0.0001$). Evidences suggest that the community forests in the region are in a degraded state and fail to meet the needs of the people dependent on them. Anthropogenic forces are considered as the major driving force for degradation of the community forests. This can be exemplified with observed high vulnerability in low to mid-altitude community

forests due to high anthropogenic disturbances (Fig.11). Forest cover changes study reveal a relationship with decrease in population and increase in cover as evident by the -21.5% of negative growth in human population in Thoubal district, between the same time frame. The same was true for again 8 districts of Jammu & Kashmir, Himachal Pradesh, Uttarakhand, and Meghalaya, Nagaland, and Mizoram states. Among the various districts of states located in the IHR variation of increase in forest cover (between 2001 and 2011) of a district varies considerably between Thoubal district of Manipur State (133%) and North Cachar hills of Assam state (0.2%).

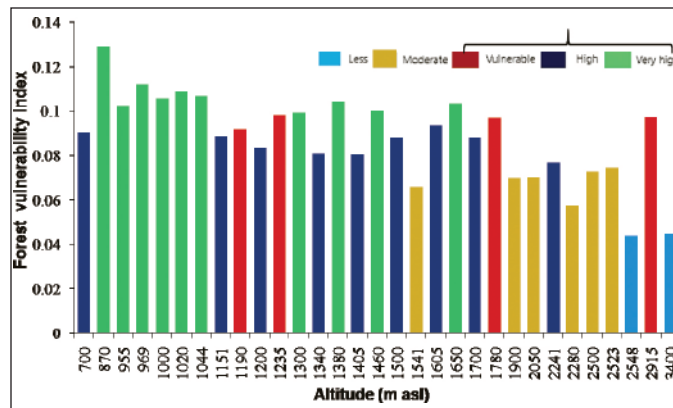


Fig 11. Inherent vulnerability of community forests w.r.t. altitudinal gradients

TF on Assessment and Monitoring of Climate Change Effects on Wildlife Species and Ecosystems for Developing Adaptation and Mitigation Strategies in the Indian Himalayan Region: The main goal of the TF is to develop strategies to mitigate climate change effects on wildlife species and their habitats in the IHR. The major findings include the estimation of potential habitat for blue sheep in the Indian Himalayan region to be 59,446 sq km(Fig.12). As Blue sheep was found to be the most influencing factor in determining the potential habitats for snow leopard. The potential habitat for Snow Leopard in the Indian Himalayan region was estimated to be 37,034 sq km.

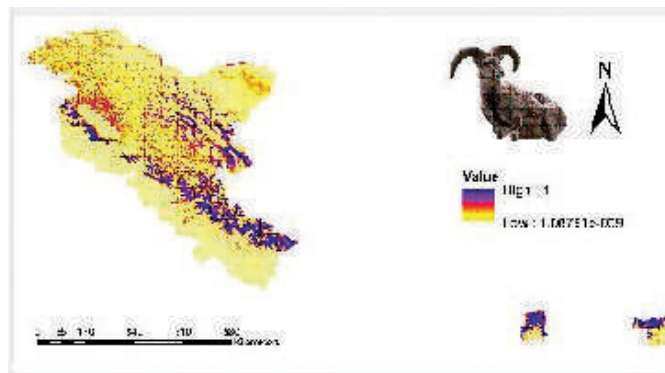


Figure. 12. Predicted suitable habitats in the Indian Himalaya region for blue sheep.

c. State Climate Change Centers (SCCCs)

DST has established State CC Cells/Centres in the 12 Himalayan States to undertake vulnerability assessment, training programmes, public awareness and institutional capacity building in the area of Climate Change science, impacts and adaptation. The most significant outcome of the of the vulnerability assessment carried out by the SCCC was the first ever Pan-Himalayan vulnerability profile map covering the 12 IHR States developed under the common framework. The Pan-Himalayan vulnerability map has been widely accepted by different stakeholders for climate adaptation planning in the IHR. Extending a similar exercise using the concept of the Common Framework for rest of the Indian states is under progress.

R&D manpower trained/generated (PhDs etc.)

A number of R&D programmes in some key areas of climate change science, adaptation and mitigation have been launched during the year. Several institutes working in these areas have been engaged in providing capacity building programmes involving research students leading to generation of trained manpower in the area of climate change sciences and technologies. Over 1000 scientists, experts and students and 200 institutions in the country are associated with CCP programmes/projects. Over 700 indirect jobs created through project staff/students fellowships.

d. International bi-lateral Programmes

a. Indo-German research collaboration in climate change

A Joint Declaration Intent (JDI) was signed between DST and BMBF, Germany for supporting Indo-German Center for Sustainability at IIT Madras. A Centre of Excellence focusing on Climate Change Impact on Coastal Infrastructure has been supported at IGCS, IIT Madras for a period of 5 years. The Centre of Excellence has been formally launched on 15th April, 2019.

b. Indo-Swiss Joint Collaborative Programme

Within the overall framework of S&T agreement between Government of India and Government of Switzerland, an Indo-Swiss Joint Committee for Scientific and Technological Cooperation was established by the two governments. In the first meeting of this joint committee held in Bern, Switzerland on 23rd September 2011, it was decided to develop a scientific cooperation between the two countries in Glaciology and related areas. The first phase of Indo-Swiss programme was launched in the year 2013 which continued until December 2015. The second phase of the cooperation began in January 2016, wherein, the Swiss agency for Development and Cooperation (SDC) though its Indian Himalayan Climate Adaptation Programme (IHCAP) programme has been working as a knowledge partner of DST in providing

technical support for undertaking vulnerability and risk assessment, stakeholder training and public awareness programme to the 12 State CC Cells established under NMSHE.

As part of this cooperation, a detailed district-wise vulnerability assessment has been carried out for all the 12 Himalayan States. A manual on Adaptation to Climate Change in the Indian Himalayan Region and a Comprehensive Report on Springs in the Indian Himalayan Region were released at the Himalayan Summit on Climate Change in New Delhi on 29th November, 2019



Fig 13. Release of Manual on Adaptation and Report on Springs for Indian Himalayan Region

- c. The 10th CMS VATAVARAN-International Film Festival and forum on Environment and Wildlife on the theme of “Celebrating Himalayas” was held from 27-30 November, 2019 at Dr. Ambedkar International Centre, Janpath, New Delhi. A Himalayan Summit on Climate Change was organized during the first two days (27-28 November 2019) of the event with an objective of disseminating various knowledge products developed under Indo Swiss collaboration, to share the lessons emerging from the collaboration and also to explore ways in which the initiatives are being sustained by various partners. The workshop saw presence of 50 participants from 11 Himalayan States. The workshop was jointly organized by the Swiss Agency for Development and Cooperation (SDC) and the Department of Science and Technology (DST).



d. Indo-US Fulbright-Kalam Fellowships in Climate Change

An Indo-US Fulbright- Kalam fellowship scheme was initiated during 2015-16. During 2016-17 to 2018-19, three batches of six fellows (3 each in doctoral and post-doctoral categories) have already been awarded the fellowships and preceded to their respective institutions in USA for undergoing courses. The selection process for the fourth batch of Fullbright Fellows on climate change is underway.

2.6 National Super Computing Mission

National Supercomputing Mission (NSM) is a National Mission initiated by Government of India in April, 2015, to boost indigenous efforts to be in the forefront of supercomputing capability for socio-economic development of the nation. The mission jointly steered by Ministry of Electronics and IT (MeitY) and Department of Science & Technology (DST), is being implemented through two leading organizations - Centre for Development of Advanced Computing (C-DAC), Pune and the Indian Institute of Science (IISc), Bengaluru with an objective to meet the increasing computing demands of the scientific and research community. Multiple supercomputers of varying capability, ranging from a few 100 Tera FLOPS to Ten's of Peta FLOPS would be set up across the country under the National Supercomputing mission (NSM). C-DAC and IISc, Bangalore are the implementing agencies of the Mission. Distinguished experts from premier national institutions like NITI Aayog, DRDO, BARC, IIT, JNU, etc. have been involved since inception and played a crucial role in guiding implementing agencies of the Mission.

There are four verticals in NSM namely - NSM-Infrastructure; NSM-Research & Development; NSM-Applications Development and NSM-Human Resources Development. The up-to date status is as follows as on 30th November, 2019.

During the year, we have installed and operationalised 2 more Supercomputers at IIT-Kharagpur named **PARAM SHAKTI** with 1.66 Rpeak (Theoretical Peak floating-point performance) with 850 TF (CPU nodes) and 195 TF (GPU nodes) capacity last month and the 2nd Supercomputer installed at IISER, Pune "**PARAM Brahma**" with indigenously designed cooling system by C-DAC (DCLC). Orders for another 3 supercomputers have been placed and these will be made operational by March, 2020. The locations are IIT-Hyderabad (650 TF), JN Centre for Advanced Scientific Research, Bengaluru (650 TF) and IIT-Kanpur (1.30 PFs).

Further, the two Departments had accorded sanctions to 6 projects in Applications Development area. The areas in which the projects have been sanctioned are as follows:

- i. Flood Early Warning and predictions systems for River basins in India
- ii. HPC Software Suite for seismic imaging to aid Oil and Gas exploration
- iii. Urban modelling development of Multisectoral simulation lab and Science based Decision Support Framework to address Urban Environmental Issues
- iv. Applications porting, scaling and optimisation services
- v. NSM Platform for Genomics and drug discovery
- vi. Materials and Computational Chemistry

These projects, each of which has a Project Monitoring Committee with the User Department Expert Chairing them so as to involve the User right from the beginning.

Under the R&D Vertical, 3 projects have been sanctioned by both the Departments. These include:

- Design and development of Direct Contact Liquid Cooling system (first version implemented at IISER, Pune - Param Brahma Supercomputer)
- HPC Applications framework - IIT-Chennai, IIT-Mumbai and IISc-Bengaluru
- Programming Model, Language and Compilers for emerging HPC systems

The NSM-Executive Board (NSM-EB) has approved a proposal for setting up 5 HPC training Centres at 4 IITs at Chennai, Mumbai, Kharagpur and Kanpur and at IISc at Bengaluru, in consultation with D/o Higher Education, who have identified these Institutions. So far under this almost 5000 manpower have been trained in various aspects of HPC including training to non-domain teachers in parallel programming skills.

NSM-Infrastructure

Another key milestone achieved recently is installation and operationionlization of

indigenously assembled supercomputer at IIT-Kharagpur “**PARAM SHAKTI**” with 1.66 Rpeak (Theoretical Peak floating-point performance) with 850 TF (CPU nodes) and 195 TF (GPU nodes) capacity last month and the 3rd Supercomputer installed at IISER, Pune “**PARAM Brahma**” with indigenously designed cooling system by C-DAC. This super Computer has a 797 Rpeak. Hon’ble Prime Minister had dedicated “**PARAM SHIVAY**”, during February 2019 to the scientific and research community of the nation to strengthen the research and development in the country. This is installed at IIT-Varanasi. All these systems have C-DAC system software stack. The system is equipped with applications from domains like Weather and Climate, Computational Fluid Dynamics, Bioinformatics and Material science. Three more indigenous Supercomputers are likely to be installed soon at IIT, Kanpur; JN Centre for Advanced Scientific Research, B’luru and IIT-Hyderabad which will be operational by 31st March, 2020. Another eleven supercomputers with cumulative capacity of 10 PF have been approved by NSM-Executive Board recently along with 3 systems in Phase III, two of 3 PFs at IIT-Bombay, Mumbai, IIT-Madras, Chennai; and one 20 PF system at C-DAC, Pune. All these systems are connected in a Grid and will have National Knowledge Network (NKN) which is used as backbone for connecting them.

These state-of-the-art facilities have been put to use not only by faculties, scientists and research scholars of these three Institutes but by engineering and research institutes of the region for solving socially relevant problems directly benefitting to common society like irrigation planning, traffic management, healthcare, affordable drug discovery.

NSM-Applications

MeitY and DST has since sanctioned 6 projects in Applications Development. The areas in which the projects have been sanctioned are as follows:

- i. Flood Early Warning and predictions systems for River basins in India
- ii. HPC Software Suite for seismic imaging to aid Oil and Gas exploration
- iii. Urban modelling development of Multisectoral simulation lab and Science based Decision Support Framework to address Urban Environmental Issues
- iv. Applications porting, scaling and optimisation services
- v. NSM Platform for Genomics and drug discovery
- vi. Materials and Computational Chemistry

NSM-Research and Development

MeitY and DST has since approved 3 proposal in R&D. These proposals are as follows:

- Design and development of Direct Contact Liquid Cooling system (first version implemented at IISER, Pune - Param Brahma Supercomputer)

- HPC Applications framework - IIT-Chennai, IIT-Mumbai and IISc-Bengaluru
- Programming Model, Language and Compilers for emerging HPC systems

NSM-Human Resources Development

The NSM-Executive Board has approved a proposal for setting up 5 HPC training Centres at 4 IITs at Chennai, Mumbai, Kharagpur and Kanpur and at IISc at Bengaluru in consultation with D/o Higher Education who have identified these Institutions. An MTech Course on HPC and related subjects is also to be started by D/o HE at 2 IITs and 1 NIT, which has started HPC as an elective subject at UG level. So far under this almost 5000 manpower have been trained in various aspects of HPC including training to non-domain teachers in parallel programming skills. A proposal has been approved for considerable number of 5 day training programme during the year 2019 and 2020 so that almost 10000 manpower could be trained in different aspects of HPC like awareness, parallel programming, system administrator, Advanced Computing etc.

Three Supercomputers at Three Institutes:



PARAM SHIVAY AT COMPUTER CENTRE, IIT-VARANASI



PARAM SHAKTI AT COMPUTER CENTRE, IIT-KHARAGPUR



PARAM BRAHMA SUPERCOMPUTER AT IISER, PUNE

2.7 Interdisciplinary Cyber Physical Systems (ICPS)

2.7.1 Interdisciplinary Cyber Physical Systems Programme

New programme on Technology Fusion & Applications Research (TFAR) to boost research in emerging technologies under single platform:

The Union Minister for Science, Health & Family Welfare, Science & Technology & Earth Sciences, Dr Harsh Vardhan launched the 'Technology Fusion & Applications Research Programme (TFAR)' addressing the ever increasing technological requirements of the society and taking into account the international trends of next generation technologies. The TFAR programme, a national initiative with Pan India applicability is to be implemented by the Department of Science & Technology (DST) at a total outlay of Rs 250 Crore for a period of three years.

The programme will boost research for fusion, convergence and application of emerging technologies like Quantum Enabled Science & Technology, Imaging Spectroscopy, Epidemiology Data Analytics and Indian Heritage in Digital Space.

The programme is being operated in the knowledge generation domain, and its beneficiaries are slated to be mainly researchers, scholars and students. However, the technology outcomes and innovations could lead to start-ups and technology-driven economic growth. Such technologies would be of benefit for the general public.

A slew of advanced technologies is shaping our lives, arguably at a rate of change never seen before. However, no single technology vertical can address or solve challenges that we face today. The fusion and convergence of various technologies is the need of the day.

Impactful road ahead

All the advanced technologies in TFAR programme are continually evolving beyond the boundaries of single disciplines, thereby generating innovations. Resulting patents can feed into a Start-up ecosystem and help employment generation. It can also create specially trained human resource & skilled workforce. These technologies are highly prominent today and compiling them on one platform could serve those engaged in R&D, translational research, policy and technology management, and accelerate the process of technical developments and societal problem solving. The TFAR programme would also establish outcome-based research collaborations within India and with International academic institutions for the advancement of interdisciplinary research in the country.

Broad research areas under TFAR and related details:

1. Quantum Enabled Science & Technology (QUEST)
2. Imaging Spectroscopy & Applications Research Initiative (ISARI)

3. Epidemiology Data Analytics Research Initiative (EDARI)
4. Indian Heritage in Digital Space Research Initiative (IHDS)

1. **Quantum Enabled Science & Technology (QUEST):** The research in Quantum field would lead the development of quantum computers, Quantum Communication, Quantum Key Distribution, Cryptography and Cryptanalysis. Quantum computing, the next generation computational paradigm, has many applications like drug discovery, nuclear research, space applications, Numerical weather predictions, aerospace engineering and many advanced Science & engineering areas. The advancements in Quantum Communication and Cryptography provides us with an edge in safeguarding our critical communication networks; protect our critical infrastructure, financial networks and services. Technology development in both fibre-based and free space communication technologies are envisaged in this initiative.

Expected outcomes:

- Development and demonstration of 8-Q-bit quantum computers, Communication (Fiber & Free Space) & Cryptography
- Development of application specific quantum-algorithms.
- Development of advanced mathematical quantum techniques, algorithms and theory of quantum information systems.
- Also, 100 PhD's in the Quantum field, training to 2000 Undergraduate, Post Graduate and Scholars in the advanced algorithm and application development using quantum systems.

2. **Imaging Spectroscopy & Applications Research Initiative (ISARI):** This area of research has potential to develop technologies for national issues like mineral exploration, water quality estimation & quantification, forest growth, crop loss assessment, pollution estimation and so on. Applications like soil health cards, management of emissions, crop health monitoring, river rejuvenation and other spatio-temporal analysis require research in advanced remote sensing technologies. Imaging Spectroscopy is an emerging area and the government has recognized its potential.

Objectives:

- To acquire and archive spatio-spectral database from field, air, and space borne platforms and augment scientific understanding by conducting synchronous experiments
- To develop software for hyperspectral data processing comprising India specific atmospheric correction models and the state of the art and conventional tools for a pre-processing, target mapping and sub-pixel classification.

- To identify the scientifically and socially relevant problems in each one of the application areas namely geology, agriculture & soil, forestry, water resource, snow and ice, built in environment and attempt to develop methodology for solving the same using HRS technique.
- To augment human resource and increase of research base

Deliverables

- Quantitative characterization and discrimination of different earth surface features like rocks, minerals, soil, vegetation, water, snow & ice and urban and man-made features
- A well characterized exhaustive spectral database
- Standard protocols and algorithms for hyperspectral data processing
- Methodology for application IS in various scientific endeavours for societal benefits such soil and crop health monitoring, water pollution, mineral exploration etc.
- A web portal containing the entire database, software tools and documents
- Generating human resources through training and Ph.D. research program.

Some of the Major Accomplishments

- A well characterized, useable and exhaustive spectral database in Geology, Agriculture, Forestry, Built-up materials, Forestry, and water
- An Indigenous software tool for processing imaging spectrometer data (NISA-Hyperspectral Data Analyses Tool (Version 0.1 released)

It includes Powerful Techniques for

- Atmospheric Correction
- Dimensionality Reduction, Endmember Extraction
- Mixture Modeling and Image Classification
- Deep Learning Based Algorithms for Sub-pixel Analysis and Super-Resolution
- Four central facilities at four corners of India facilitating spectroscopy research
- Soil fertility and quality assessment through imaging spectroscopy from ground and air borne platforms like AVIRIS-NG of JPL-NASA.
- Developed also soil fertility map using newly developed digital soil mapping concept

- Characterized spectral bands for different plant parameters for crop health and precision farming
- Hyperspectral remote sensing-based algorithms developed for estimating water constituents in Ganga river, Chilika lagoon in Odisha, Hoogly estuary in West Bengal, Kolavai lake in Tamil Nadu, and Mandap islands in Tamilnadu
- Creation of Spectral Library using Reflective and Emissive Spectra for Delineating Terrain Features and Associated Materials in Hyper-Spectral Domain.
- Developed methodologies for spectral discrimination, biochemical characterization, stress monitoring and productivity assessment of forest trees.
- Well trained human resources, expected 50 PhD's and 3 IPR filed.
- More than 50 publications in Journals and 80 in conferences.

3. Epidemiology Data Analytics Research Initiative (EDARI): This area aims to create a scalable data-oriented open platform for public health epidemiology in India and to gain a systems view of the spectrum of population health challenges. EDA programme will identify, collate, clean and analyse diverse data that reflect the health of a larger rural or urban population in varied locations across India. It will also create the digital platforms and tools that enable such work. It will also lead to the creation of an open public health data platform with built-in tools for epidemiology data analytics, visualisation and analysis.

Expected outcomes will be a Health Data Analytics technology platform. Nearly 10 projects in a networked mode were supported so far.

4 (i). Indian Heritage in Digital-Space Research Initiative (IHDS): India is known for her rich historical and cultural heritage enshrined in its monuments, architecture as well as written, visual, and performing arts and craft forms. Wars and conflicts have led to partial destruction of its monuments, while evolving tradition of higher art has kept their history and origin unknown to many people. The task of documenting, archiving, and sharing India's heritage is monumental, and despite dedicated efforts by many people and the government, it still remains a challenge. We live in an age of technologies for digital storage and recreation. These technologies can protect memories of the past against the destructive forces of time, nature and man-made events. Already there are Digital Library projects underway to capture the written documents and manuscripts in digital form. These projects hold the promise of being able to preserve the wealth in these documents for many years and also to make them available to use by people from around the world. The Indian Heritage in Digital-Space (IHDS) Research Project aims to extend the power of digital technologies for storing and sharing historical, architectural and cultural data and knowledge. Besides, emerging technologies in computer vision, graphics, audio and video technologies and user interface design offers the prospect of creating vivid experiences of the heritage for common

users. It also can provide analytical tools for art historians, architects and scientists interested in conducting scholarly studies on related subjects.

4 (ii) One of the focused area of research is Under water studies of submerged cities like Dwarka and Poempuhar and nearly 30 Cluster proposals have been initiated so far. The study involves under water surveys by remotely operated vehicles and photography, sea bed drilling, remote sensing based geo dynamics studies to bring out a comprehensive information on the time series evolution and extinction. The study also involves the visualisation of geo dynamic processes of the last 20,000 years like land subsidence, sea level rise, Cauvery's migration, floods, tsunami, cyclones and erosion. Finally, the life history of Poempuhar will be digitally re-constructed.

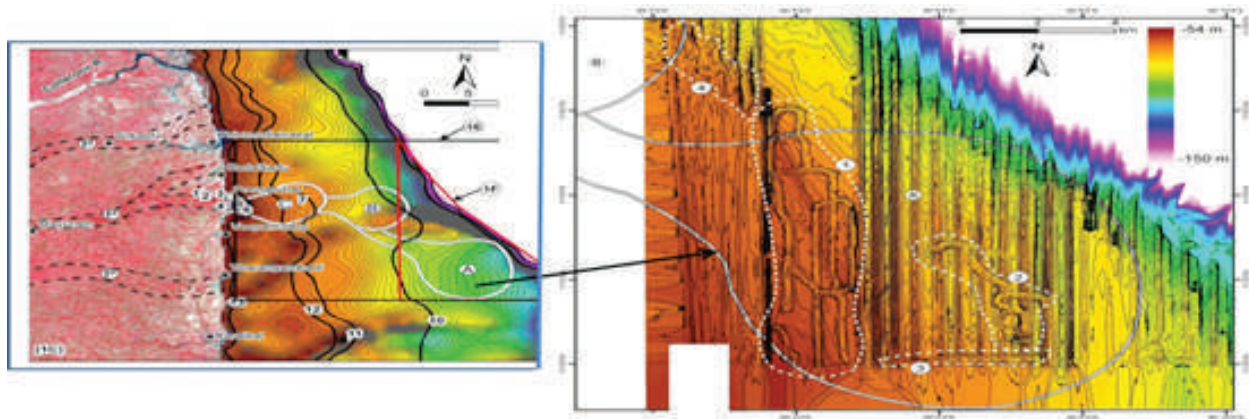


Fig. Digitally reconstructed submerged possible Poempuhar port in Bay of Bengal (50-60 m depth)

The initial studies carried out using the IRS LISS IV remote sensing and GEBCO (General Bathymetry Chart of the oceans) data sets have brought out exciting following newer information:

- (i) The Poempuhar city was initially established in Cauvery delta-A, 30kms away from the present Poempuhar city around 15,000 years ago (left figure)
- (ii) Thenshifted further 10 kms westerly to Delta-B around 11,000 years ago
- (iii) Further 10 kms westerly to delta -C around 8000 years ago and
- (iv) finally re-established at the present location at the mouth of river Cauvery around 3000 years ago. All these are due to the continuous rise of sea levels and the submergence of the deltas.

Further studies, using Multi Beam Eco sounder data of National Institute of Ocean Technology (NIOT), Chennai has led to the discovery of possible North-South oriented 10 kms long and

3 kms broad harbour like structure (1), sea walls (2&3) and a probable bridge (4) (right fig).

This has opened up hierarchy of newer openings on the life history of Poompuhar and the social, cultural and technological evolution of this part of the country and the age of Poompuhar from 3000 years to 15,000 to 20,000 years.

The study is also expected to provide packages of scientific information not only on the life history of Poompuhar and the socio- cultural evolution but also the science and technological evolution and the disaster history of this region.

5. ICPS Research Initiatives:

i) Data Science Research Initiative (DSRI)

Data science encompasses the areas of Statistics, mathematics, Computer Science, Information Theory, Information Technology and artificial intelligence (AI). Data driven scientific discovery is an important emerging paradigm for computing in areas including social, service, Internet of Things, sensor networks, telecommunications, biology, health-care and cloud, environment and Social Systems. There are certain associated scientific challenges, ranging from data capture, creation, storage, search, sharing, modelling, analysis and visualization. Nearly 32 projects (8 proposals under individual category and 24 cluster proposals) have been initiated so far.

Expected outcomes:

- Tools and applications applied to Data Mining, Databases and Analytics
- Promotion of indigenous interdisciplinary research focusing on large-scale data analysis in India
- Quality Research Publications
- Patents
- 60 Ph.D's

ii) Internet of Things Research Initiative (IoTRI)

The Internet of things (IoT) is the extension of Internet connectivity into physical devices and everyday objects. Embedded with electronics, Internet connectivity, and other forms of hardware (such as sensors), these devices can communicate and interact with others over the Internet, and they can be remotely monitored and controlled. The definition of the Internet of things has evolved due to the convergence of multiple technologies, real-time analytics, machine learning, commodity sensors, and embedded systems. Research Challenges for IoT research are architecture, Identification, Communications, Network Technology & Discovery, algorithm, signal processing, Search Engine, Net-work Management, Low Power devices,

Security, Robustness, Privacy, Cloud computing and edge Computing. Nearly 32 projects (15 proposals under individual category and 17 cluster proposals) have been initiated so far.

Expected outcomes:

- Hardware and software systems leading to connected and smart IoT based system for our country's Economy, Society, Environment and global needs
- Promotion of cross disciplinary research and Innovation
- Quality Research Publications
- Patents
- 60 Ph.D's

iii) Cyber Security for physical infrastructure (CSRI)

CSRI is an attempt to define a national R&D agenda that will enable to develop Cyber Security technologies to secure/protect our National Information Infrastructure (NII) and National Critical Infrastructure (NCI). The R&D, testing, evaluation and other life cycle considerations are required to meet the Cyber Security challenges. Nearly 32 projects (13 proposals under individual category and 19 cluster proposals) have been initiated so far.

Expected outcomes:

- Promotion of interdisciplinary research in cyber-social systems in India
- Development of indigenous interdisciplinary technology for cyber-attack detection, prevention, and countermeasures
- Quality Research Publications
- National/International research collaborations
- Indigenously developed quality research prototypes/products to secure national IT Infrastructure
- Training to UG/PG/Scholars in the emerging field of Cyber Security.
- Patents
- 50 Ph.D's

A special Call For Proposal (CFP) was launched to train Scheduled Caste (SC) & Scheduled Tribes (ST) students in advanced technologies like Artificial Intelligence, Sensors, Data Science, Computer networks, cyber Security, Block Chain technologies etc. Around 860 training/workshop proposals processed.

- 38 proposals were supported for conducting training programmes for ST Students in 14 districts in advanced technologies like Artificial Intelligence, Sensors, Data Science, Computer networks, cyber Security, Block Chain technologies.
- 33 proposals were supported for conducting Workshops for ST Students in 12 districts in advanced technologies like Artificial Intelligence, Sensors, Data Science, Computer networks, cyber Security, Block Chain technologies.
- For building ICPS technology awareness at School level especially at rural and remote areas, around 11,500 schools was initiated covering 115 aspirational districts across the country. Each districts have got 100 schools and each school will cover around 300 students studying in class 6 to 8 in Government Middle Schools in all the 115 Aspirational Districts. Two teachers from each of the 100 schools of each District will be trained about the emerging technologies. Hence, in total, 3450000 (i.e. 115 X 100 X 300) students will be trained in 115 aspiration districts of India.

2.7.2 National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS)

Union Cabinet on 6th December, 2018 has approved the launching of NM-ICPS to be implemented by DST at a total outlay of Rs 3660 crore for a period of five years.

Background

CPS and its associated technologies, like Artificial Intelligence (AI), Internet of Things (IoT), Machine Learning (ML), Deep Learning (DP), Big Data Analytics, Robotics, Quantum Computing, Quantum Communication, Quantum encryption (Quantum Key Distribution), Data Science & Predictive analytics, Cyber Security for physical infrastructure and other infrastructure, have pervaded and is playing a transformative role in almost every field of human endeavour in all most in all sectors. It has become imperative for government and industries to be prepared to adopt these emerging and disruptive technologies in order to remain competitive, drive societal progress, generate employment, foster economic growth and to improve the overall quality of life and sustainability of the environment. The Mission will address the ever increasing technological requirements of the society and takes into account the international trends and road maps of leading countries.

Implementation strategy

The Mission will be implemented through 25 Hubs, i.e., 18 number of Technology Innovation Hubs (TIH) and 7 number of Sectoral Application Hubs (SAH). After one year, based on performance, 4 out of these 25 hubs will be elevated to Technology Translation Research Parks (TTRPs). These Hubs will connect to Academics, Industry, Central Ministries and State Governments in developing solutions.

Expected Impact

CPS technologies provide a cutting edge to a Nation's scientific, engineering, and technological innovative capabilities; support other missions of the government, provide industrial and economic competitiveness and have truly become a Strategic Resource. The proposed Mission would act as an engine of growth that would benefit national initiatives in health, education, energy, environment, agriculture, strategic cum security, and industrial sectors, Industry 4.0, SMART Cities, Sustainable Development Goals (SDGs) etc. The job opportunities will be enhanced through the Mission by imparting advanced skills and generating skilled manpower as per the requirement of the industry/ society.

Expected Outcomes/Targets of the Mission

1. To promote and foster R&D in Cyber-Physical Systems (CPS) and related areas like Data Science (DS), Internet of Things (IoT), Cyber Security and quantum communication.
2. To develop technologies, prototypes and demonstrate associated applications pertaining to national priorities.
3. To enhance high-end researchers base, Human Resource Development (HRD) in these emerging areas.
4. To establish and strengthen the international collaborative research for cross-fertilization of ideas.
5. To enhance core competencies, capacity building and training to nurture innovation and Start-up ecosystem.
6. To set up world-class interdisciplinary collaboration centers of excellence in several academic institutions around the country, with a substantial amount of funding to enable them to achieve significant breakthroughs.
7. To involve Government and Industry R&D labs as partners in the collaboration centers. Incentivise private participation to encourage professional execution and management of pilot scale research projects.
8. To set mission mode application goals and foundational themes for excellence for different centers. Set up CPS test beds at various centers.
9. To tie up with incubation centers and accelerators to foster close collaboration with entrepreneurship eco-system.
10. To address some of the National issues and development of sector-specific solutions.
11. New knowledge generation, Start-ups, Dedicated translational centers, Generation of pool of trainers, Scaling up of CPS activity, Acceptability of CPS, Delivery of skilled human

resource, Start-up culture enhancement, Scaling up of CPS in various areas, Academic-Industry interactions etc.

Current Status and progress: Following tasks related to implementation of NM-ICPS has been accomplished/initiated:

1. Mission Governing Board (MGB), Scientific Advisory Committee (SAC) and Inter-Ministerial Coordination Committee (IMCC) members have been finalized.
2. School awareness programme on ICPS technologies has been started.
3. To evolve Request for Proposals (RFP) framework, discussions initiated with stakeholders.
4. 1st meeting of the Mission Governing Body (MGB) was held on 11th September 2019 and 2nd meeting was held on 12th December 2019.
5. 1st Meeting of Scientific Advisory Committee (SAC) Meeting was held on 10th December, 2019.
6. Criteria for selection of Host Institutes for the establishment of hubs have been finalized.
7. Call for proposal has been issued for selection of Host Institutes for creating Hubs and TTRP's
8. A working Group has been constituted which will act as think-tank for the Mission for holistic advice on all issues relating to corporate affairs and impact, corporate functioning.
9. It is expected that by the end of this Financial Year, Hubs will be Set-up.

INNOVATION TECHNOLOGY DEVELOPMENT AND DEPLOYMENT

3.1 Technology Development Programme

The Technology Development Programmes (TDP) aims to convert proof-of-concepts for technologies/ techniques/ processes/products into advance prototypes for validation and demonstration in field settings. The main objectives of the program include:

- Support R&D for development of innovative technologies in identified areas.
- Promote application of advanced technology for improving the performance and value addition to existing technology.
- Capacity building in the area of technology development in terms of human resource and infra-structure.

All the components under TDP are aligned to National priorities and ongoing National programmes.

S No	Sub-scheme	Number of projects sanctioned
1	Advanced Manufacturing Technologies (AMT)	28
2	Biomedical Device and Technology Development Program (BDTD)	33
3	Device Development Program (DDP)	15
4	Technology Development Program (TDP)	07
5	Waste Management Technologies (WMT)	01
6	Science and Heritage Research Initiative (SHRI)	20

Science and Heritage Research Initiative (SHRI): Brainstorming meeting was organized during September 29-30, 2019 at Institute of Technology (IIT) Delhi for Identification of areas for next call of SHRI. More than 40 experts participated and suggested to create Centres of Excellence to nurture this important area.

Technology Mission on Indian Railways (TMIR) is a consortium of Ministry of Railways, Ministry of Human Resource Development, Ministry of Science and Technology and Ministry of Industries on an investment sharing model for taking up identified railway projects for

applied research and use on Indian Railways. Under TMIR, DST has sanctioned the project entitled, “Pilot Project on Development and Implementation of Industry 4.0 Protocols for Rail-Coach Design & Manufacturing at Modern Coach Factory, Raebareli” to IIT Kanpur, RDSO Lucknow & MCF Raebareli with an objective to develop and implement Industry 4.0 protocols for rail coach design and manufacturing processes for improved productivity and process flexibilities.

Technology Enabling Centres (TEC) have been established in the Universities to bridge the gap between technology development and incubation activity and enable the investigators to pursue applied research involving stakeholders like industry, society and local government. Nine TECs and two satellite centres have been established in the universities across the country.

Hubs for Development of Biomedical Devices

1. National Hub for Healthcare Instrumentation Development (NHHID) at Anna University: NHHID, in 2019, transferred the technology for three prototypes (Mass Screening Gadget for Ophthalmic Lesions, Hystero Electrical Activity Mapping Device & RFID based Infant Theft Prevention System) and automated its Antibiogram device for commercialization through another programme. One-of-its-kind Testing and Calibration Centre has now served more than 250 hospitals and attracted prospective investors for replicating the facility under NHHID banner. Among nine clinician-driven medical device projects in the current phase addressing unmet device needs of India, three (Instrument for Transosseous Repair, Real Time Urinometer & Web-based Audiometer) have reached the validation stage within a year. Networking with various facilities and agencies enabling MSMEs to commercialize indigenous medical devices, partnering with Medica - the largest medical equipment expo, and newspaper coverage of its inventions and innovations are promoting its cause and attracting new stakeholders to expand its activities and scope.

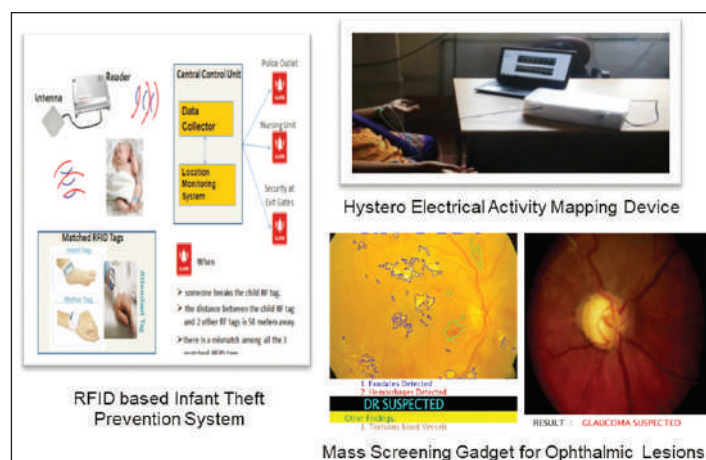


Fig. Technologies transferred to industry by NHHID

2. Biomedical Instruments/Devices Hub- A Centre for Innovation, Design and Testing by Post Graduate Institute of Medical Education and Research Chandigarh (PGIMER), Chandigarh

The Biomedical hub based at PGIMER, Chandigarh is promoting indigenous development & validation of biomedical devices & instruments. Besides, the Hub is working to bring the promoters, the investors, Investment committee, innovators and other partners together to expedite the idea-to-product-development process. The Hub further aims towards in-house testing and calibration of other conventional devices used in a hospital setting like infusion pumps, defibrillators, ventilator, patient monitors, X-ray machines, Operation Theatre Lights, and related instruments, ECG, Pulse Oximeter among others. Individually, patent search services, patent filing, office action among others are practiced under the shadow of the BID-Hub, PGIMER, Chandigarh.

The prototypes of “Anaesthesia Robot”: the device that aims towards automatic anesthesia delivery, thereby assisting the clinicians, especially in the high-pressure and high load situations; IV-ALERT- the “Low-Cost indigenous Alarm system for Monitoring of Intravenous Infusion”, laryngoscope for the laryngoscopy training of medical professionals and AIMS: Anesthesia Information Management System are under clinical testing.



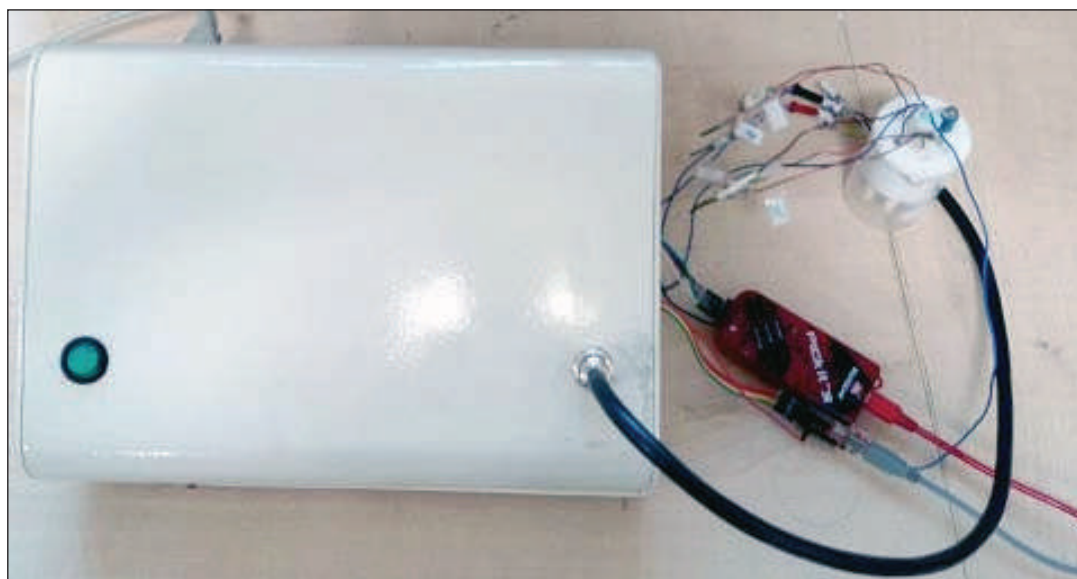
Fig. Technologies Developed by Biomedical Instruments/Devices Hub- PGIMER

Around 1000 project proposals were received during 2019-20 under various sub schemes of Technology Development Program and 115 new projects were sanctioned after stringent systematic evaluation by Expert Advisory Committees. 30 projects were successfully completed and some leading demonstrable technologies are as follows:

1. Potentiostat system for general purpose electrochemical applications by Jadavpur University, Kolkata, West Bengal

The potentiostat is one of the most widely used device used for electrochemical characterization. The voltage applied at the working electrode is measured and controlled with respect to the applied voltage. Specifications of the developed system are as follows:

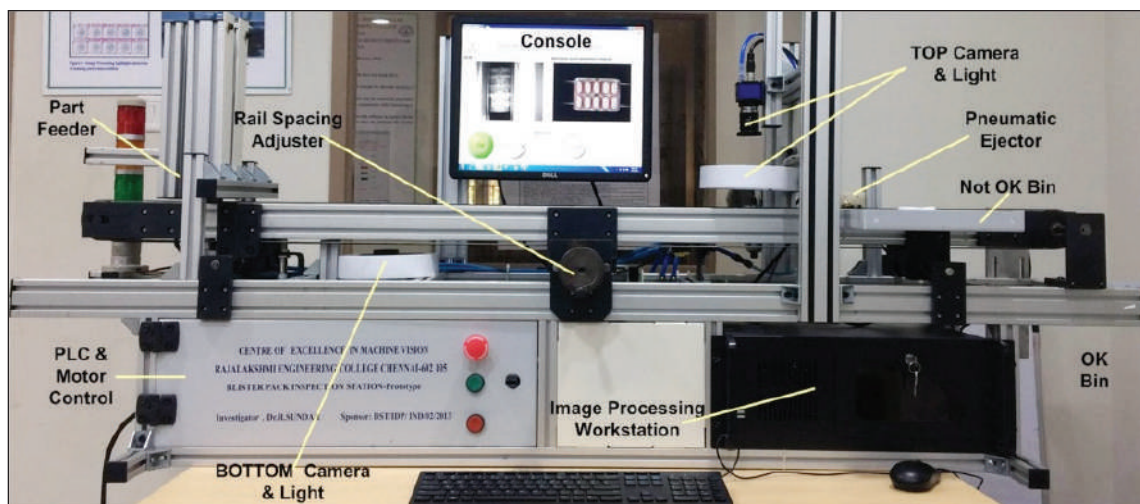
Feature description	Specification
Compliance voltage	$\pm 10V$
Current range	Four software selectable current ranges: (i) 10 nA - 100nA (ii) 100 nA - 1 μ A (iii) 1 μ A - 1mA (iv) 1 mA - 10 mA
Resolution of AD Converter	16 Bits
Resolution of DA Converter	16 Bits
Analysis supported	Pulse Voltammetry Normal Pulse Voltammetry Differential Pulse Voltammetry
Bandwidth	50 Hz



The developed Potentiostat instrument

2. Machine-Vision based Blister-pack inspection Station for Pharmaceutical Industries by Rajalakshmi Engineering College, Chennai, Tamilnadu

A customizable table-top inspection station has been developed with dual cameras and illumination system to enable capture of both sides of blister-packed tablets. An innovative conveyor system has been developed with mechanically adjustable dual conveyors that can be easily configured for different blister-pack dimensions while permitting simultaneous view of both sides of the blister pack. The inspection station provides turn-key solution with customizable software and image processing functions that may be tuned to manufacturers' quality process.



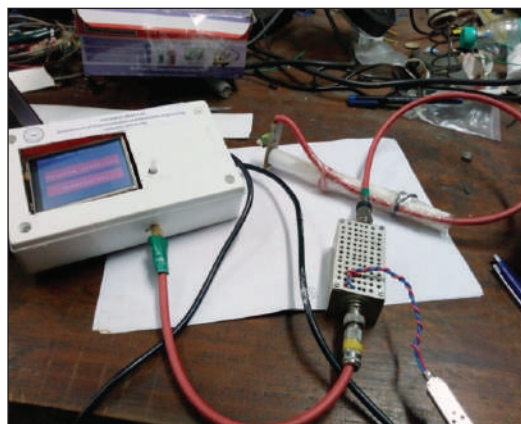
Blister-pack Inspection station

3. Development of QCM gas sensors for quality monitoring of agro products by Jadavpur University, Kolkata, West Bengal

QCM sensors are developed to detect important volatile components of black tea viz. linalool, geraniol and methyl salicylate; and mango tea viz. 3- Carene, β - Myrcene, β -Caryophyllene and Ocimene, respectively. A prototype of QCM sensor based electronic nose and thickness monitor instrument for thin film coating unit has been developed.



Developed Electronic Nose

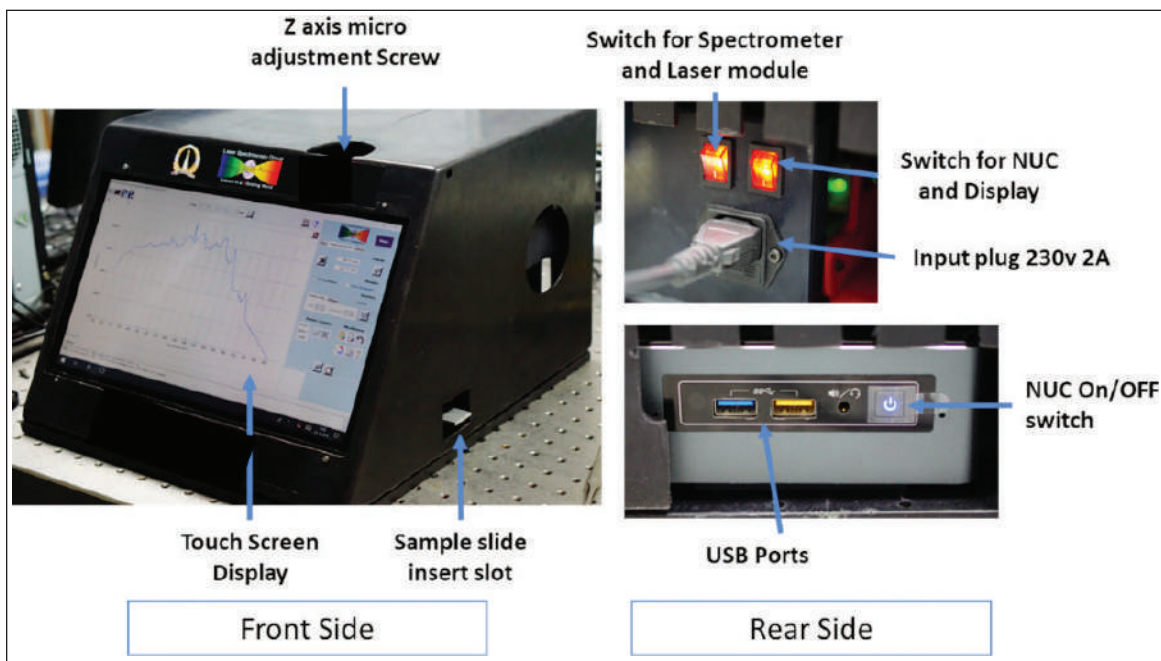


QCM sensor based Thickness Monitor

4. Design and Development of Portable Raman Spectrometer by Indian Institute of Science, Bangalore, Karnataka

A prototype of Raman spectrometer with microscope set up along with an in house software

to acquire, pre-process and analyse the Raman spectrum is developed and tested successfully. We obtained very good signal to noise ratio using the novel optical set up Based on UMARS technology. The set up was used to obtain Raman signals from biological samples such as bacteria, biomolecules etc. This technology is ready to transfer and has lot of potential in various fields such as pharmaceuticals, biomedical diagnostics, nanotechnology and material research to name a few.



Prototype of portable Raman spectrometer with microscope set up

5. Electric-Field Assisted Lithography and Direct Patterning of Standalone Structures at Multiple Length-Scales by Indian Institute of Science, Bangalore, Karnataka

This work aims to use electric current of high densities for creating standalone micro- and nano-scale structures, which are difficult to create using traditional cleanroom tools, and develop a prototype for direct patterning at micro- and nano-scale. While these goals have been accomplished, as shown in Figures 1 and 2, new insights into instabilities in the electric current induced flow of liquid metals have been obtained, whose continuum mechanics based treatment is currently being explored. The role of ambient conditions, including gaseous composition, vacuum level, etc. and pattern writing parameters, such as tip diameter, tip force, etc., in electric field induced etching of thin Cr film have also been successfully determined.

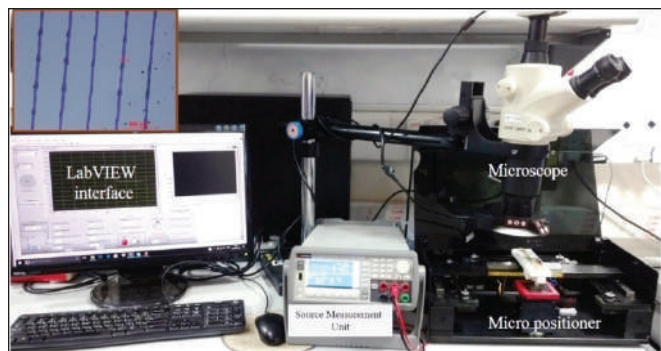


Fig. A prototype designed and fabricated under this project for creating patterns in metal film (Cr) using pointy electrode. As the cathode tip is traversed on the metal film, it etches away the metal film, thereby creating a pattern, as shown in the inset, which can later be transferred to any other material using conventional thin film deposition techniques.

6. Low Cost Air Conditioner Efficiency Meter (ACE Meter) by Central Scientific Instruments Organisation, Chandigarh

ACE Meter has been designed to evaluate the running performance of window air conditioners installed in residential and commercial establishments by logging basic physical and electrical parameters of air-conditioner installed. It is a tool for technician for estimating the efficiency of air-conditioner unit and to suggest various options like Maintenance, Retrofit, etc. for Energy Management in Building Management Systems. Technology developed on ACE Meter was transferred to M/s. Harivansh Consulting OPC Pvt. Ltd., Lucknow on 5th August 2019

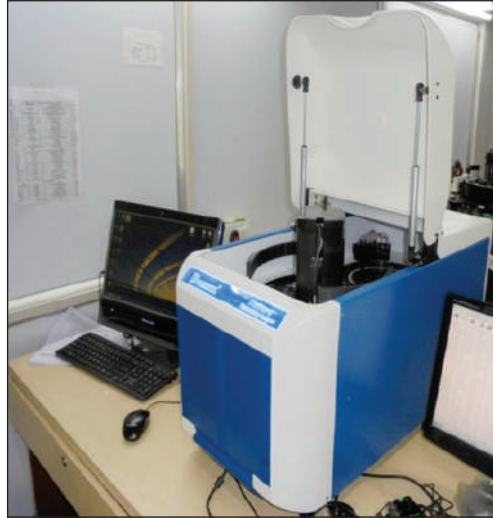


Air Conditioner Efficiency Meter (ACE Meter)

7. Automatic Multi-Parameter Soil testing Device with Online Data Display by Indian Institute of Technology, Bombay, Maharashtra

The soil nutrient testing capabilities need a multi-fold enhancement. With this in view, our project aimed at developing an automated soil testing system which is laboratory based and relies on the proven techniques of the chemical methods that are employed for soil testing. The design and fabrication of the instrument for automated soil nutrient testing has been done with the help of our industry partner, M/s Robonik India Pvt. Ltd, Navi Mumbai, and has been named as 'AthoraSOIL'. The proof of concept for detection of Carbon, Potash, Phosphorous, Sulphate, Chloride, Iron, Zinc, Copper, Manganese and Boron

through colorimetric soil testing protocols were implemented on AutoraSOIL by employing Ferticheck™.



AutoraSOIL along with the computer interface

8. Bioelectric toilet: A novel approach for treatment of human waste and generating onsite electricity for lighting toilets by Indian Institute of Technology, Kharagpur, West Bengal

Bioelectric toilet (BT) is a decentralized sanitary wastewater treatment system, where reuse of treated water with suitable disinfection significantly reduces fresh water consumption. Bioelectrochemical oxidation of biodegradable organics generates electrical energy, which can be stored into supercapacitors and used for illumination of toilet surroundings. Less sludge generation is another key feature of BT and dried sludge can be used as manure. Odour problem near the toilet is eliminated in this system. Six articles in international journals are published and a provisional patent is filled from this project. Research outcome of this project received Swachhathon 1.0 and GYTI 2018 awards.



Established bioelectric toilet at IIT Kharagpur

9. Electrostatic Dust Mitigation and Smog Control Device Multi-Functional High Range Electrostatic Sprayer by Central Scientific Instruments Organisation, Chandigarh

CSIR-CSIO, Chandigarh has come up with Electrostatic Dust Mitigation and Environment Protection device which is very efficient and effective in addressing the major pollutants PM10 and PM2.5 (suspended particles) in the smog. This technology uses electrostatic field to generate charged spray droplets which combine with oppositely charged dust and smog particles and settle down onto the ground very efficiently and effectively. It will be transferred to industry i.e. M/s. Cloud Tech Pvt. Ltd, Yamunanagar, Haryana.



Electrostatic Dust Mitigation and Environment Protection Device

10. Air purification device for harmful pollutant and VOC sequestration: economical and reusable at Institute of Nano Science and Technology (INST), Mohali, Punjab

This air-purification device can effectively remove particulate matter, VOC and ammonia. It has reusable filters which uses nanomaterial based ink for filter regeneration and also removes ammonia apart from particulate matter and VOC. The application sites include household air purification; animal house; hospitals; poultry farms at high altitudes; fertilizer/chemical industries; chemical laboratories. It is easily scalable for higher volume. Patent Filing and technology transfer is in process.



Air purification device

12. An instrument for analyzing performance of fire protective clothing and determining second degree burn time for skin by Indian Institute of Technology, Hauz Khas, New Delhi

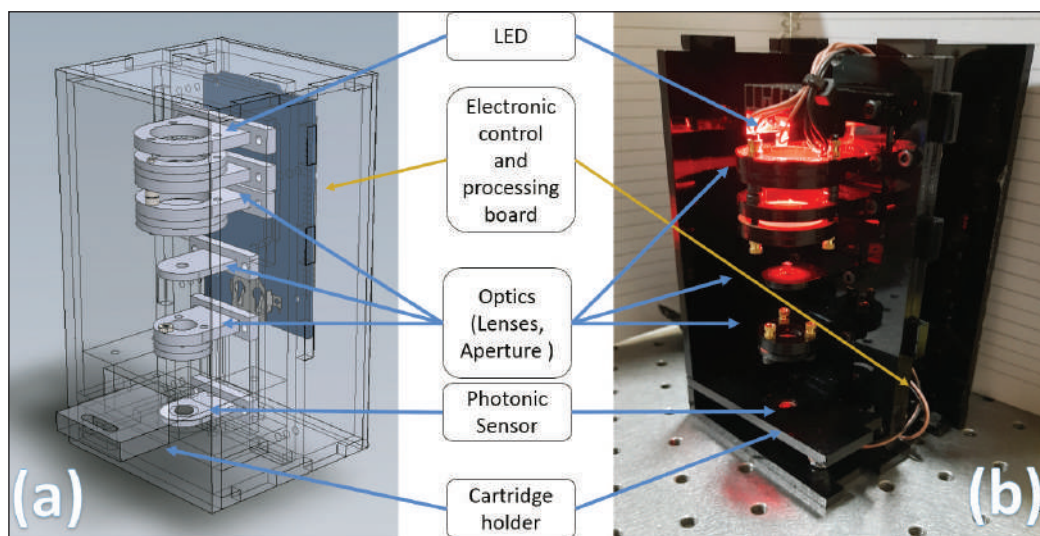
Apparatus is provided with facility to simulate radiative heat, flame and combined convective-radiative exposures and can measure heat transmitted through the fabric mounted vertically on the exposed side of the chamber. Thermocouple readings are integrated with a finite-difference based computer code to determine depth of skin burn and second degree burn time accurately. Prototype of Vertical TPP Tester is developed to simulate testing conditions more closely to reality in case of structural fire outbreak. This equipment can be used for testing fire protective clothing/fabrics and R&D purpose and in aerospace and building structure industry. Patent has been filed and Agreement of Non-Disclosure is signed between IITD and Texlab Industries Pvt Ltd, Ahmedabad for technology transfer.



Photograph of the equipment

11. Handheld chemical-diagnostic device with replaceable cartridges for the estimation of Creatinine and pH by Indian Institute of Science, Bangalore, Karnataka

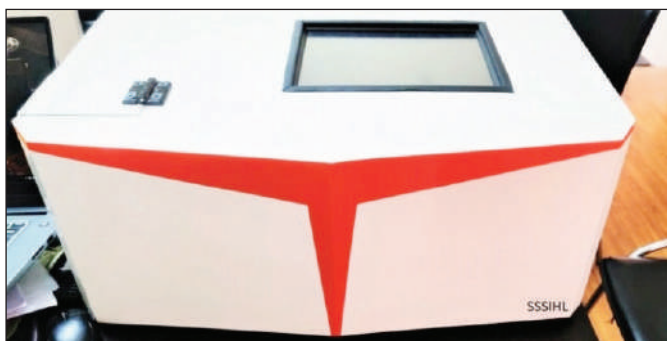
A portable device has been developed to estimate the pH and quantify creatinine in blood and urine using a single disposable cartridge. pH is a very important clinical parameter which helps in predicting abnormality based on basicity or acidity of urine. Similarly, Creatinine is a metabolic waste and estimation of its concentration in blood is used to diagnose renal function disorders. The developed device is capable of both these measurements in only a few minutes. It works via opto-electronic sensing and is easy to use due to the simplicity offered by a disposable, reagent pre-loaded cartridge.



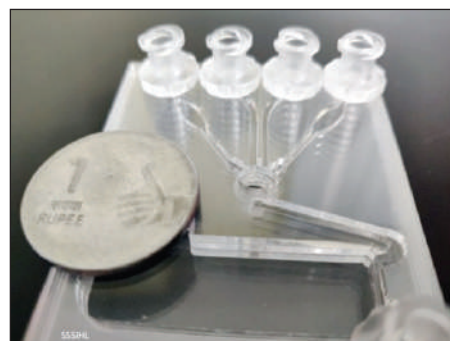
(a) CAD design of the device and (b) internal view of the fabricated prototype, depicting the opto-electronic system and the cartridge holder.

12. Benchtop Device for Cardiac Troponin T Quantification by Sri Sathya sai Institute of Higher Learning, Prasanthi Nilayam Campus, Anantapur, Andhra Pradesh

The automated portable benchtop device is based on state-of-the-art plasmonic technology that will be able to detect cardiac Troponin T in human serum at very low concentrations ($<50\text{pg/mL}$) in <30 minutes, thus facilitating quicker diagnosis of heart attack. Figure 1 & 2 show the prototype benchtop device named "Throb-1" and the microfluidic chip used to detect cardiac Troponin T. The compact size of this device will enable its usage in ambulances, mobile hospitals and rural healthcare centers. This low-cost device has comparable sensitivity and selectivity to conventional devices used in healthcare sector.



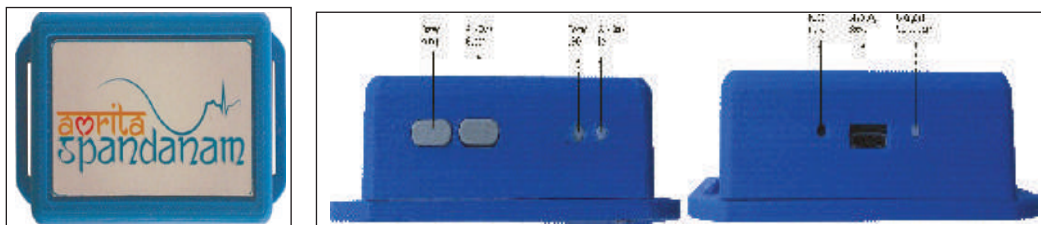
Throb-1: A benchtop device for detection of Cardiac Troponin T



Microfluidic chip for processing of human serum in Throb-1

13. Remote ECG Monitoring system for postoperative and high-risk cardiac patients by Amrita Vishwa Vidyapeetham Kollam, Kerala

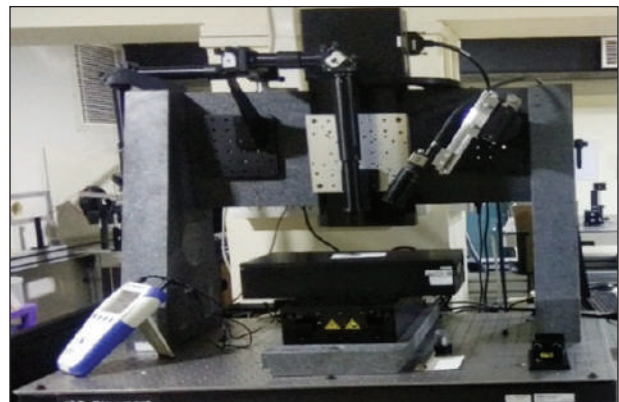
A USB rechargeable 3-lead wearable continuous ECG monitoring device that can be used for arrhythmia and ischemia detection was successfully developed. This device transmits the live ECG to the user's mobile phone as well as to cloud for further analysis. We integrated this device with a decision support system by providing live activity tagging of ECG and primary disease detection algorithms in the mobile device itself. Field deployment pilot studies were successfully completed on 101 patients in two remote village hospitals in Kerala (Wayanad and Kollam districts) and Amrita Institute of Medical Sciences, Cochin, Kerala. Two patents for this device and technology were filed and Technology was transferred to Amrita Technologies Pvt. Ltd. for further production and commercialization.



The 3-lead ECG device, top view, and side views.

14. FemtoSecond Pulse Ultraprecision micromachining system for Soft- and Hard-materials - Indian Institute of Technology Madras, Chennai, Tamilnadu

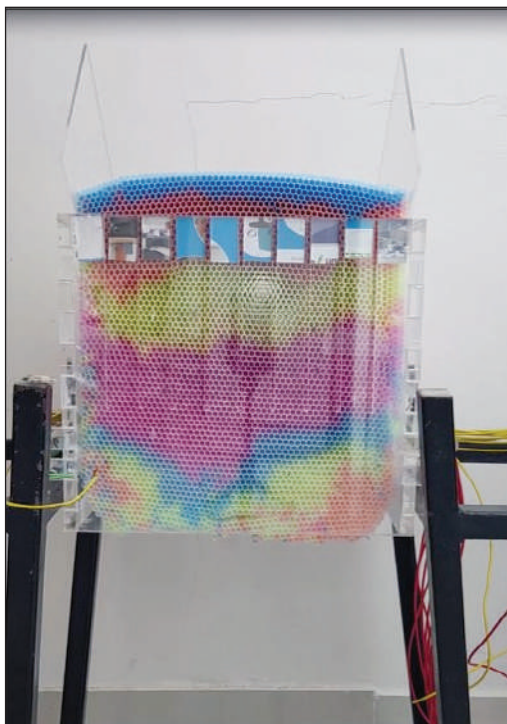
Microstructuring of materials plays a crucial role in modern manufacturing and fabrication at the cutting-edge of technology. Though it is well-established that laser based micro-structuring or -machining employing a focused laser beam as the 'tool' has unsurpassed capabilities, the limit of precision or ultra-precision can only be explored using ultrashort laser pulses. We have developed in-house a relatively inexpensive micromachining end-station using the beam from an existing laser system to perform ultra-precision micro- and sub-micro-structuring at high speed. Figure 1 below depicts the complete automated end-station at IIT-Madras which has been used for various technological developments by in-house faculty as well as local institutions like SSN University, SRM University, VIT and others in Chennai.



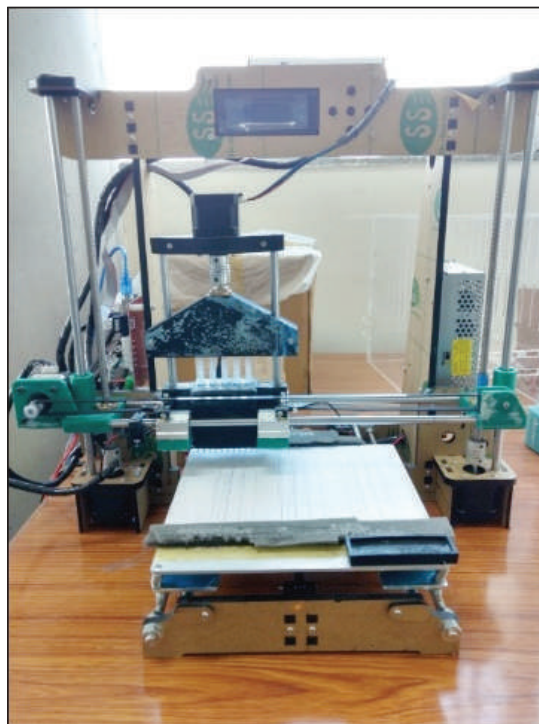
(a) The complete setup of Micro-Machining Workstation with enclosure in IITM and (b) The inside view of the working area with IDS camera

15. Development of Low Frequency Noise Control Sheet Absorber: A Biomimetic Solution by Indian Institute of Technology Hyderabad, Telangana

Natural honeybee hives have good acoustic properties in the low-frequency range. as an engineering solution. Accordingly, a design methodology has been developed mimicking this phenomenon; this has been validated with the help of narrow tube experiments on the small size sample. Subsequently, the fabrication methodology to realize a large sample (dimensions of 0.3m x 0.3m x 0.017m) was developed. Two different approaches and their respective prototype machines catering to two different kind of materials were developed for making the large samples: (1) one prototype is for paper honeycomb based on indexed HOBE process, and (2) another prototype machine is for polymer honeycomb structure based on hot wire technique. A test facility to measure the absorption coefficient of large samples has also been established as part this work.



Tubular Polypropylene



Paper honeycomb

Prototype Machines for large sample fabrication

16. Rejuvenation of discarded Reverse Osmosis membrane elements by Central Salt and Marine chemical research Institute (CSIR-CSMCRI), Bhavnagar, Gujarat

The process was developed to convert discarded (end-of-life) membrane elements from Seawater Reverse Osmosis into useful brackish water Reverse osmosis membrane elements by restoring the flow performance of membrane elements with a modest decline in salt rejection. Such membrane elements can find applications in low salinity brackish water desalination applications. The membrane elements with low salt rejection can be converted to ultrafiltration like membrane elements. Discarded membrane elements should not have any prior mechanical damage and performance enhancement will depend on the prior performance and the extent of fouling on the membrane. The image below shows the pilot plant to rejuvenate the discarded membrane elements at Experimental salt farm CSMCRI Bhavnagar by a DST sponsored project entitled "Value creation from solid waste: Discarded Reverse Osmosis membrane elements".



Membrane rejuvenation Pilot plant at Experimental salt farm, CSIR-CSMCRI Bhavnagar

17. Pilot studies on microwave conversion of eggshell into nanostructured hydroxyapatite for biomedical applications and to design and fabricate continuous flow microwave reactor for scaling up the process by Periyar University, Salem, Tamilnadu

Synthetic nanohydroxyapatite (nHAp) finds wide applications in biomedical field and other fields. The cost of commercial nHAp is high, as it depends upon the purity of the precursors and synthesis process utilized. Employing a strategy combining low cost calcium rich biogenic waste as calcium resource and a method with multifold enhanced reaction rate like microwave assisted synthesis may be suitable for producing HAp in large scale at economic cost. Large amount of eggshell waste generated from food processing industries and hatcheries is mostly disposed as landfills that creates environmental pollution. To switch over from small scale synthesis using batch process from microwave ovens and small sized reactors to large scale, a continuous flow microwave reactor is designed and fabricated. The product obtained with EDTA as the organic modifier is biocompatible mesoporous, thermally stable (up to 1100°C) and dispersible nanoparticles. In vitro and In vivo validation of the nHAp prepared evidenced the potential of the material for biomedical applications. This project is a green synthesis process for recycling a biowaste from bench to bedside.

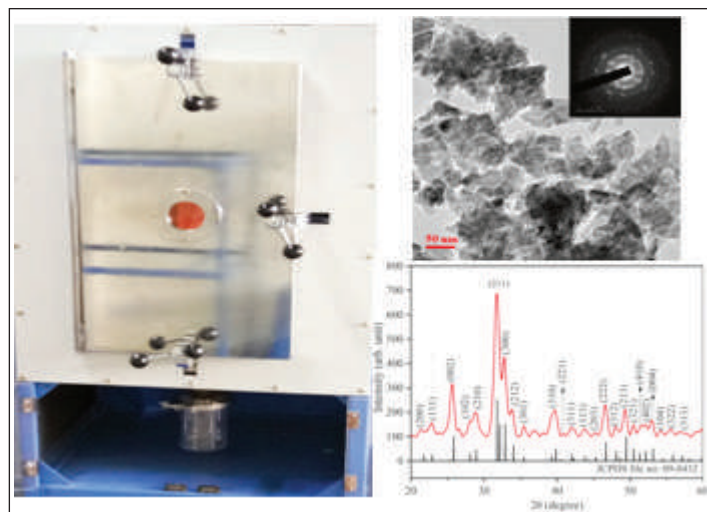


Fig. Fabricated Continuous flow microwave reactor and TEM image with SAED pattern & XRD pattern of the nHAp derived by it from eggshell.

18. Integrated and sustainable sewage and organic solid waste treatment for decentralized applications by CSIR-Indian Institute of Chemical Technology (IICT), Hyderabad, Telangana

A pilot plant for the integrated treatment of sewage (50-100 m³/day) and organic solid waste (200-250 kg/day) is established at CSIR-IICT campus, Hyderabad for demonstrating the technology to stake holders. The aim of the project is treatment of sewage by Aerobic Moving Bed Bioreactor (MBBR) + side stream NF followed by treatment of organic solid waste and sewage sludge in high rate anaerobic gas lift reactor (AGR). The products from the plant, biogas and water could be used purposefully making the technology sustainable. The technology developed by CSIR-IICT (NF and AGR) is useful for decentralized applications.



High rate Biomethanation of organic solid waste based on anaerobic gas lift reactor (AGR)



Aerobic Moving Bed Bioreactor (MBBR) + side stream NF integrated with anaerobic gas lift reactor (AGR)

3.2 Technology Missions Division (CERI & WTI)

3.2.1 Clean Energy Research Initiative

Clean Energy Research Initiative (CERI) aims to develop national capacities and capabilities in developing research led competitive and cost effective clean energy and energy efficiency options for power and non-power applications. The areas of research are identified through stakeholder consultation based on national needs. The research spectrum covers entire gamut of clean energy viz. smart grid, off grid, energy storage, building energy efficiency, cleaner fuels, clean coal and energy materials. It supports both upstream end of research where knowledge, more advanced than the current practice in the industry finds a space. It also envisages to successively enhance Technology Readiness Level (TRL) of promising options in partnership with industries and other stakeholders. The programme has close linkages with concerned line ministries and stakeholders for identification of research needs. During the year 2019-20, several new dimensions were added to the programme to accelerate the pace of clean innovations to meet national needs, which are as under:

1. **Mission Innovation:** Mission Innovation (MI) is a global initiative of 25 countries to dramatically accelerate global clean energy innovation. Participating nations have committed to double their governments' clean energy research and development (R&D) investments over five years, while encouraging greater levels of private sector investment in transformative clean energy technologies.

1.1 Mission Innovation Challenge #1: Smart Grids:

The IC#1 on smart grids is co-led by China, India and Italy. The Challenge targets innovation and deployment of reliable, efficient and affordable smart grids technologies at regional, distribution and micro-grids levels in various geographical areas to achieve the ability to accommodate 100% renewable based energy sources in power grids. In addition, IC#1 also focuses on the aspects related to cross innovation.

- Fifth Mission Innovation Challenge (IC#1) international workshop was held in Vancouver, Canada from 30th -31st May, 2019. Thirteen IC1 countries represented at the workshop together with participation from industry, academia and international organizations (such as ISGAN). During the workshop 'IC1 Country Report 2019 on strategies, trends and activities' on jointly identified research topics of 17 MI IC1 countries (CR2019) has been released and Smart Grids Innovation Accelerator (SGIA) platform was launched.
- Deliberations with MI member countries led to Identification of following six Program-of-Work (PoWs) (i) Storage Integration (ii) Demand Response (iii) Electricity Highways (iv) Flexibility Options (v) New Grid Control Architectures, and (vi) Power Electronics. India is taking lead on two areas viz., Flexibility options and Electricity Highways and also actively participating in other four PoWs. DST took initiative to

create six groups each for the afore-mentioned PoWs. Rigorously followed-up, and coordinated with all six groups; enabled in organizing regular meetings, identifying the gap areas, preparation of status reports ensuring elimination of duplicity of research work, integration of different research activities carried out by the different institutions to strengthen the indigenous capability of the country. This initiative is a first-of-its-kind among all MI member countries.

- The UK-India Joint Virtual Clean Energy Centre (JVCEC) Conference was held on 12-14 September 2019 in Jaipur, India. Attendees included some 60 Indian academics and 20 UK academics and researchers. The conference brought together the leading academics in the Clean Energy field from the UK and India and enabled valuable discussions on key challenges and collaborative work in the integration of solar PV, energy storage and electrical networks. Presentations of ongoing collaborations between UK and Indian academics within the virtual centres namely JUICE, IUCERCE and UKICERI, helped strengthen the existing links and identify emerging possibilities for collaboration between the two countries in Clean Energy.
- A joint meeting cum workshop was held on December 18-19, 2019 at New Delhi, wherein Indian and US academic institutions and Industry participated and presented the work done on US-India collaborative for smart distribution System with Storage under the Indo-US Joint Clean Energy Research and Development Centre (JCERDC) programme.

1.2 Mission Innovation Challenge #7: Affordable Heating and Cooling of Buildings:

The objective of this challenge is to make low-carbon heating and cooling affordable for everyone. Under IC 7 six thrust areas have been identified in consultation with MI member countries for Research, Development and Demonstration (RDD). DST is leading one of the thrust area viz. Thermal Comfort and actively participating in other five thrust areas.

- An inter-ministerial workshop on “R&D and Innovation in Cooling and Refrigeration” was jointly organised by DST, Ozone Cell, Ministry of Environment, Forest and Climate Change (MoEFCC) and Bureau of Energy Efficiency, Ministry of Power at India Habitat Centre, New Delhi on 6th May 2019. This is a first-of-its-kind inter-ministerial collaboration between Ministry of Science and Technology; Ministry of Environment, Forest & Climate change and Ministry of Power to promote innovation in low energy cooling technologies and encourage participation in Global Cooling Prize, which is a global competition. The event witnessed participation of 58 delegates- 10 delegates representing 5 academia / R&D labs; 28 delegates representing 12 leading industries.
- Department of Science and Technology (DST), Government of India along with UK, European commission and UAE organised a deep drive workshop on Mission Innovation Challenge 7: Affordable Heating and Cooling of Buildings on 6th November 2019 at IIT

Delhi, focusing on thermal comfort. Stakeholders from 5 MI member and participant countries, industry leaders, representatives from administrative bodies, policy agencies, academic and research professionals attended the workshop. The main output of the workshop is a strategic roadmap to accelerate research and development in thermal comfort innovation and identifying cross cutting issues and future research needs.

Global Cooling Prize (GCP)

Department of Science & Technology (DST), Government of India and Rocky Mountain Institute (RMI), USA jointly initiated first-of-its-kind global competition-Global Cooling Prize under the umbrella of Mission Innovation Challenge #7 to spur development of a residential cooling solution that has at least five times (5x) less climate impact than today's standard products. The objective of this competition is to develop a cooling technology that requires radically less energy to operate, utilizes refrigerants with no ozone depletion potential and with low global warming potential, and has the potential to be cost-effective at scale. The Prize has drawn on global talent to design a cooling solution for a typical housing unit in a highly populous city in India.

Hon'ble Union Minister for Science and Technology, Earth Sciences and Health & Family Welfare announced the Global Cooling Prize Award at Global Cooling Prize Finalist Award Ceremony (Fig. 1) on 15th November 2019, at New Delhi. There was a overwhelming response across the globe for this competition. Out of 139 applications received, 8 finalists were announced of which 2 finalists are from India.

The finalists are Godrej and Boyce Mfg. Co. Ltd., and S&S Design Startup Solution Pvt. Ltd. - all two from India; M2 (Square) Thermal Solutions, Transaera Inc. and Kraton Corporation (in collaboration with IIT Bombay, Infosys and Porus Labs) - all three from the US; Gree Electric Appliances Inc. of Zhuhai, China; and Barocal Ltd of UK, Daikin Air Conditioning India Pvt. Ltd., from Japan. Each of these selected teams will develop and deliver two working prototypes of their cooling technology for ISEER and filed testing in India.



Figure 1. Global Cooling Prize Finalist Award Ceremony on 15th November 2019, at New Delhi

Dissemination of outcomes of DST supported projects

ACREX India, an International conference-cum-exhibition of Air-conditioning and Refrigeration and other home automation, was held during 28th February, 2019 to 2nd March, 2019. DST provided a platform for national and bi-lateral projects which were supported by DST to showcase their technology in the “ACREX India- 2019”. In order to connect these innovators with industry for exploration of commercialisation, this workshop served the purpose. The platform helps to promote GCP. Several AC manufacturers’ showed keen interest about the GCP competition and expressed their willingness to participate. This event witnessed a huge industry participation (about 400), and more than 10000 attendees.

2. Research & Development on Clean Coal Technologies:

Hon’ble Union Minister for Science & Technology, Earth Sciences and Health & Family Welfare Dr. Harsh Vardhan inaugurated the National Clean Coal Research & Development Centre (NCCRD) on 16th September, 2019 at IISc, Bangalore (Fig. 2). The aim of the centre is to address several critical R&D challenges towards development of clean coal technologies, in tandem with developing supercritical power plant technologies, both at the system level as well as development of materials.



Figure 2 Inauguration of the National Clean Coal Research & Development Centre (NCCRD) on at IISc, Bangalore

3. Research & Development on production and Utilization of Methanol & Di-Methyl Ether

DST supported a major development programme for production of Methanol from various input sources including Indian coal and, CO₂ from thermal plants, steel plants etc. The programme aims to include direct utilization of Methanol and DME as drop-in fuel in automobiles and fuel cell-based vehicles. DST supported a project to IIT Delhi and Thermax Limited, Pune for development of 1 tonne per day (TPD) capacity of pilot plant for methanol production (Fig. 3a). Hon’ble Member NITI Aayog, Dr. V.K. Saraswat

launched this project on 22nd February, 2019 at IIT Delhi. This project serves as a fine example of focused academic-industry interaction to address the challenges of sustainable energy solutions. Another project supported to BHEL, Hyderabad which aims to produce methanol having capacity of 0.1 TPD.

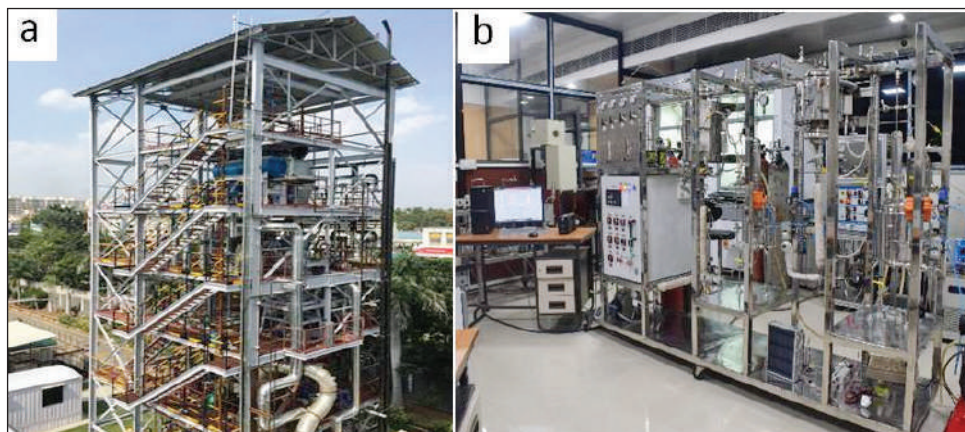


Figure 3. a) A photograph of the gasifier at Thermax RTIC, Pune
b) Membrane Reformer Test Rig

- Membrane Reformer test rig for methanol fuel cells (Fig. 3 b) provides the facility for both simultaneous and sequential integration of membrane with reforming reaction. It can accommodate 23 membrane tubes of 20 cm length, which is sufficient to produce 1 kW power supply.

4. Advanced Ultra Super Critical (AUSC) Thermal Power Plant -R&D Phase:

The mission programme progressed as per schedule. Two DST projects also made good progress. Highlight of the work are listed below:

- High Temperature Spin Test Rig (HTSTR) has been established in BHEL (R&D), Hyderabad for the design validation of 800MW steam turbine (Fig. 4). The test rig is capable of testing rotors upto 9000 kgs and sizes upto 1500 mm diameter and 1500 mm height, with a heating capacity upto 800 deg C and cooling by Nitrogen gas.



Figure 4 HTSTR with test rotor, BHEL, Hyderabad

5. Building Energy Efficiency

- Pilot test beds (Fig. 5) are constructed in Delhi and Bangalore to test the thermal and visual performance of Shade Smart. These are currently being tested for Shade Smart applicable for residential buildings.



Figure 5 Test beds

- The 2 TR prototype solar assisted cold storage (PSCS) system has been fabricated at NIT Tiruchirappalli to store the agriculture products like fruits and vegetables. In this system, the shelf life of fruits and vegetables can be increased by maintaining the temperature and humidity of the fruits and vegetables on recommended range of standards. Separate humidifier is fitted inside the cold room for maintaining the humidity. Controllers are used to govern the temperatures and humidity inside the cold room.

6. Materials for Energy Storage

Under DST supported 'High-Performance Graphene-Based Supercapacitor' project, IISER Pune has developed a process technology for generating functionalized graphene at low-cost for the development of graphene-based supercapacitors for energy storage to be fabricated at SPEL Pune. The cost of raw chemicals for the production of 1 gm of rGO is estimated to be less than Rs. 700 – much cheaper than the commercial rGO from reputed international chemical company. The team is also working for pilot-scale production of rGO at IISER Pune campus with DST Support for use in supercapacitor application.

Honourable Prime Minister Shri Narendra Modi during his visit to IISER Pune on December 8, 2019 witnessed this cutting edge technology presentation, took cognisance of this effort, and stressed on need for affordable clean energy solutions.

7. Solar Energy

The following are the major outcomes of the Research and Development work supported under Solar Energy domain:

7.1 Dual use of land for farmers using a combination of Solar Photovoltaic Panels and Agriculture - Agri-Voltaics

The science of Agri-voltaics aims to maximize a piece of land by combining solar

harvesting and crop growing, much like the science that applies in Agroforestry. The present innovative concept is that the Agrivoltaic systems (Fig. 6) can provide a good support to the farmers during the extreme conditions (natural or economical) as well as can produce electricity, which provide an additional source of income to farmers. The total agriculture land area of 37 x 17 meter has been used as the proof of the concept, to install the solar panels with a particular optimized design. The solar panels have been installed with the electric power generation of 10KW and 2KW. Here, the 2KW, power is used to run the solar water submersible pump.



Figure 6 Test Bed of Agri-voltaic farm at Amity University, Noida, Uttar Pradesh

7.2 Development of Solar Energy Operated Agricultural Machinery for Paddy Crop

A solar energy operated paddy thresher (Fig.7) is being developed. It comprised of a standalone solar photovoltaic system (SPV) to power the thresher with a storage unit. It was fitted with a maximum power point tracker, a DC to DC booster and a motor controller. The DC current obtained from suitable solar photovoltaic (SPV) system. Threshing was carried out at different peripheral speeds of the threshing cylinder of the wire-loop type thresher and the optimal speed at which desirable threshing quality was obtained was found out. For controlling the motor, a matching DC motor controller was also developed. According to the power requirement i.e. current and voltage during threshing, the thresher could be operated for nearly 2 hours without charging.



Figure 7. Field trials of the Agricultural machinery for paddy crops at IIT-Kharagpur

7.3 Development and Demonstration of High Energy Density Valve-Regulated Lead Acid (VRLA) Batteries

The scientific development made in the project addresses the issues of Sulfation and grid corrosion (Nanostructured materials and coatings have been developed to reduce sulfation, hydrogen evolution, subsequently improving charge acceptance, formation-efficiency. Further, Polypyrrole surface coatings on grids reduce grid corrosion.) An overall energy-density of 45 Wh kg^{-1} have been achieved.

7.4 Application of Ultra capacitor based Energy Storage as smart grid initiative for recuperation and reuse of energy in elevators for high rise buildings in smart cities

With the proliferation of multi-storied buildings in all major cities, and the expected infrastructure drive through the smart cities program in India, penetration and use of elevators are expected to grow significantly, and expected to constitute a significant share of overall building energy consumption. The system has been developed by Aartech solonics limited in collaboration with IIT Bombay. The Ultracapacitor Powered Lift (UPLIFT) system stores the regenerated energy in an Ultracapacitor bank and reuses it at the time of demand or during power failure. It also provides an uninterrupted supply of AC power for auxiliaries of the elevator such as doors, lights, sensors, controller etc. The major challenges addressed were to size and build a large Ultracapacitor module as per the application requirements with suitable industrial grade capabilities and to efficiently charge and discharge large amounts of power to and fro an ultracapacitor module using a bi-directional dc-dc converter with large operating range, high voltage gain and high efficiency and ensure performance is in a safe operating zone at all times. UPLIFT has been developed to the level of a product of Technology readiness level 7 and is being tested by professional's partners in lift installation. The technology is available for license to the potential users.

7.5 Design and fabrication of spectrally selective absorber coatings for high temperature solar thermal power applications

The direct method of harnessing solar energy is the solar thermal conversion using solar collectors. These collectors use spectrally selective absorber surface which has high absorptance (a) in the solar spectrum region ($0.3\text{-}2.5 \mu\text{m}$) and low thermal emissivity (ϵ) in the infrared spectrum region ($2.5\text{-}30 \mu\text{m}$). For solar thermal power generation, high-temperature absorber coatings (Fig.8) are used in concentrating solar power (CSP) systems. In addition to high absorptance, for CSP applications, low thermal emissivity is an important property. Requirements of a High Temperature Solar Absorber: High absorptance, $\alpha > 0.90$, Low thermal emissivity, $\epsilon < 0.10$, Long term stability at higher temperatures ($>450^\circ\text{C}$). In order to develop manufacturing capabilities of receiver tubes and other CSP technologies in the country, a composite spectrally selective absorber coatings on 5 inches long stainless steel tubes using a sputtering process. These coatings exhibit $a = 0.955$ and $\epsilon = 0.10$ on stainless steel substrates and are stable in vacuum for 200 h at 750°C and in air for 500 h at 350°C

under cyclic heating conditions. This would pave the path of indigenous development of absorber tubes require for collectors used in solar thermal power application.



Figure 8. Sputter Deposited Coatings for High- Temperature Solar Thermal Applications at NAL

7.6 Design and development of Smart Autonomous In-Service inspection and cleaning ground vehicle for large scale solar PV Farm

One of the main reasons for the poor output from solar farms is the dust deposition on solar panels. Different observations on effect of dust and other particles on solar panels states that the efficiency of solar farms will reduce drastically. To get the maximum output from solar panels, frequent cleaning is necessary. To resolve the problem of an electric vehicle mounted solar panel cleaning robot (Fig. 9) has been developed, which can be installed in any kind of solar farms without disturbing the existing structure. The entire system consists of two major parts – the cleaning unit and the ground vehicle. The cleaning unit is placed on the top portion of solar panel array and it moves above the solar panels in a horizontal path. The brush unit is hanged from the main cleaning unit with electric cable with load bearing capacity. The cleaning unit can be launched to the array of solar panels from the ground vehicle. The launching is achieved by two linear actuators which controls vertical and horizontal movement of launching unit. Few enterprises have shown interest in the development of the prototype and is keen to upscale it.



Figure 9. Photovoltaic Panel cleaning system working at solar Farm developed by PSG College of Technology

7.7 Development of Dye Sensitized Cells Module Fabrication Unit

By 2020, it is predicted to have around 50 billion connected smart devices in the internet of things (IoT) domain which will be powered by batteries. Considering a 3-year lifespan, there

will be more than 900 million battery replacements per year which eclipses the benefits of IoT sensors due to additional cost for monitoring and replacing these batteries. In addition, replacing the batteries/extending its life cycle can tremendously reduce the carbon foot print caused by its disposal. Conventional solar technologies may not be a suitable choice for indoor environments. This is where the unique advantages of dye sensitized cells (DSCs), most efficient third generation indoor light harvesting technology, become extremely important. By developing indoor light harvesting photovoltaic cells (Fig.10), self-powered sensors can be realized and the battery life can be extended. CSIR-NIIST with support of DST has successfully indigenously developed the entire equipment and optimized the fabrication process thereby developing international competency in this photovoltaic sector. More than 60 % cost reduction was successfully achieved through indigenization. The team has successfully demonstrated the production of 5cm×5cm, 10cm×10cm and 15cm×15cm DSC modules from the fabrication unit.

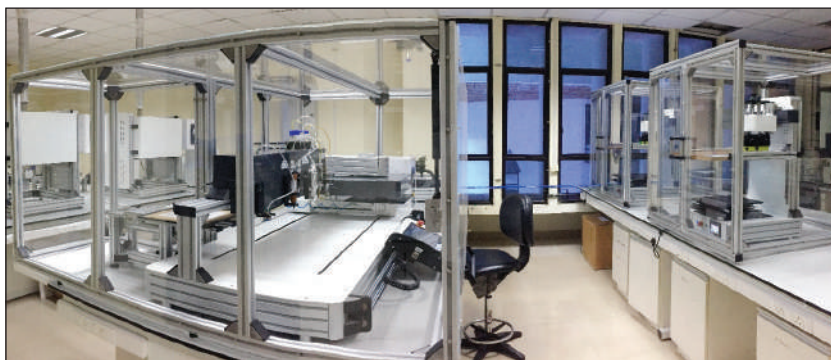


Figure 10. Indigenous DSSC Module Fabrication Facility at CSIR-NIIST

8. Other initiatives

- A Brainstorming Meeting on “Alternative fuels and Associated Automotive Technologies” was organized to develop R&D roadmap for Indian context at IIT-Delhi on 29.04.2019. About 30 Experts consisting of Academia, Industry, Industry Associations, Ministry of Petroleum, Department of Biotechnology, Bureau of Indian Standards participated in the discussion.
- On the eve of 150th Birth Anniversary of Mahatma Gandhi ji, to promote his ideals of independent rural villages a call inviting applications on “National Grand Challenge Awards for Designing User Friendly Smart Solar Cooking Solutions” was launched in October 2018. Applications received against the call were evaluated during this year. Dr. Ajay Chandak (Fig. 11a) has been nominated as Awardee under Small Community Cooking Category and Mr Vivek Kabra has been recommended for “Certificate of merit” for his contribution (Fig. 11b).

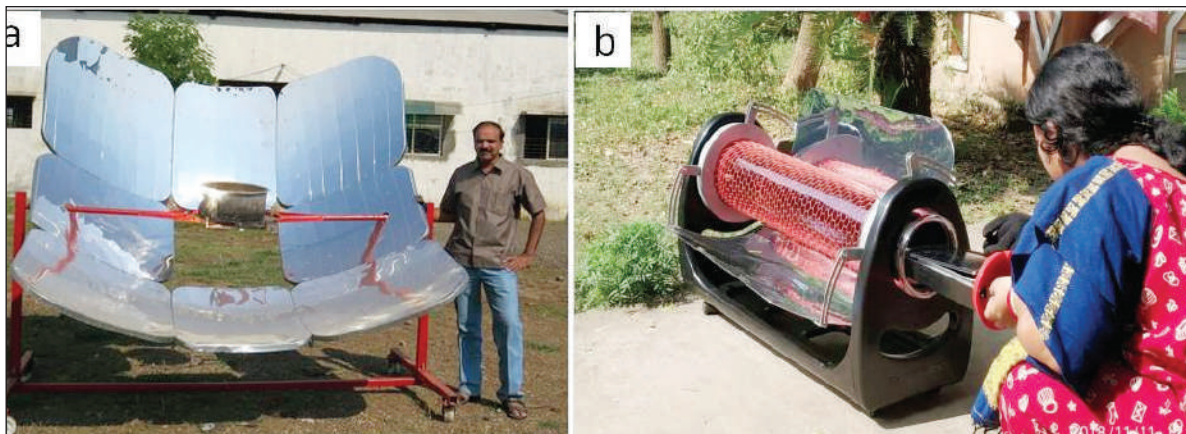


Figure 11. (a) Solar Concentrating Community Cooker with Square Segmented Reflector Dish developed by Dr Ajay Chandak, 'Suman Foundation' and (b) Tubular Solar Cooker developed by Mr. Vivek Kabra, Simplified Technologies.

- Mission Innovation Champions were announced at the 4th Mission Innovation Ministerial (MI-4) event held in Vancouver, Canada during 27-29th May 2019. Prof. Santi Pada Gon Chaudhuri has been selected as International Champion. While Mr. Prateek Bumb, Mr. Manik Jolly, Prof. Sukumar Mishra and Lt. Col. (Retd.) Monish Ahuja were selected as National Champions.
- DST in collaboration with ERA-NET Smart Energy System and MI launched a call entitled 'Energy Storage Solutions (MICall19)' on 18.09.2019. DST has committed € 2 million for this call. 49 consortiums have registered interest in participation.
- A collaborative project entitled "Development and field demonstration of paddy straw based briquetting plant for decentralized applications in State of Punjab" was been funded to the consortium consisting of The Energy and Resources Institute (TERI), Delhi/ Punjab State Council for Science & Technology/ International Advanced Research Centre for Powder Metallurgy & New Materials, Hyderabad and Hi-Tech Agro Energy Private Limited. The main objective of the project is to demonstrate and develop paddy straw based briquetting machine, with advanced high resistant surface coating material to avoid wear and tear of components such as hammer, chopper blades, ram, piston and baler blades.
- To increase the abrasion wear resistance of the biomass briquetting machine components (Hammer blades, Ram, etc.), two varieties of abrasion resistant coatings: TiN and TiCrN were developed on three different substrates hardened D3 Steel, Annealed D3 Steel (soft), and EN 19 Steel. The TiCrN coating has sustained the abrasive conditions for longer periods than the TiN coating. The high abrasion resistance of TiCrN was due to its high toughness.

3.2.2 *Water Technology Initiative:*

Water Technology Initiative is a pro-active India - centric 'solution science' endeavour aims to strengthen the R&D capacity and capability to develop the research based solutions for existing and emerging water challenges facing the country. It includes development research in laboratories and application research in field. The overarching goal of the scheme is to promote RD&D activities which enable winning of water from sustainable sources, augmentation of water quality for specific applications and recycling and reuse of water. This is a need based demand oriented thematic initiative encompassing the entire technology development chain to successively progress to higher technology readiness levels culminating into sustainable solutions. Several achievements made during the FY 2019-20 are as under:

1. **Field Interventions to provide Convergent solutions:**

1.1. A demand driven convergent water solution in mission mode project for new strategies for optimal operation of water supply schemes by use of scheduling and decentralized infrastructure has been implemented jointly by IIT Bombay and IIT Madras at Umberpada-Saphale village in Palghar district of Maharashtra. The Gram and Zila Panchayat is actively participating as the utility partners with the knowledge partners (IITB & IITM) under the intervention. The Karawale dam is the source for project water supply scheme for Umberpada-Nandade and 17 villages. Approximately 20,000 rural regional population is expected to benefit after commission of the project.

1.2 DST has supported a project for clean and safe drinking water supply to rural community using river bank filtration techniques in parts of hard Rock Regions of Karnataka over Tungabhadra river. On 5th June'2019, on the World Environment Day, RBF wells installed at Somlapur village were inaugurated by DST official and local administration officers. More than 100 villagers along with Panchayat Heads participated in the installation program. In this connection an awareness program for riparian villagers was also conducted in association with state department such as with Panchayat Raj, Water supply and sanitation, Karnataka Pollution control board, Rural development etc.

1.3 DST-WTI has supported a field extensive project under WTI scheme with an objective for large scale implementation of the patented Arsenic and Metal Removal by Indian Technology (AMRIT) developed by IIT Madras, Chennai. On 15th July 2019 there was a site visit by DST official along with the project team and local administration officers to project sites (Fig 12). The Hand pumps with arsenic contamination of 10-200 ppb have been located with geotagging and test results confirmed by Dakshin Raipur water treatment plant laboratory and Behampur PHED (Public Health Engineering Department) laboratory as well as confirmed by the test facility developed at IIT madras under the project.



Fig. 12. AMRIT units installed in schools in 24 South Parangas District of West Bengal.

2. Research in emerging areas:

- 2.1 DST has supported Water Innovation Centre in Gujarat for developing a Low Cost-Renewable Energy Driven (LC-RED) Water Treatment Solutions Centre, The Thermal Energy driven Reverse Osmosis methodology comprises a combination of analysis, modelling and experimentation at subsystem and system level. By modelling and designs optimization of subsystem (e.g. cycles, power units, linkage mechanism) a prototype has been prepared. Experimentation with the resulting prototypes is being conducted for verification and refinement of the models, thus leading to improved designs in an iterative process.
- 2.2 Flood management: A multi institutional project has been supported to IISc as lead to develop an urban flood model, capable of simulating hydrologic and hydraulic behavior of storm water in existing and natural drainage systems using high-resolution terrain data. This intervention also aims at creating a huge database for Bangalore city in terms of terrain data using LiDAR Technology and flow data through a high-density sensor network, which will improve the accuracy of the urban flood forecasting and management model. The urban flood model will be tuned for the Bangalore city conditions and will be customized for existing and expected urbanized, low lying areas, etc. The work also envisages reusing flood water by harvesting and storing to improve ground water level of the city and rejuvenate the lakes to address the water crises.
- 2.3 An emerging technology has been developed at CSIR-NCL Pune at lab scale that successfully demonstrates greener methodology of hydrodynamic cavitation using rotational flows for disinfection of water (Fig. 13). Disinfection of two model microbial

strains- gram negative (*Escherichia coli*) and gram positive (*Staphylococcus aureus*) using vortex diode has been evaluated.

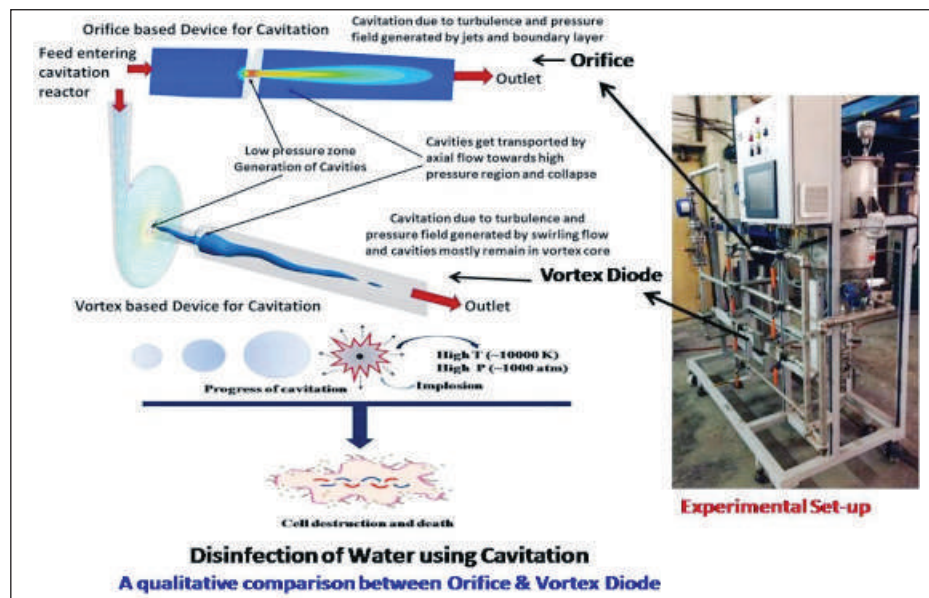


Fig.13. Experimental set up and schematic of disinfection using cavitation

- 2.4 DST has supported Urban Water Systems (UWS) consortia under Water Technology Initiative led by IIT Kharagpur titled “Fast forward to SDG6: Acceptable and affordable water in secondary Indian cities - 4WARD”. The other collaborative partners in the consortia are Tata Institute of Social Sciences (TISS), Mumbai; Amrita Vishwa Vidyapeetham, Kochi; Indian Institute of Sciences, Bangalore; Indian Institute of Technology Bombay
- 2.5 DST has supported another Urban Water Systems (UWS) consortia under Water Technology Initiative led by BITS Pilani titled: Structured Dialogues for Sustainable Urban Water Management (SDSUWM) and other collaborative partners are Aligarh Muslim University, Aligarh; Birla Institute of Technology and Science, Hyderabad; and Amrita School of Engineering Coimbatore, Tamil Nadu.
- 2.6 DST-IITM Water Innovation Centre for Sustainable Treatment, Reuse and Management (SuTRAM) for Efficient, Affordable and Synergistic Solutions is a network of 9 research institutions namely IIT Madras, VIT Chennai, IIT Thirupathy, Anna University Chennai, PRIST, CSIR-CLRI Chennai, CSIR-IITR Lucknow, IISERB Bhopal and Kumaun University Uttarakhand, will be looking into a sustainable approach for water resources protection and augmentation through wastewater treatment and reuse and storm water management. The overall goal of the center is to ensure adequate, safe, reliable and sustainable sources of drinking water for rural and

urban India and process water for highly polluting and water intensive industries, through research, technology development and capacity building. The objective of the proposed centre is to develop strategies and technologies for sustainable treatment, reuse and management of water.

3. Global Collaborations:

- 3.1 In an India- United Kingdom collaborative programme, Yamuna river in the north (in the most polluted stretch, contributing to 70% of Delhi's water supply needs) and the Cauvery river in the south (the most abstracted river in India) are being studied for prevalence of emerging contaminants. Investigations will also be made on the fate of ECs and use of bio-solids during wastewater and sludge treatment line at 10 Waste Water Treatment Plants (WWTPs) in India. The attempt is to develop evidence based wastewater discharge standards and guidance for safe use of contaminated sludge.
- 3.2 The project REVIVAL was initiated under Indo-UK Water Quality Initiative to identify reservoirs of *Vibrio cholerae* in Vembanad Lake using field studies and laboratory experiments; investigate their association with environmental conditions; relate the findings with remote-sensing data; and prepare epidemiological models for predicting the evolution of *Vibrio* in the infested waters. Risk maps from remote sensing and epidemiological models, in combination with public engagement are designed to identify locations of high risk, possibly identify sources of contamination and minimize pathogen-human interactions, and thus prevent outbreak of cholerae diseases. Vembanad Lake (VL) has been selected as the study area.
- 3.3 DST has supported bilateral Indo-UK project FAR-GANGA (Future Secular Changes & Remediation of Groundwater Arsenic in the Ganga River Basin) with IIT Roorkee and University of Manchester as leads from the two sides. The project team has carried out and completed groundwater arsenic mapping across Ballia and across all 38 districts of Bihar along with completion of groundwater sampling across the city of Patna, installation of field monitoring (river/groundwater) stations along the length of the Ganga is in progress and successful running of a series of stakeholder events, including in Roorkee, Varanasi and Patna.
- 3.4 DST has supported one Indo-Dutch consortia titled "Water for Change. Integrative and Fit-for-Purpose Water Sensitive Design Framework for Fast Growing Livable Cities" that was evolved through the extensive Sandpit mechanism in the area of Urban Water Systems against the DST-NWO Call on bilateral consortia. This consortium is being led by IIT Roorkee as lead along with other consortia member named MANIT, Bhopal; CEPT University, Ahmedabad; IIT Gandhinagar; CWRDM, Calicut.

4. Important Events and Meetings:

- 4.1. The Union Minister for Science, Technology & Earth Sciences and Environment

Forests & Climate Change and Earth Sciences Dr Harsh Vardhan launched two technology mission centres (Fig. 14) in the area of water set up by Department of Science and Technology, Government of India which was nucleated at Indian Institute of Technology Madras in Chennai, Tamil Nadu on 25th January 2019. These centres, which have been established have the mission of providing state-of-art research led innovative technological solutions for prevalent and emerging water and energy challenges facing the country. These two centres are water oriented projects and an overview is given below:



Figure 14. Launch of WIC SUTRAM and DST-IIT-KGDS Test bed for Solar thermal desalination solutions at IIT-Madras

- a. DST-IITM Water Innovation Centre for Sustainable Treatment, Reuse and Management (SuTRAM) for Efficient, Affordable and Synergistic Solutions is a network of 9 research institutions namely IIT Madras, VIT Chennai, IIT Thirupathy, Anna University Chennai, PRIST, CSIR-CLRI Chennai, CSIR-IITR Lucknow, IISERB Bhopal and Kumaun University Uttrakhand, will be looking into a sustainable approach for water resources protection and augmentation through wastewater treatment and reuse and storm water management.
 - b. DST-IITM-KGDS Water Innovation Centre for Test bed on Solar thermal desalination solutions set up at Naripaaiyur, Ramanathapuram District, Tamil Nadu is a network of IIT Madras, DBT-ICT Mumbai, KGiSL Institute of Technology (KITE) Tamilnadu and Empereal-KGDS Renewable Energy Private Limited (Empereal-KGDS) Coimbatore, which aims to demonstrate the Solar powered Forward Osmosis to produce high quality drinking water from sea water in this coastal village to benefit approximately 10,000 population which faces severe drinking water scarcity.
- 4.2 DST-WTI supported project to PSG College of Technology, a pilot plant has been launched using Internet of things based water supply and distribution systems in the Coimbatore city on 29th May 2019 in Coimbatore. The project envisages to work

on providing customized technological solutions for water challenges, balancing the water supply and demand using advanced technological tools, understanding the utilization pattern of the consumer and applying computational algorithms for predicting the future requirement, as well as providing solutions to optimize the water distribution network and water modeling with real-time data input and mapping of population distribution and water requirements through latest innovative computing methods.

- 4.3 India-UK Joint Review meeting was held from 9th to 10th July 2019 in London, UK for midterm review of 8 India-UK bilateral projects supported under the Water Quality Research program. On 9th July 2019, progress of eight Indo-UK bilateral projects was presented by their respective consortium partners during the meeting to the joint committee.
- 4.4 Department of Science & Technology (DST) has participated and co-sponsored the 6th India Water Week (IWW)-2019 organized by Ministry of Jal Shakti, which was held on 24-28th September 2019 at Vigyan Bhawan, New Delhi to showcase the technologies developed in collaboration with different institutes/Laboratories /Organizations. One session was dedicated to Indo-UK Collaboration for Water Quality Research in which Dr. Sanjay Bajpai Head TMD EWO was Chairperson. And different technologies dealing with Water quality and quantity issues were also exhibited during the IWW 2019.
- 4.5 DST has supported one Indo-Dutch consortia titled “Water for Change. Integrative and Fit-for-Purpose Water Sensitive Design Framework for Fast Growing Livable Cities” that was evolved through the extensive Sandpit mechanism in the area of Urban Water Systems against the DST-NWO Call on bilateral consortia. This consortium is being led by IIT Roorkee as lead along with other consortia member named MANIT, Bhopal; CEPT University, Ahmedabad; IIT Gandhinagar; CWRDM, Calicut. This DST-NWO supported consortia on Urban Water Systems was launched by Union Minister for Science, Health & Family Welfare, Science & Technology & Earth Sciences, Dr Harsh Vardhan during Indo-Dutch Technology Summit 2019 held during 15th - 16th October 2019.
- 4.6 Union Minister for Science, Health & Family Welfare, Science & Technology & Earth Sciences, Dr Harsh Vardhan launched on 6th December 2019, a Water Innovation Centre for enhancing Food and Water security in Arid Region set up by Department of Science and Technology (DST), Government of India nucleated at Indian Council of Agricultural (ICAR) –Central Arid Zone Research Institute (CAZRI), Jodhpur. This centre, which has been established at a collective investment of around Rs 6 Crores, has the mission of providing state-of-art research led innovative technological solutions for enhancing food and water security which is a major challenge for arid regions. DST-ICAR-CAZRI Water Innovation Centre for Enhancing Food and Water Security in Arid Region through Improved Understanding of Quantity, Quality and

Management of Blue, Green and Grey Water is a network of 6 research institutions.

3.3 Natural Resources Data Management System (NRDMS)

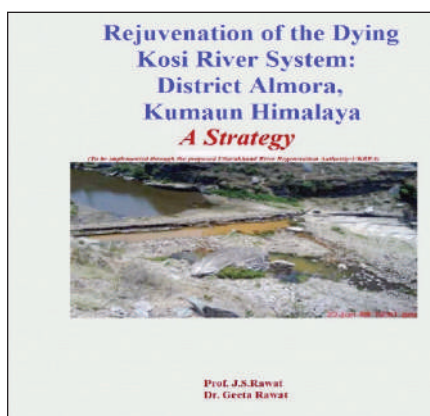
Natural Resources Data Management System (NRDMS) is an interdisciplinary research programme which is promoting R&D in emerging areas of Geospatial science, technology and applications for providing solutions to area specific problems. It is also very much helpful for better decision making and efficient planning to address the Sustainable Development Goals (SDGs). Over the years, NRDMS has developed capability for handling resource management at State, District and Panchayat levels. NRDMS have direct relevance for the societal development and converging with the digital India programmes. The progress made under various sub-programmes of NRDMS is as under:

3.3.1 Geospatial Oriented R&D Programmes:

I. State Spatial Data Infrastructure (SSDIs):

State Spatial Data Infrastructure (State SDI) was launched about a decade back with the participation of the concerned states and also sharing the cost of the project at the ratio of 70:30 between DST and the concerned state, in order to enhance the applications of Geospatial Technologies in implementing developmental schemes in the country at state and below levels. State Geo-Portals have been set-up in 10 states to provide relevant datasets / information for implementing various developmental schemes.

- Applications of Uttarakhand Geoportal in Water Resources, Disaster Management, Policing/Security along with Urban Governance has been Developed. **Formulation of GIS based Rejuvenation Plan** for the Dying Kosi River in district Almora received **First Prize National Water Award -2018** from the Ministry of Water Resources, Government of India (Fig.1). Same has qualified into Semi-finals of the **SKOCH** award 2020.



1a. Strategy Document

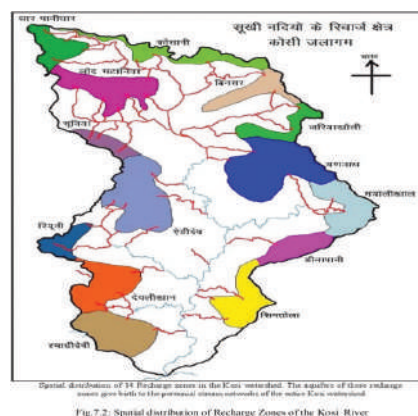


Fig. 7.2: Spatial distribution of Recharge Zones of the Kosi River

1b. Spatial distribution of recharge zones of the Kosi river

II. Applications of State SDIs for Urban Governance:

Eleven R&D projects have been supported in order to demonstrate the concepts of Spatial Data Infrastructures (SDIs) in Urban Governance in the emerging areas related to city development using Geo-ICT and other techniques. The various areas where the projects are supported are: Estimation & Navigation in Autonomous Sensor Networks; Auto BIM; City GML; Shapley value, BIM to GIS integration, Modelling Interdependencies; Geospatial location estimation and Navigation

III. Village Information System:

Development of rural areas is among the top priorities of present government. In this context, NRDMS division has supported, 10 R&D projects located in various geo-environmental conditions in the country to develop scientific methodology for geospatial planning at village level. Large-scale mapping on 1:10,000 scale was carried out in about 120 villages to collect primary data on natural resources and other allied sectors. Asset mapping and Geo-tagging has also been carried out in different village panchayats. This scientific methodology has helped in integrated village developmental planning.

IV. Revival of Village Ponds:

Village ponds are the lifelines in rural areas. It plays a vital role for water conservations and ground water recharge at local level. It has been seen that most of the ponds are not functional. This led to scarcity of water and increase run off. In order to utilize this opportunity for enhancing the ground water recharge as well as increasing its capacity, NRDMS has developed a sub-project on revival of village ponds. To demonstrate the efficacy of such experiment about 12 R&D projects have been supported. The locations of these ponds are spread over in entire country to see the climate and topographical variations and their impact on the recharge of ground water in ponds. Hon'ble Prime Minister of India also emphasized the need for water conservations and particularly revival of ponds at panchayat level.

Outcome/ Impact of revival of village ponds:

- Increased storage capacity of the ponds for rain/runoff water. The revival of ponds will result in their increased capacity or increased seepage rates. The harvested water could be utilized for groundwater recharge or for supplemental irrigation depending on the purpose of revival of these ponds.
- Rise in groundwater table through groundwater recharging. The revival of the village ponds for groundwater recharge will result in improved water table.
- Prevention of soil erosion by water and loss of soil fertility: Reducing the runoff

velocity and volume reduced soil detachment. The taming of runoff water in water bodies on scientific lines will also aim at reducing the soil erosion rates.

- Mitigation of drought and flood conditions. The availability of stored water will help in mitigation the drought conditions in rainfed areas due to timely sowing and also providing one of two supplementary. Irrigation to the crops.
- Decrease in water drudgery. The Women have always been at the receiving end due to scarcity of water. The easy availability of water for irrigation and other purposes will reduced the burden on women to carry water from far off places.
- Improved crop productivity: Providing life-saving irrigation to the crops apart from ensuring timely sowing of crops in rainfed is expected to improve the crop productivity.

V. Capacity Building on Geospatial Technologies

- Under NRDMS programme, number of R&D projects and sub programmes are being supported to develop tools and techniques for promoting geospatial technologies and applications. Total 32 training programmes on short term (for 3 days) and long term (for 21 days) have been supported, wherein 7 short term programmes, 17 long term (Level I) & 8 long term Level II were conducted at pan-India level.

As a knowledge partner, a portal has been developed to standardize the course curriculum (www.dst-iget.in) for various training modules/ tutorials for targeting various stakeholders (Fig 2). Around 800 stakeholders across the Country have been trained in the field of Geospatial Science, Technology and its application.



Fig 2: Screenshot of dst-iget Portal.

- Under the National Geospatial Chair Professor Scheme, G-Governance has been developed and established in the State of Uttarakhand by strengthening Technological and Institutional capacity within the different line departments of the State Governments through i) development of a healthy ecosystem of GIS development in the State; ii) a template of modernization of land records at cadastral scale; iii) a models of g-Election,gRoads, g-Tourism; and iv) and a nationally recognized template of GIS based Himalayan River Rejuvenation.
- Technological capacity building of Indian Institute of Survey & Mapping (IISM), SOI under the Geospatial Chair Professor Scheme has been strengthen in the areas of Hyperspectral Remote Sensing, Microwave Remote Sensing, and 3D City Modelling. Teaching materials/ manuals for one-year training programme on Geo-spatial Technology and Applications in Rural Development were also developed under the same scheme.

3.3.2 Disaster Mitigation Programmes

I. Landslide Hazard Mitigation (LHM):

Landslide Hazard Mitigation is also multi-disciplinary and multi-agency programme being coordinated by NRDMS Division of DST. As part of the programme, concerted efforts had been made to develop the inventory of landslides, methodology for landslide hazard zonation, monitoring of selected critical landslides, development of slope stability models, Early warning system, design of suitable preventive measures including soil nailing technique and training/dissemination of technologies.

II. Landslide hazard mitigation for North-Eastern Region (NER)

NER is important from strategic point of view for the country. Entire NER have landslide problems. In order to tackle such issues a network programme for this region was developed with the participation of the institutions/universities of these states. The focus is for identifying the active/unstable slopes and carrying out scientific analysis for developing suitable remedial measures.

III. Large-scale Geological and Geotechnical mapping in Uttarakhand

Large-scale mapping was undertaken from Rishikesh to Kedarnath (about 150 km corridor). Relevant data on geological and geotechnical parameters were collected and integrated to categorize all the slopes with the magnitude of risk. All the study area has been demarcated with the probability of risk and factor of safety. In addition, the areas were also identified which are safe for reconstruction of infrastructure facilities. Integrated final report and vulnerability have been prepared for this particular area.

IV. Coastal Hazard and Risk Assessment (CHRA):

A sub-programme, CHRA was launched with aim to develop S&T enabled techniques for coastal disaster studies encompassing disaster genetics, propagation, disaster vulnerability mapping, detection of causative factors, mitigation measures etc and come out with quantifiable/actionable outputs so that the state governments and the stake holders can readily use them during the disasters for relief, restoration and rehabilitation. This new initiative was taken to cover the coastal areas of India from a perspective of Disaster Risk Reduction, Vulnerability assessment including coastal erosion, Tsunami modelling with historical data to determine possible hotspots etc. Identified areas of research for Coastal Disaster under CHRA are (i) land subsidence and Sea level rise, (ii) tsunamis, (iii) cyclones (iv) floods and (v) coastal erosion have been taken up to start with. To strengthen the above areas, Eight R&D projects have been supported for east-coast of India to assess the soil erosion, sea water intrusion into fresh water (inundation modeling) & identification of the hot spot/ infrastructure which is likely to be affected due to the inundation at the time of Tsunami. The outcome of the programme would address the local issues being encountered by the coastal states with the active participation with the stakeholders.

V. National Geotechnical Facility (NGF)

In order to develop soil and rock mechanics, testing facilities, NGF has been set up in Survey of India, Dehradun. The advanced data acquisition instruments like ground penetrating radar, drone and other testing facilities to estimate the shear strength of the material were also developed. NGF is the state of art facility in geotechnical engineering.

3.3.3 New Initiatives:

I. Gravity Recovery and Climate Experiment (GRACE):

Gravity Recovery and Climate Experiment (GRACE) satellite gravity mission is one amongst latest technological development available to researchers to evaluate changes in the Earth's gravity field caused due to redistribution of mass inside on and around the Earth surface at regular intervals. In the view of contemporarily scientific importance of utilizing GRACE data in particular and other remote sensing data in general, it is important to develop Indian expertise in collaboration with global peers in this cutting edge scientific field. In view of the above, a National network project on 'Assessment of Regional Hydrological Systems using Space Borne Gravity Observations' has been developed. At present, 12 R&D projects have been supported to various institutions to undertake research work. A Centre of Excellence, is being established in NGRI, Hyderabad to facilitate the outcome of the R&D projects and to enhance the capability at National level in this area.

II. National Programme on Geodesy

A National Centre in Geodesy has been set up in Indian Institute of Technology (IIT), Kanpur with the following objectives:

- Promotion of outreach activities: capacity building by educating on the use of Geodesy by imparting regular training programmes (long term and short term), dissemination of relevant information, development of courses and reference material in Geodesy.
- Promotion of the state-of-the-art research and development activities (academic research, sponsored/consulting) in Geodesy.
- Extension of all laboratory support (equipment, training, library, SW, etc.) for students and researchers from universities and institutions and advise state/central government departments on various issues related to Geodesy.

An indicative list of R&D activities in Geodesy proposed to be taken up at the Center is given below:

1. Employment of precise geodetic techniques for polar motion studies and in determination of Earth rotation parameters.
2. Estimation of essential climate variables using geodetic sensors
3. Determination of *precise gravity field* using *satellite gravity missions* such as GRACE, GOCE, CHAMP, etc., and hence to realize *precise gravimetric Geoid* in combination with *Airborne and terrestrial gravity data*. Development of *regional precise gravimetric Geoid* for Indian subcontinent and establish *Indian vertical datum*.
4. Recovery of temporal variations of the gravity field from GRACE and GRACE-FO
5. Simulation studies for future satellite gravity field missions
6. Characterizing catchments with terrestrial gravimetry
7. Development of regional precise gravimetric Geoid for Indian subcontinent and establish Indian vertical datum.
8. Use of precise geodetic techniques for crustal deformation and plate motion studies and in the determination of earthquake precursors.
9. Satellite Altimeter for sea level variation studies and climatology modeling. Specifically, analysis of ISRO'S SARAL mission altimetry data for Ocean, Earth systems and Climate research.
10. Disaster management studies such as flood modelling, Tsunami warning, and

landslides using satellite images and satellite/ ground based geodetic measurement techniques.

11. Development of Indian Grid Reference System on GPS along with subroutines for coordinates data computation.
12. Error analysis in map projection and transformation.
13. Positioning algorithms for GNSS satellite systems- GPS, GLONASS, GALILEO, COMPASS, IRNASS, etc.
14. GNSS reflectometry of soil moisture and sea-level
15. Crustal deformation studies using GNSS.
16. Setting up of IGS Station at IIT Kanpur for Studies *on the Realization of ITRF and ICRF*
17. Monitoring the hydrological load using GNSS
18. Development of low-cost GNSS permanent stations
19. Hydrological modelling using GRACE data.
20. Use of machine learning techniques with massive data from various geodetic sensors.
21. SAR interferometry for deformation studies.
22. Participate in the International Association of Geodesy (IAG) activities.
23. Airborne and terrestrial laser scanning for various applications.
24. Integration of various sensors for navigation and mapping.
25. Camera calibration for photogrammetric applications.
26. Mobile mapping systems.
27. GIS applications in open source environment.

III. Development of an Early Warning System for Landslide Research:

During the 106th Indian Science Congress, held at Jalandhar, the honorable Prime Minister emphasized the need to develop Early warning system for Landslides particularly in Sikkim and other parts of the North-Eastern region, Himachal Pradesh, Uttarakhand, Jammu Kashmir and Western Ghats. Based on the directions given by honorable Prime Minister, Expert Committee on Landslide Hazard Mitigation has recommended to support 10 Research and Development projects to develop an early warning system for landslide at various sites.

3.3.4 International Activities:

United Nations Global Geospatial Information Management (UNGGIM) is a global platform for Geospatial Information (GI) sharing and management with its reports being fed to United Nations Economic and Social Council (UN-ECOSOC). UN-GGIM seeks to promote international collaboration in global geospatial information management, and as the relevant body on geospatial information management in the United Nations, to report on all matters relating to geography, geospatial information and related topics to the United Nations Economic and Social Council (ECOSOC). Within UNGGIM, UN-GGIM-AP (Asia and the Pacific) aim to identify regional issues relevant to geospatial information management and take necessary actions for the furtherance of the discussions in UNGGIM. UN-GGIM-AP forum provides an opportunity to exchange the views and knowledge on latest trends in Geospatial Information management and facilitate to understand the United Nations policies, related to Global geospatial Information management including fundamental data requirements, data quality, maintenance and standards, to make India's international participation in sharing data, expertise and technology in geospatial and geomatics areas more meaningful and effective.

- Indian delegation participated in the UN-GGIM-AP Executive Board Meeting and

Program for the Fourth Expert Consultation and review of the implementation Guide of the Integrated Geospatial Information Framework (IGIF) held in Kuala Lumpur, Malaysia from 18 June to 21 June 2019. The objective of this expert consultation and meeting is to continue the consultation as well as the review, refine and ready the draft implementation Guide for the consideration of the Committee of the experts as Ninth session of UN-GGIM held in August, 2019. The Framework aims to assist countries to move towards-economies, e-service etc. To improve services to citizen, built capacity for using geospatial technology, and to bridge the geospatial digital divide in the implementation of national strategic priorities and the 2030 Agenda for the Sustainable Development. The Framework document consists of nine chapters such as: Policy and Legal, Financial, Data Innovation, Standards, Partnerships, Capacity and Education, Communication and Engagement

3.3.5 Application of GIS for addressing the SDGs:

Addressing Drinking Water Issues (**SDG-6**) in Slums in Greater Mumbai and its Mapping using GIS SIES Indian Institute of Environment Management, Navi Mumbai has generated a GIS based water quality maps of slum locations of Greater Mumbai with an aim to address area specific drinking water issues in slums. Various low-cost water purification methods were recommended for slum residents. Ground water quality was also analyzed for selected wards of Greater Mumbai. Poor ground water quality areas and saltwater mixing zones were identified since the study area is located in coastal region. Salt water

intrusion zones were identified and mapped in selected wards of Greater Mumbai using GIS (Fig 3).

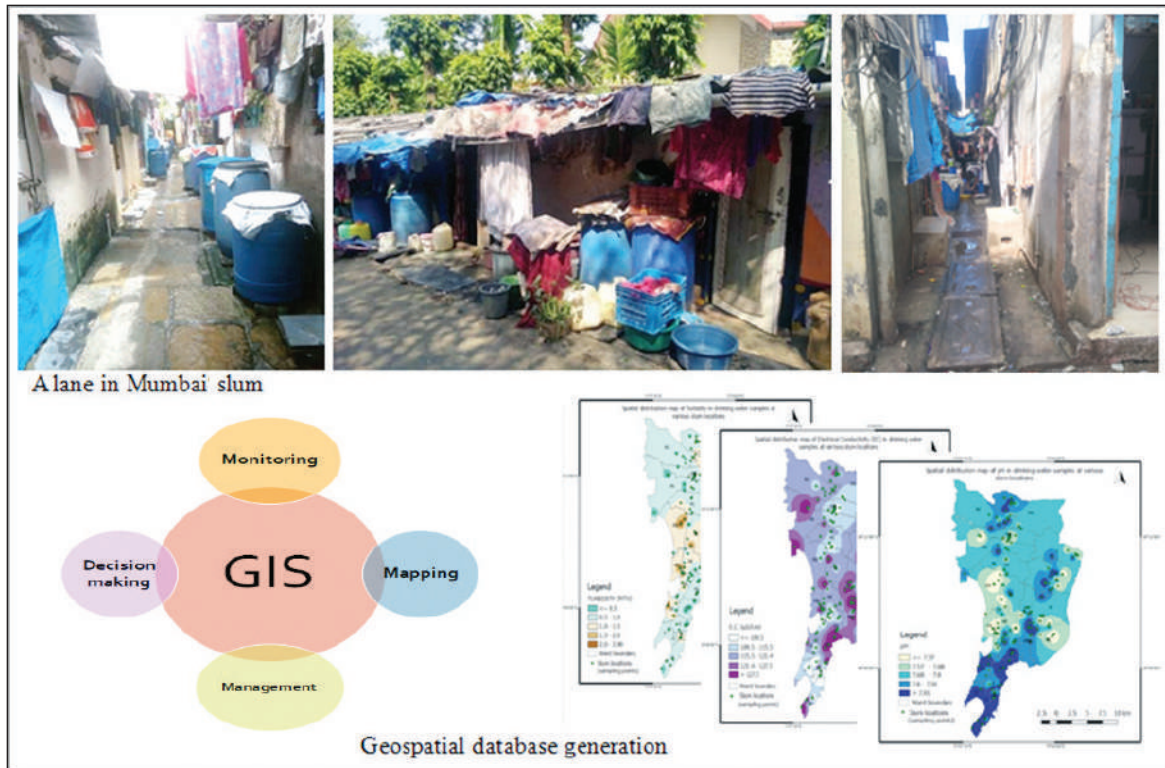


Fig 3: Monitoring of water quality in the slum areas of Navi Mumbai

3.4 National Science & Technology Entrepreneurship Development Board (NSTEDB)

3.4.1 Programs under National Initiative of Developing and Harnessing Innovations (NIDHI)

1. NIDHI- Technology Business Incubators (TBIs)

Department of Science and Technology has been supporting establishment of Technology Business Incubators primarily in and around academic, technical and management institutions to tap innovations and technologies for venture creation. These startup incubators support and nurture knowledge driven innovative start-ups into successful enterprises. Enabling environment like TBI has helped to enhance the prospects of success of S&T based startup ventures. The TBI cater to different technology sectors like ICT, agri-technology, medical devices, healthcare, manufacturing, nanotechnology, biotechnology etc. The initiative has also given Indian incubators good credibility in the international arena. During the year 2019-20, eight new TBIs under NIDHI program have been established at:

Indian Institute of Technology, Patna; Savli Technology Business Incubator- Gujarat State Biotechnology Mission (GSBTM), Vadodara; C. V. Raman College of Engineering, Bhubaneswar; Indian Institute of Public Health (IIPH), Gandhinagar; G. H. Rasoni College of Engineering, Nagpur; Pandit Deendayal Petroleum University (PDPU), Gandhinagar; Ambala College of Engineering, Ambala; Indian Institute of Management, Kashipur.

Some of the innovative products developed by Start-ups at various TBIs:

- **Driipo** is developed by Evelabs Technologies Pvt Ltd which is supported by TBI at Sree-ChitraTirunal Institute for Medical Sciences and Technology (SCTIMST), Thiruvananthapuram

Driipo is a connected infusion monitor, which counts the drop and calculate real-time drop rate to help the nurse set IV drop rates precisely and easily. The device will send data to a central hub installed at the nursing station, where rate changes and completion of every source will be alerted. The hub is also a smart infusion chart, where the status of every ongoing and upcoming infusion and the patient histories will be shown.



Fig Startup Supported by TBI at SCTIMST:
Evelabs Technologies Pvt Ltd

Product :**Driipo Smart Infusion Monitor**

- Oral Scan is a biomodal multispectral imaging device developed by Sascan Meditech Pvt Ltd, a startup incubated at SCTIMST, Thiruvananthapuram, for non-invasive and real time screening and detection of oral cancer. On completion of a screening process, the captured images and the histopathological results of biopsy gets pushed to the cloud from the device and the patient data can be accessed by authorized persons for follow up and patient care.

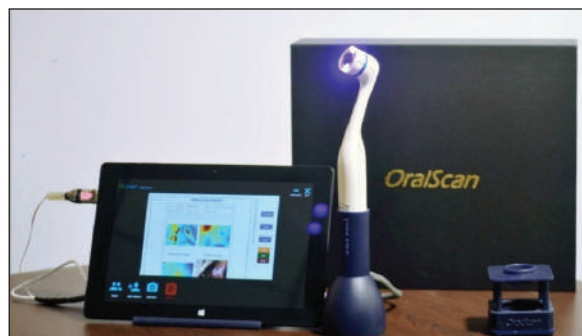


Fig Startup Supported by TBI at
SCTIMST: **SascanMeditechPvt Ltd**

Product :**OralScan**for non-invasive screening and detection of oral cancer

- Varaha Studios incubated at TBI at S R Engineering College, Warangal specializes in building solutions through next-generation Human Computer Interfaces such as AR/VR/XR. Varaha Studios implements DeepTech viz. Artificial Intelligence, Block chain, Augmented Reality to solve difficult problems for companies across the world. Varaha Studio's core product is the WonderShop - the world's first mixed-reality virtual trial room to solve the returns problem for all e-commerce stores globally.



Fig Product “Wonder” – An AI enabled, 3D/Mixed Reality (XR) application to create ultimate customer experiences – Product by Varaha Innovation Studios and Technologies Pvt Ltd with their

- RCHobbyTech incubated at TBI at IIM Calcutta. The Startup provides smart customized unmanned surveillance solutions for diverse sectors. The company has reached to around 90 Units of Indian Army, 10 Organizations and 2 Municipal Corporations





Fig: RCHobbyTech incubated at IIM Calcutta

- Bioconjugated Nano Theranostic Delivery System for Alzheimer's Disease by Innpharx Research Pvt. Ltd. incubated at Nano Tech TBI at PSG College of Engineering, Coimbatore

Theranostics is Therapeutic and Diagnostic response in the same delivery system. The bioconjugated nanotheranostic delivery system will remove the root cause amyloid beta protein plaque from the brain and improve the memory functions of the Alzheimers patient. Simultaneously, the treatment effect will be easily diagnosed in the body fluid like blood/plasma/serum than the present complicated CT or MRI methods.

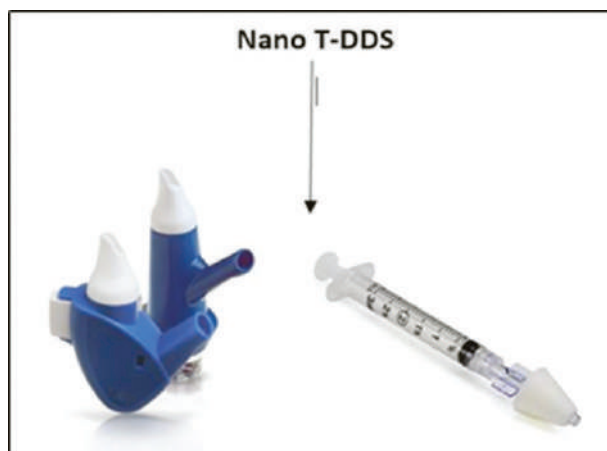


Fig Bioconjugated, nanotheranostic delivery system

2.0 NIDHI Centre of Excellence (NIDHI-CoE)

NIDHI-Centre of Excellence (NIDHI-CoE) provides an enabling environment to technology based new enterprises which are high risk and high growth ventures. NIDHI-CoE strengthens existing capacities of TBIs and supports potential start-ups with different pursuits and practices in transferring technological innovations into marketable products and high-growth ventures.

The ongoing five NIDHI-CoE (Centre of Excellence) are at PSG-Science & Technology Entrepreneurial Park (PSG-STEP) at PSG-College of Technology, Coimbatore, SINE IIT-Bombay, CIIE-IIM-Ahmedabad, TBI-Veltech Univ. and EDC NCL-Pune.

Some of the innovative products developed by Start-ups at various CoE are:

- **LEOTEK COATINGS incubated at SINE, IIT Bombay.** Corrosion due to acid and alkali attack is prominent in chemical and fertilizer manufacturing facilities. **KORRTEK™ RCP 351** is a surface tolerant coating system specially designed for excellent adhesion on chemically corroded metallic substrate. The coating has a unique property of converting active red oxide rust to a stable black oxide complex, allowing superior corrosion protection. The product has superior penetration to chemically corroded steel, better coverage and faster drying.



Fig Chemically attacked metal, Before and After protective coating

- **ENDIMENSION TECHNOLOGY, incubated at CoE at SINE IIT Bombay.** The startup is developing an AI cloud / desktop-based software platform to identify abnormalities from medical scans which improve the efficiency of radiologists by reducing misdiagnosis. Their first product has been clinically validated at Tata Memorial Center. It uses AI for automatic detection of early stage lung cancer.



Fig. ENDIMENSION TECHNOLOGY - Using Artificial Intelligence to automatically detect abnormalities in Medical Scans

- **Fuma Labs**, incubated at CoE at Venture Centre, NCL Pune, aims to build a highly durable, environmentally friendly, cost-effective, wood-equivalent, crop residue derived straw panel board using a formaldehyde-free adhesive. The company is targeting innovative processes which is greener and does not discharge any toxic effluents.



Fig Particle board made out of crop residues by Fuma Labs.

3.0 NIDHI- Seed Support System (SSS) for start-ups in Incubators

The Seed Support Scheme under NIDHI equips the TBI with the much needed early stage financial assistance to be provided timely to deserving start-ups under incubation in a relatively hassle free manner. During F.Y. 2018-19, 11 TBIs/STEPs were supported under “National Initiative for Developing and Harnessing Innovations- Seed Support System (NIDHI-SSS)” programme as new cases of seed grant and 8 TBIs were supported as on-going cases of seed grant to benefit 100 startups under incubation. The TBIs supported as new SSS cases are as follows: MaDeI’T Innovation Foundation, Indian Institute of Information Technology, Design and Manufacturing (IIITDM), Kancheepuram, Chennai, Tamilnadu, NS Raghavan Centre for Entrepreneurial Learning (NSRCEL), Indian Institute of Management (IIM) Bangalore, Karnataka, Society for Innovation and Entrepreneurship (SINE), Indian Institute of Technology, Bombay (IITB), Maharashtra, Bhartiya Vidya Bhavan’s Sardar Patel Technology Business Incubator, Mumbai, Maharashtra, Dayanand Sagar Entrepreneurship Research & Business Incubation Foundation (DERBI Foundation), Dayanand Sagar College of Engineering, Bangalore, Karnataka, Indigram Labs Foundation (ILF), Indian Society of Agribusiness professionals (ISAP), Mathura Road, New Delhi, Indian Institute of Management, Laboratory for Innovation venturing and entrepreneurship (IIMK LIVE) Kozhikode, Kerala, IIT Mandi Catalyst, Mandi, Himachal Pradesh, Dlabs Incubator Association at the Indian School of Business, Hyderabad, Telangana, Jain University Incubation Centre, Bangalore, Karnataka, CIIE Regional Innovation Foundation, Startup Oasis, Jaipur, Rajasthan.

Some of the startups supported under Seed Support System of DST are as follows:

Micro-Chip Payments Private Limited: A startup incubated at DST supported TBI- Sandbox Startups Initiatives (FSSI), Deshpande Foundation, Hubli, Karnataka, are the amongst the world’s one of its kind startup to Built completely Non Internet powered Digital transaction Mobile Application and a Point of Sale Device.

Nanoclean Global Pvt. Ltd- A seed supported startup at FITT, IIT Delhi has developed a Nasofilter. The product has been successfully commercialized and it contains a highly porous substrate that does surface filtration and auto-cleans itself as one exhales. The team used nanotechnology to build the filters that can stick on the user's nasal orifice while restricting the entry of particulate matter, including PM2.5 particles and pollen allergens. Nanoclean has also been recognised among the top 50 tech startups of the world by South Korea from over 118 countries and was selected among the top 100 startups in the world by Hong Kong - it is the only Indian startup to have achieved this feat.

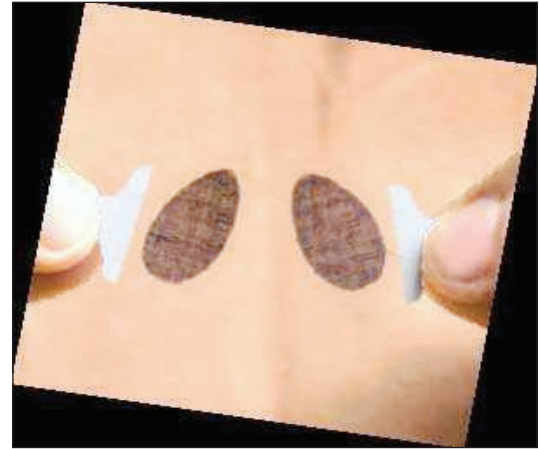


Fig: Nasofilter incubated at FITT, IIT Delhi

4.0 NIDHI-Accelerator Programme

Under the NIDHI-Accelerator Program, nine new programs, were supported to boost the provide a quality mentorship program enabling start-ups to build a customer centric validation model which enhances their investment readiness as well as market access. These 9 Accelerator programs were supported in the areas of Digital technologies, Climate Change, Energy, Entrepreneurship and Innovation, Health, Waste Processing, Water, Health tech start-ups Manufacturing Sector, AgriTech, CleanTech, Food Tech, Health & Sanitation, benefitting 152 startups.

5.0 NIDHI -PRAYAS (Promotion and Acceleration of Young and Aspiring innovators and Start-ups)

NIDHI-PRAYAS grant focuses on addressing the funding gap from idea to prototype and it is positioned as a pre-incubation initiative. The program is managed by PRAYAS centres (PC) across the country. NIDHI-PRAYAS program was started in the year 2016, and the third cycle of program has started. Total 31 centres across the country have been approved for implementing the PRAYAS program. Each PRAYAS Centre supports the innovator with a prototype grant up to Rs. 10 lakhs for converting their idea into a prototype. The centre also sets up DST PRAYAS Shala (Fab Lab) to facilitate mechanical and digital fabrication besides providing physical infrastructure, technical guidance and business mentorship to the PRAYASEEs (innovators). A total of 394 innovators have been supported. Key impact of 18 month cycle of first version of PARYAS Program is given below.

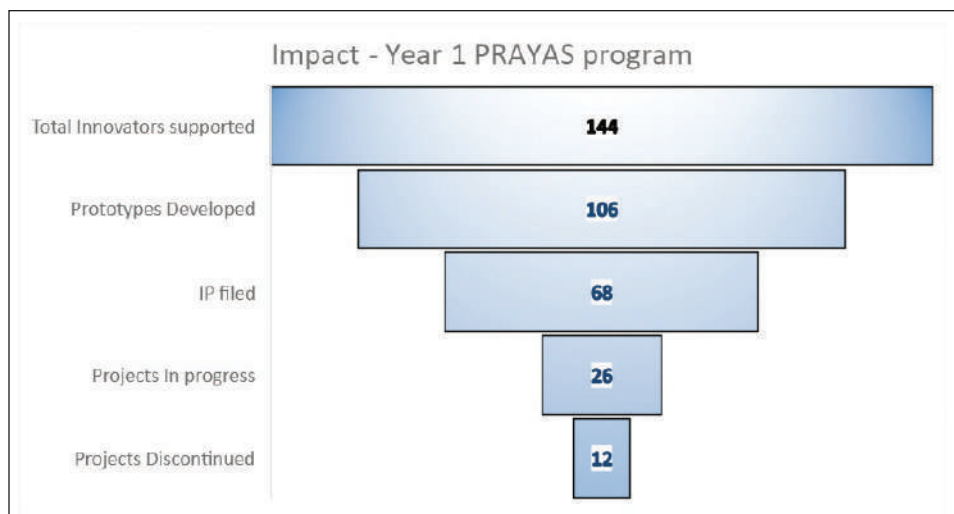


Fig: Prototype developed for Biocatalytic system for the re-purpose of used cooking oil by PC SCTIMST-TIMED, (SreeChitraTirunal Institute, Trivendrum)

6.0 NIDHI-Entrepreneurs-in- Residence (EIR) Programme

Entrepreneurs-in- Residence (EIR) Programme under **National Initiative for Developing and Harnessing Innovations (NIDHI)**, which supports aspiring or budding entrepreneur of considerable potential for pursuing a promising technology business idea over a period up to 18 months with a subsistence grant up to Rs 30,000/- per month with a maximum cap of total support of Rs 3.6 lakh to each EIR. Entrepreneurship Development Center, Pune is the Program Implementation Partner (PIP) and 10 Program Execution Partners (PEP) have been selected who execute the programme under PIP's guidance under each round.

Key objectives of the program are:

- To provide guidance to these aspiring entrepreneurs from experienced, innovative and highly successful entrepreneurs on the business concept, strategy or venture and insight into specific industries or markets
- To share best practices for starting a business and broaden the professional network.
- To facilitate co-working spaces for developing the idea into a marketable product.
- To encourage scientists and engineers to become entrepreneurs.

Measuring Impact:

- 206 EIRs supported
- 119 companies formed
- Rs 1520.564 lakh of follow-on funding and investments raised
- 13% EIRs are women entrepreneurs
- 131 IPs generated (includes 60 Patents, 53 trademark and 18 copyrights)
- 70% EIRs were under 30 years of age
- EIRS represented all corners of India (at least 21 states)

3.4.2 COLLABORATIVE PROGRAMS ON INNOVATION

1.0 DST-Lockheed Martin-Tata Trusts India Innovation Growth Programme 2.0

The India innovation Growth Program (IIGP) 2.0 is a unique annual partnership programme of the Department with the leading US Aerospace Company Lockheed Martin Corp. and the Tata Trusts, which aims to offer an enabling platform to tap and support and scale up technology based innovations in the country. After conducting various pan India road-shows and social media campaigns, a total of 2482 applications were received including 1641 applications under Open Innovations Challenge (OIC) and 841 under University Challenge. Evaluation of applications was carried out by a team at IIT Bombay and IIM Ahmedabad respectively during May/June 2019. A one week intensive mentoring session for the top 50 innovators from OIC was conducted during July in IIM Ahmedabad. The finals of the IIGP 2.0 took place on 16th-17th July 2019 followed by the Award ceremony on 17th July, 2019 in New Delhi. During the year, U.S. Ecosystem Learning and Training Visit was undertaken during November 2019 to learn how innovation and cutting-edge research is being used to solve global challenges and how these solutions could be scaled up in global markets.

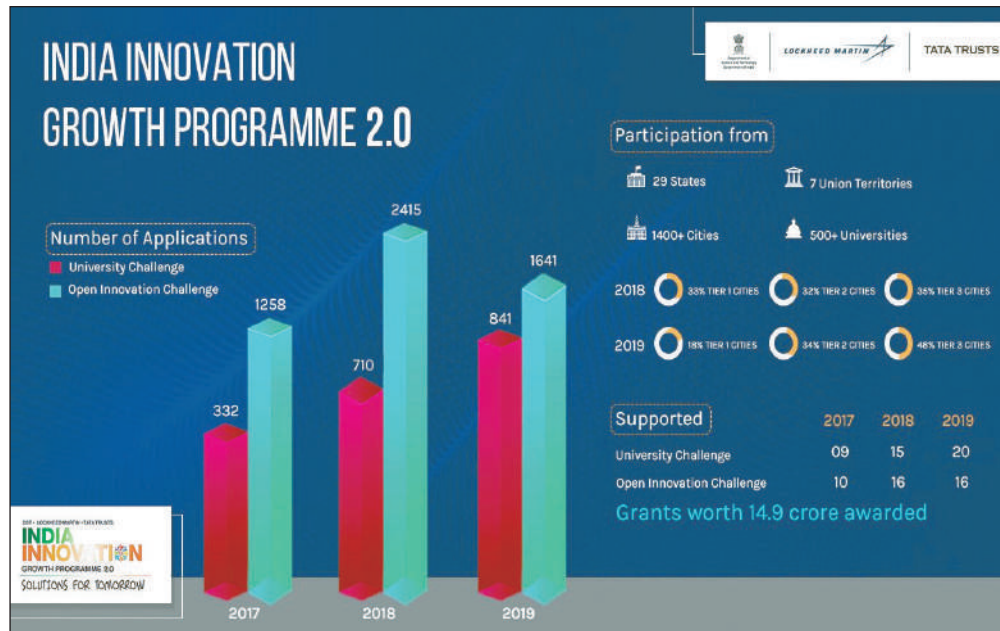


Fig : Snapshot of IIGP 2.0 (2017-2019)



Fig : Winners of IIGP 2.0 Open innovation Challenge for the year 2019

2.0 DST-Texas Instruments “India Innovation Challenge Design Contest (IICDC) 2019- Nurturing Innovations in Engineering Students of the Country

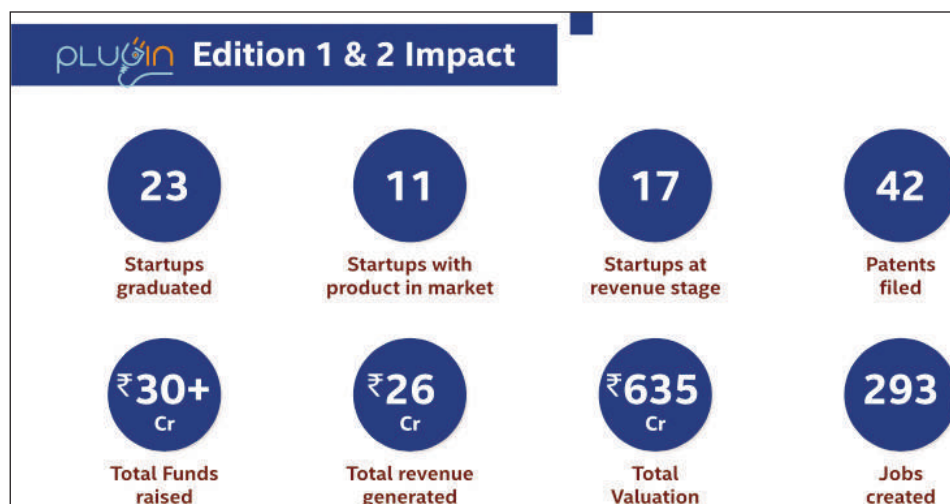
DST has partnered with the Texas Instruments to scout, motivate, validate and incubate Engineering students driven innovative design ideas with commercial potential under Make in India anchored by MyGov platform and implemented through NSRCEL, Indian Institute of Management, Bangalore. During the current version of the program, AICTE

has joined hands and came on board as the knowledge partner. In IICDC, during last three years of successful implementation has witnessed increase in participation from students exceeding one lakh in numbers from over 2100 universities/colleges. Total 175 Indian patents were filed out of which 2 have been already granted patent. Nearly 1023 e-CELL of colleges are engaged in this program. 236 Faculty members have been recognized for outstanding contributions and contributed in all phases of the program.

3.0 First hardware acceleration and incubation program: Plugin by DST-Intel India and SINE- IIT Bombay conducted in 2019-20

Plugin, the government-industry-academia collaboration (DST; Intel India; SINE-IIT Bombay) is a unique, one of its kind, one year accelerated incubation program to support hardware & electronics systems startups in the country. The program aims to help startups to get customer & business model validation, develop their products, assist in go-to-market strategies. Components of the program include cash support (for Edition 1&2 an upfront cash support of INR 10 lakhs per startups was given). For the 3rd edition of 2019, a total of 206 startups were received and top 20 startups were shortlisted by an external jury panel for the Plugin bootcamp, held during January 17-20, 2020 in Bangalore. The top 10-11 startups have been selected for full program benefits of Plugin on 1st March 2020, which includes seed funding to top 3-4 startups as convertible equity to be given towards the end of the program, apart from training, one-on-one mentoring, technical support from Intel mentors, business service support, product development support, and international ecosystem learning visit. So far, a total of 25 startups have been supported through 2 editions of Plugin of which 23 of them are operational as of January 2020. Over three years into implementation, Plugin has become a benchmark for many other programs which were introduced later.

Impact of Plugin Editions 1&2



4.0 Mentorship Program: “Women Entrepreneurship and Empowerment (WEE)”

WEE (Women entrepreneurship and empowerment) Mentorship program is 4-month program initiated by WEE Foundation to empower and encourage women entrepreneurs. It facilitates training women in entrepreneurship skills, mentoring and enabling them to convert their idea(s) into a successful business models. During the year, one WEE program was conducted at IIT Delhi. Top 5, out of the cohort of 40 women entrepreneurs were awarded upto Rs.5.00 lakh each.

3.4.3 Other Programs

1.0 i-STED (Innovation, Science and Technology led Entrepreneurship Development) Programme

i-STED programme is five-year project, aimed at supporting micro-enterprises in semi-urban or rural people focusing on products targeting domain specific, area relevant validated innovative technologies. During F.Y. 2019-20, 11 ongoing projects were supported across the country. No new proposals are being supported, as the programme has been recommended for discontinuation by EFC from F.Y. 2017-18.

2.0 New Generation Innovation and Entrepreneurship Development Centre (New-Gen IEDC)

NSTEDB, DST has supported **26 academic institutions under the program** located in **13 States** namely; Andhra Pradesh, Assam, Gujarat, Haryana, Karnataka, Maharashtra, Meghalaya, Punjab, Rajasthan, Tamil Nadu, Telangana, Uttar Pradesh, Jammu & Kashmir. Some of the important host institutions are; University of Kashmir-Srinagar, Indian Institute of Technology (IIT)-Guwahati, Indian Institute of Information Technology-Allahabad, Jawaharlal Nehru National College of Engineering, Shimoga, DattaMeghe Institute of Medical Sciences, Wardha, Sumathi Reddy Institute of Technology for Women, Warangal, College of Technology and Engineering, Udaipur, Dr. MGR Educational and Research Institute, Chennai etc.

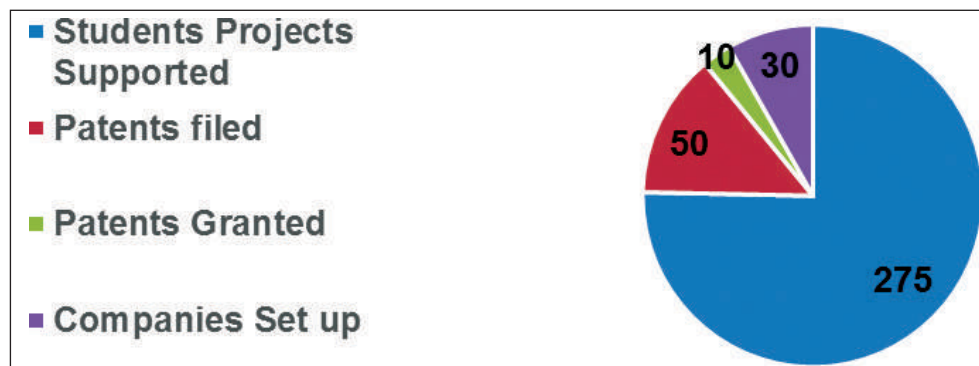


Fig: Key Impact of New Gen IEDC

3.0 Training Programmes on Entrepreneurship

The training programmes on entrepreneurship are conducted under NIMAT Project by national implementing agency i.e. Entrepreneurship Development Institute, Gandhinagar, Gujarat. The Training programmes of NSTEDB are aimed at creating trained human resources in entrepreneurship with requisite knowledge, skills and aptitude. Various modules of training i.e. Entrepreneurship Awareness Camp (EAC), Entrepreneurship Development Program (EDP), Women Entrepreneurship Development program (WEDP) and Faculty Development Program (FDP) are conducted by various entrepreneurship agencies. These programs had geographical coverage in nearly all the states and union territories across the country.

Table: Training programs on Entrepreneurship conducted during F.Y. 2019-20

S. No	Programme	No. of Programmes Sanctioned	Programme %
1	EAC	1585	77.50
2	EDP	120	5.87
3	WEDP	86	4.21
4	TEDP	134	6.55
5	FDP	120	5.87
	TOTAL	2045	100.00

3.5 National Council for Science & Technology Communication (NCSTC)

Public awareness of science as well as promotion of scientific temper amongst masses are two major objectives of Indian science communication programme spearheaded by the NCSTC, DST. Highlights of various activities and achievements are summarized here under different areas:

3.5.1 Content Development Programme

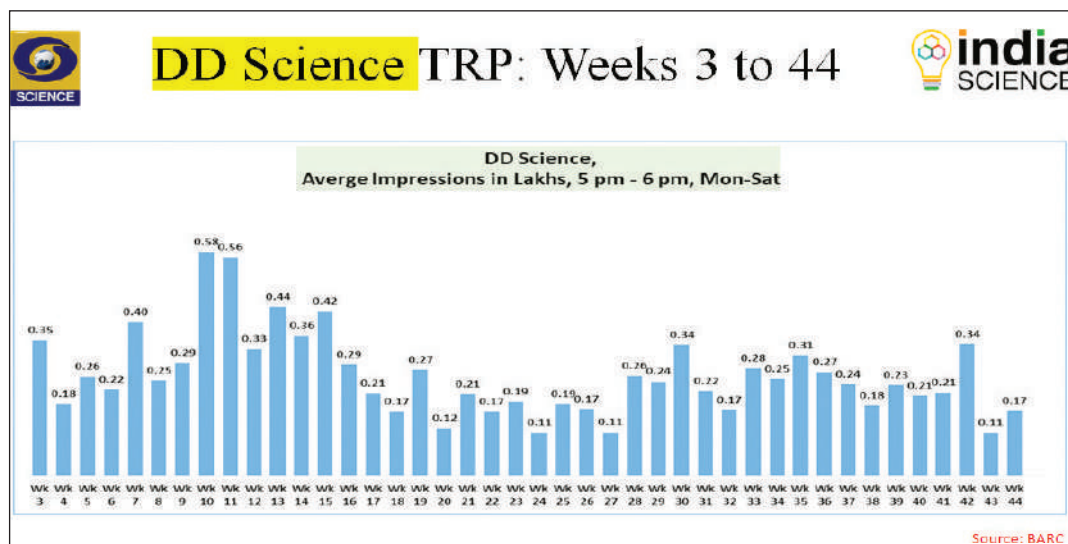
Science Channel:

The Science Channel project, covering DD Science for DTH as one-hour slot on DD National and India Science as a 24x7 internet-based OTT channel, was mandated to Vigyan Prasar by DST and formally inaugurated by Hon'ble Union Minister for Science and Technology, Dr Harsh Vardhan.



Fig. Dr. Harshvardhan, Minister of Science & Technology and Earth Sciences addresses at the launch of DD Science

Ever since January 15, 2019, DD Science has been available on DD National from 5 pm to 6 pm, Monday to Saturday. Similarly, India Science has been available on the web (www.indiascience.in) and as downloadable apps on Android and iOS smartphones. Both the channels have a mix of English and Hindi films, comprising documentaries, interviews, studio-based discussions, weekly wrap-ups of science news, etc. A total of 619 programmes have been produced since launch of the Channel. All films produced by Vigyan Prasar are hosted on India Science, while some are telecast on DD Science based on relevance and audience interest. DD Science has been telecasting one Hindi and one English film every day, from Monday to Saturday since January 15. A weekly science news wrap-up programme in Hindi and English is telecast every Monday.



India Science has a predominantly youth audience, who consume content mostly on smartphones. As much as 72% of the audience accessed India Science on smart phones while desktops/laptops brought 26% of the audience. The rest of the audience used tablets or i-pads. The OTT channel has so far been accessed from 144 countries, of which India constitutes 85% of the audience.

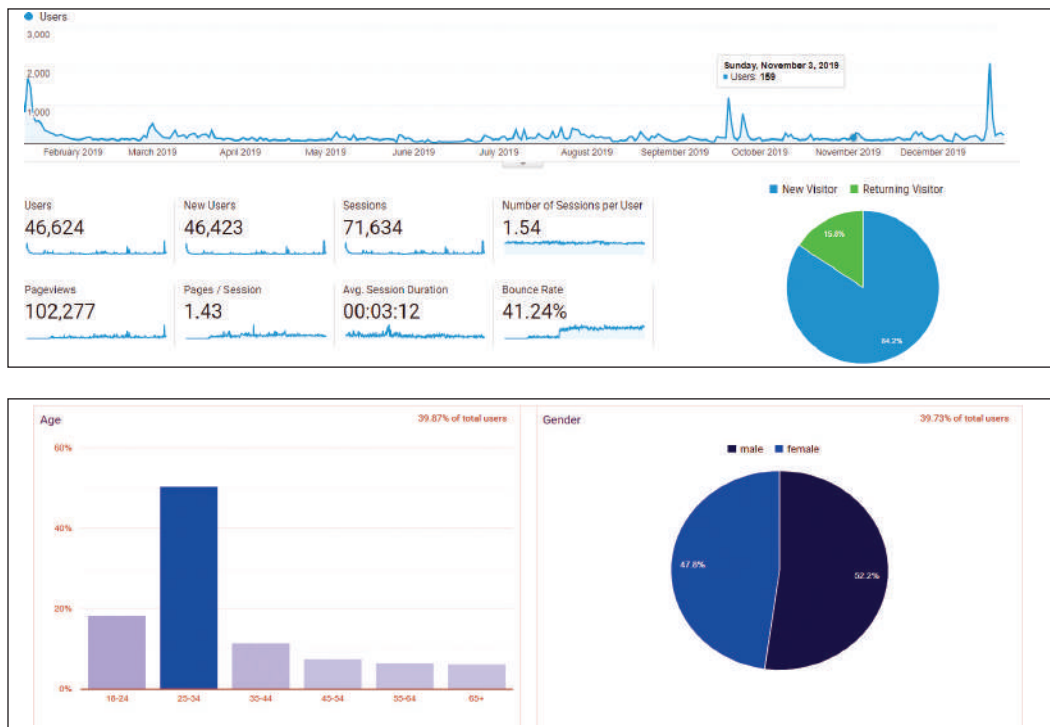


Fig. Global reach of OTT Channel India Science

Development of S&T Content on Wikipedia in Indian Languages

Development of S&T Content on Wikipedia in Indian Languages - a new initiative which supports the government's Digital India and Information for All vision. The key objectives of the initiative are as follows:

- To scale up the qualitative S&T content on Wikipedia in Indian languages
- To build the S&T open knowledge communities for sustainable growth of Wikipedia and other similar platforms sharing knowledge. The communities may include students, teachers, schools, lecturers, professors, Wikipedia enthusiasts, Wikipedia volunteers, organizations, institutions, etc.
- To promote the S&T content so as to create awareness of the available knowledge resources for the need to contribute to community knowledge creation.

- d) To employ technology by fine tuning the natural language processing tools for Indic Languages, by development of machine translation framework and using bots.
- e) To upload created S&T content in Indian Languages on Wikipedia.

The beneficiaries of this initiative would be all the citizens of India and global communities, especially those interested in Science and Technology information in Indian languages. Proposals from IIIT Hyderabad, IIT Kanpur and CDAC- Noida have been recommended in-principle for DST support.

3.5.2 Professional Development Programme

Augmenting Writing Skills for Articulating Research (AWSAR)

First national competition for ‘popular science story’ submission was organized under AWSAR, a unique initiative of Department of Science and Technology (DST) that aims to connect existing gap in communicating research to common person by utilizing the latent potential of PhD Scholars and Post-Doctoral Fellows (PDFs). AWSAR Award ceremony was organized on the National Science Day, 28 February 2019 to felicitate the awardees of top three stories under PhD Category and one outstanding story under PDF category. A book compiling AWSAR awarded articles on 124 popular science stories under both PhD and PDF category was released by Secretary, DST, during the interaction meeting with Science Correspondents on 12 September 2019. Six workshops were organized at Chennai, Gandhinagar, Kolkata, Guhawati, Delhi and Lucknow to guide scholars about “How to write a popular science article”. More than 600 scholars attended these workshops.



Fig. Presentation of AWSAR Awards and release of publication

National Awards for S&T Communication and Popularization

NCSTC instituted National awards in 1987 to stimulate, encourage and recognize outstanding efforts in the area of science popularization and communication. Presently, there are six awards given as follows:

- *National Award for Outstanding Efforts in Science & Technology Communication in general:* It is presented to an individual or an institution for outstanding work in communication of science and technology and/or promoting of scientific temper which had the widest impact in the country during the past five years. The award consists of Rs.5, 00,000/- (Rupees Five Lakhs), a memento and a citation.
- *National Award for Outstanding Efforts in Science & Technology Communication through Print Media including Books and Magazines:* The award is presented to an individual or an institution for outstanding efforts in popularization of science & technology and/or promoting scientific temper through books, magazines, Internet, etc, during the past five years. The award consists of Rs. 2, 00,000/- (Rupees Two Lakh), a memento and a citation.
- *National Award for Outstanding Efforts in Science & Technology Popularization among Children:* The award is presented to an individual or an institution for outstanding work in popularization of science & technology and/or promotion of scientific temper among children which has had the widest impact in the country during the past five years. The award consists of Rs. 2, 00,000/- (Rupees Two Lakh), a memento and a citation.
- *National Award for Outstanding Efforts in Translation of Popular Science & Technology Literature in Languages Mentioned in the Eighth Schedule of Constitution of India and in English:* It is presented to an individual journalist or an institution for outstanding work in translating popular science and technology literature in and from regional languages during the past five years. The award consists of Rs. 2,00,000/- (Rupees Two Lakh), a memento and a citation.
- *National Award for Outstanding Efforts in Science & Technology Communication through Innovative and Traditional Methods:* It is presented to an individual correspondent or an institution for outstanding efforts in communication of science & technology and/or promotion of scientific temper through print media during the past five years. The award comprises Rs.2,00,000/- (Rupees Two Lakh), a memento and a citation.
- *National Award for Outstanding Efforts in Science & Technology Communication in the Electronic Media:* This award is presented to an individual correspondent or an institution for outstanding efforts in communication of science & technology and/or promotion of scientific temper through radio and/or television media during the period under consideration. The award comprises Rs. 2,00,000/- (Rupees Two Lakh), a memento and a citation.

3.5.3 Hands-on Science Programme

National Children's Science Congress 2019

National Children's Science Congress (NCSC) is a flagship programme of the Department of Science & Technology to initiate the young students of the age group of 10-17 years in the

process of scientific thinking and satisfying their quest for scientific knowledge through doing projects. Started in 1993 by National Council of Science and Technology Communication (NCSTC), NCSC encourages a child scientist to identify some societal problems and motivate to arrive at a possible solution through his research based solutions. The process encourages the scientific thought process of child scientists, analyses an application of scientific theories to the problem solving through innovative approach. NCSC covers almost all the districts of the country with a participation of over 500,000 students. Through a process of evaluation, best of promising ideas and projects were shortlisted for presentation at State level. The current edition of National Children's Science Congress is being convened with a theme of Science Technology and Innovation for Clean, Green and Healthy Nation.

About 655 projects were shortlisted for a presentation at national level. This included 15 projects of Indian children studying in school in Gulf countries. The whole process of NCSC is guided by an Activity Guide Book (AGB) which was prepared in consultation with experts. The final of NCSC was held during 27-31 December, 2019 at Thiruvananthapuram. Eminent scientists from agencies like Bhabha Atomic Research Centre, Homi Bhabha Centre for Science Education, Indian Institute of Science Education and Research, ISRO participated in NSCS and interacted with the participants and address their queries.

Rashtriya Kishore Vigyanik Sammelen

The Child Scientists from the best projects of NCSC 2019 also participated in Rashtriya Kishore Vigyanik Sammelen held at University of Agricultural Sciences, Bengaluru as part of 107th Indian Science Congress during 4-6 January, 2020. The students got an opportunity to interact with the best of the Indian scientists who visited their exhibition during the Indian Science Congress.

Low Cost teaching-learning Aids

Training workshops were supported in different states such as Andhra Pradesh, Goa, Madhya Pradesh, Punjab, Haryana, Himachal Pradesh, Uttarakhand, Rajasthan, etc. with an aim to empower teachers in understanding the importance of learning through hand-on and/ or through one's own personal experience. Regional training workshops on 'Teaching Mathematics through Origami' were organised for school teachers and other mathematicians working in professions related to Mathematics in Punjab, Haryana, Himachal Pradesh, Uttarakhand and Rajasthan. Workshops were supported for making Mathematics learning interesting and enjoyable through innovative and interactive methods. 163 Mathematics teachers were trained with guidance from the well-known Origami expert, Sh. VSS Sastry. The workshops imparted skills to teachers for promoting hands-on learning of Mathematics among students by training them to use their motor skills to fold and crease paper into fun shapes and structures and build skills involving spatial reasoning, following precise directions in sequence, fractions, geometry, etc.

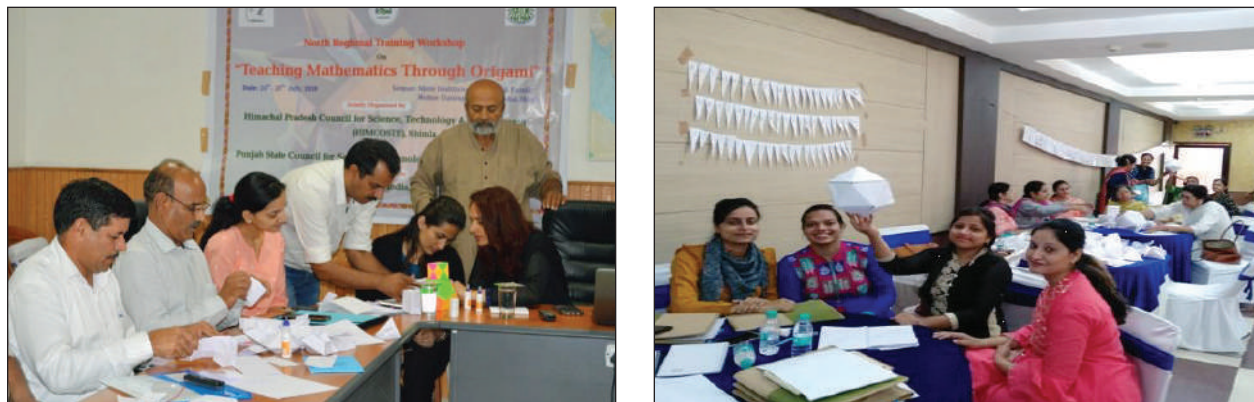


Fig. Workshop on Mathematics through Origami

Explaining Science behind so-called Miracles

Training workshop and performances were supported in different states such as Assam, Jharkhand, Uttar Pradesh, Uttarakhand, Haryana, and Madhya Pradesh, to create local activists (science communicators) who can go to the field and expose prevalent blind beliefs and help inculcate scientific temper among the masses. Training workshops and awareness programmes were carried out in three districts of Haryana i.e. Karnal, Panipat and Jind. 247 participants attended the workshops and after the workshop, performed activities in 125 schools and 43 gram panchayats, and also directly reached to 93167 people under awareness programme.

Science Exhibitions on Wheels

Mobile Science Exhibitions/ Mobile Science Lab (MSL) is a unique initiative. It aims to generate awareness and reach the unreached with the message of effective Science Communication and for developing scientific temper among the masses, especially students at their school premises. The activities include science model exhibition, regular sky gazing camps through telescope and scientific explanation to so-called miracles, etc. The target group for these activities includes general public, school & college students, youths, women, teachers, gram panchayat members, voluntary organizations and policymakers, etc. This includes schools from interior, rural and peri-urban areas; and focusing on those from aspirational districts. One such Mobile Lab is being run by Vikram A. Sarabhai Community Science Centre (VASCSC), Ahmedabad. It directly reached out to 119 schools. The project included schools from aspirational district of Dahod and schools in other districts from interior and rural areas. 33673 students and 1279 teachers participated in activities of the Mobile Science Lab. In Punjab the Mobile Science Exhibition (MSE) bus is equipped with 24 indoor and outdoor interactive exhibits and information panels, which will give students/visitors an opportunity to learn through the process of interaction and discovery. The broad components of exhibition are Health Education, Energy Education, Waste Management, Water Management and

Environment Education. Besides, MSE is also equipped with Mobile Planetarium. During the year 2019-20, 490 schools comprising 79992 Students, besides 32432 general public visited MSE bus from April 2019 to December 2019. The main focus of MSE during the year was on Swachh Bharat Mission. STEMM BUS run by ANMOL in Delhi region has many interactive and information Science exhibits and informational models, which give an opportunity to learn science through the process of interaction and discovery, with an emphasis to develop an informed and knowledgeable society. The team of bus is also conducting activities like Fun with Science, quiz competitions, poster making, Science lectures and Science Magic workshops side by side at different locations. The bus has been on tour since April 2019 covering many govt., semi govt., pvt. Schools and many public places, aiming at reaching out to the people from all walks of life. The bus has covered approximately 102 schools and many Public places. Almost 25000 students have visited the bus along with approximately 1700 teachers. Similar kind of Mobile Science Exhibitions / Lab Buses also run in Assam, U.P, Haryana, M.P, Kerala, and Andhra Pradesh for Science Popularization. STEMM-Mobile Science Exhibition Buses is a new initiative, a joint endeavour of NCSTC, DST and National Council of Science Museums (NCSM), Ministry of Culture. it is a collaborative effort of its division NCSTC, programme INSPIRE/ MANAK and Vigyan Prasara. This comprises of twenty five mobile science exhibition (MSE) buses fitted with exhibits on scientific topics, jointly finalized by NCSM and DST. The initiative aims to trigger the spark among the rural children for nurturing interest in Science in of 117 Aspirational districts in 28 states.



Fig. Mobile science exhibition visits rural areas

3.5.4 Science Literacy Programme

National Science Day (NSD) & National Mathematics Day (NMD)

The National Science Day 2019 programme was supported all over the country on the theme, "Science for the People and People for Science", through State S&T Councils.

Celebration of National Science Day begin or culminate on 28 February and activities such as essay competitions, painting competition, science lectures, debates, quizzes, exhibitions, lectures, workshops, awareness programmes, etc. were organized in states through schools, colleges, universities, R&D laboratories, S&T based NGOs, academic institutions etc. These activities are organized nationwide through State S&T Councils. Subsequently, National Mathematics Day 2019 programme was supported all over the country through State S&T Councils. Celebrations of National Mathematics Day begin or culminate on 22 December to commemorate the birthday of Srinivasa Ramanujan, the great mathematician, with a focus on popularizing Mathematics.

Science communication through folk forms

Training workshops and awareness programmes were supported in different states such as Jharkhand, Madhya Pradesh, Orissa, Karnataka, Punjab, Tamil Nadu, and Uttarakhand with an aim to develop resource persons as science communicators through folk media. Training workshops were organized in 5 districts of Karnataka State – Gadag, Koppal, Dharwad, Bagalkote, and Haveri. During the workshops, 390 young science communicators among teachers, students and professional folk artists were trained which also resulted in a manual in Kannada on “Puppetry and Science communication in Education”.

Bharat Vigyan Darshan- STEMM India

‘Science, Technology, Engineering, Mathematics and Medicine (STEMM) India’ activities comprise of Science fairs, melas, expositions, mobile science exhibitions, lecture-demonstrations, interactive media, visits to S&T establishments like labs and industry, hands-on-STEMM activities, and so on. Different kinds of demonstrations on a variety of STEMM themes and also on environment, health, medicine, etc. are held across the nation. Science exhibition is one of the most important activities to create and enhance scientific knowledge of children, teachers, parents, people’s representatives and common man. It also brings about change in their attitude. DST initiated static and mobile Science Exhibitions, Motivational Talk visits to S&T establishments like labs and industry, S&T Fairs, Basic Science experiment workshops, technology and innovation workshops, etc. besides lectures, Hands-on activities, demonstration of workmanship on different engineering processes, technological development and innovative methods. More than 64 static and mobile exhibitions were organized in Andaman & Nicobar Islands, Andhra Pradesh, Arunachal Pradesh Assam, Chattisgarh, Bihar, Delhi, Punjab, Madhya Pradesh, Jammu & Kashmir, Jharkhand, Haryana, Uttarakhand, Uttar Pradesh, West Bengal, Orissa, Rajasthan, Tripura, Kerala, Nagaland, Manipur and Maharashtra.



Fig. Children at science mela

26th MTNL Perfect Health Mela was organized by Heart Care Foundation of India (HCFI). NCSTC participated in this event for science popularization & outreach activities for students & general public and organized exhibition with science activity corners 18th-20th October 2019 at Jawaharlal Nehru Stadium, New Delhi. 40000 people from all age groups and walks of life visited the Mela on the theme Fit Delhi - Fit India with Mottos "Mein Fit to Hai India Fit" and "Mein Khush to Hai India Khush". 3000 children participated from slum areas. More than 3600 children from over 100 Schools and Colleges participated in 52 health competitions with the help of 1000 volunteers and 129 organisations including 18 government departments. 220 specially challenged children from 11 schools were sensitised. NCSTC put up a Mobile science activity bus, Taramandal and science activity corners from 16th Oct to 20th October 2019.

India International Science Festival 2019

With an endeavor to promote scientific attitude amongst masses including young students, NCSTC set up an activity corner in the DST pavilion during the India International Science Festival (IISF) 2019 from 5-8 November, 2019 at Kolkatta. The prime objective of the IISF is to instil scientific awareness amongst the masses and showcasing India's contribution in the field of science & technology over the years. It was inaugurated by Dr. Harsh Vardhan, Hon'ble Minister for S&T and ES on 5-8 November, 2019. Apart from routine activities, there were corners like Hydroponics, Vermin composting, fun with science, Low cost, aids Science behind Miracles, etc.



Fig. Prof. Ashutosh Sharma, Secretary, DST interacts the IISF delegates

Mission Eco Next

Eco Eureka and Eco Studio Trainings/Workshops:

Youth engagement workshops, Eco Studio and Eco Eureka Workshops, are supported about instilling scientific temperament among the young minds by adopting experiential learning methodology. Youth/ students from various parts of Palakkad District of Kerala State were engaged in the five days Eco Next Studio workshop focused on capacity, imagination Skill/ Competence Building. They also identified based on GIS the landslides which happened in 2018 and Kerala Floods of 2019. Eco Next Studio trainings under the initiative through Madurai Kamraj University, Madurai have led to sensitized citizens of protecting our own ecological and natural resources.

In Coimbatore District of Tamil Nadu students attended the five days Eco Eureka workshop and got an opportunity to learn about local ecology and environment. Eco Eureka trainings were also conducted by TERI for the age group of 18 – 25 years, in Delhi, Bangalore and Goa by about 60 experts for around 250 students drawn from different disciplines on environment and sustainability, Science Communication and WASH related issues.

Eco Eureka & Eco Studio Trainings involving nature trails and field workshops were organized by KSKV Kachchh University, Bhuj for the selected youth from various fields and hone their leadership skills as 'Young Change Makers' through eminent mentors for reaching with their message to the community on the issues that are climate change induced in environmentally vulnerable zone and its marginalised population in rapidly degrading Kachchh region.

The farmers of different agro-climatic zones of Himachal Pradesh have become eco literate on various aspects of climate change and variability. The eco literacy was enhanced by training about 400 farmers and officers of development departments of the state at YS Parmar University of Horticulture, Nauni, Solan and generating 50 Eco-risk managers from all agro-climatic regions of Himachal Pradesh. The Eco-risk managers are continuously in touch with the university scientists for time to time agro-advisories in context to climate variability. Now the farmers have been equipped with appropriate location specific adaptation and mitigation strategies by offering the practical solution of the problems and supplying relevant literature.

Eco Routes: Eco and wash dialogues for eco intelligent rural rejuvenation field capacity enhancement for states of Uttar Pradesh, Uttarakhand: The disadvantages like water stress or weather extremes was converted into advantage through scientific knowledge dissemination on Integrated watershed management, afforestation provision of alternate livelihood ensured that communities are not affected by vagaries of climate change. Training people, creating champions of change along with government functionaries and community together made the initiative policy wise viable and sustainable.



Convergence meeting of stakeholders with officials Chitrakoot



Multi Stakeholder consultation Bahraich

Eco Media Dialogues and Training of Trainers (E3 Lab) on Eco Media, Eco Design and Eco Innovation centered Science Communication:

Eco Media Dialogues, under multistate youth eco talent development campaign, have been held in Uttarakhand, Himachal Pradesh, Madhya Pradesh and Rajasthan on science communication and eco media for eco cultural rehabilitation and participants were identified for working on Green Media in their respective regions. Training of Trainers (E3 Lab) on Eco Media, Eco Design and Eco Innovation centered Science Communication has been organized for trainers from Uttarakhand, Himachal Pradesh, Madhya Pradesh and Rajasthan who are now training the youth as Young Community Advisers on eco conservation and eco innovations.

Eco Digital Literacy Campaign

As part of the Eco Digital Jan Vigyan Jagriti outreach programme in Aspirational and Eco Rise Districts of Tamil Nadu, Karnataka and Andhra Pradesh, many innovative activities on Eco Digital awareness for youth were organized by P.N. Panicker Foundation, Thiruvananthapuram. This is giving impetus to opportunities for youth in green economy sector as trained youth also served as youth skill facilitators in diverse capacities of eco media educators with schools, young community associates & advisors with Panchayats, Grama Sabhas, SHGs, NGOs etc.

3.5.5 Cooperation in Science Communication

UNESCO Kalinga Award & Kalinga Chair for Science Popularization (Biennial)

The UNESCO Kalinga Prize for Popularization of Science is a prestigious award given by UNESCO for exceptional skills in presenting the scientific ideas to lay people. The Prize is co-funded by DST, Government of India, Kalinga Foundation Trust and DST, Government of Orissa. The recipient receives US\$40,000 and a UNESCO Albert Einstein Silver Medal.

The recipient is also awarded the Kalinga Chair, introduced by the Government of India in 2001 to mark the 50th anniversary of the Kalinga Prize. As holder of the Kalinga Chair, the winner visits India for a period of 2-4 weeks as the guest of Government of India. The Chair also comprises a token honorarium of US\$5,000.

Prof Erik Jacquemyn from Belgium is the winner of UNESCO Kalinga Award for Science Popularization for 2017. He was invited by Secretary, Department of Science and Technology to visit India as guest of Government of India for duration of 2-4 weeks to give lecture in various cities in India. Prof Jacquemyn was awarded the Kalinga Chair.



Fig. Prof. Erik Jacquemyn from Belgium, UNESCO Kalinga Prize Winner visits DST

3.5.6 Recognition for NCSTC

Indira Gandhi Prize for Popularisation of Science for 2020 has been announced by the Indian National Science Academy (INSA) during its Anniversary General Meeting held on 16-18 December 2019 at Goa. Dr. Manoj Kumar Patariya, Scientist 'G', NCSTC has been awarded the Indira Gandhi Prize for Popularisation of Science for 2020 under the category of science popularisation efforts in English language by career media personnel. The award carries a cash prize of Rs. 25,000, a memento and citation. The INSA awards are to be conferred on the awardees in a function to be held in 2020.

3.6 Science for Equity for Empowerment and Development (SEED)

Science for Equity for Empowerment and Development (SEED) Division of DST has been implementing several field-based schemes & programs with a view to integrate Science & Technology (S&T) primarily to enhance livelihood opportunities and the quality-of-life of different cross section of the society, through adaptive research, capacity building and skill development at local level. Initiatives taken through such technology driven field-based interventions have been contributing to address UN-Sustainable Developmental Goals (SDGs) 1-8,10-11, 13-15 & 17 as well as in National development programs like Unnat Bharat Abhiyan, Sugamya Bharat Abhiyan (Accessible India Campaign), Swachh Bharat

Abhayanand so on. Specific achievements made during the year under various schemes/ programs are as under:

3.6.1 Technological Advancement for Rural Area (TARA)

Long Term Core Support: SEED Division of DST extended long term Core Support under Technological Advancement for Rural Areas (TARA) scheme to select S&T capable NGOs to enable them primarily to provide affordable technological solutions to challenges in rural as well as remote settings through adaptive R&D under field conditions. These groups having strong linkages with R&D labs/ academic institutions for technical backup support besides in-house capabilities - play crucial role in technology scaling, delivery & adoption in respective geographical area with local institutional arrangements to empower local community in utilizing field-tested technologies and packages.

Specific Outcomes: Core Groups & Social Innovation

- a) **Education Box with offline server (Edu-Box V.03) for E-education:** Barefoot College, Tilonia, Rajasthan developed the above product that ignited the teaching sector by giving freedom to teachers/students to bring in curriculum all around the world at a touch of a button. This innovative product has an inbuilt SOC (system on chip), contains a 550 lumens projection unit backed with 18 Ah lithium-ion batteries that can last throughout a classroom session and can give access to 50+ individual nodes at a point in time. Currently, 46 schools across the country are using this innovative product catering to 1500 children from low resource communities.



Solar/grid-based Edu-Box V.03 developed by Barefoot College, Tilonia for non-formal education systems

- b) **Technology packages for flood resilient farming:** The Gorakhpur Environmental Action Group (GEAG), empowered the marginalized farming communities in flood prone areas of Eastern Uttar Pradesh and Bihar through innovative technologies such as gradient based cropping system, elevation-based farming, post-harvest, drainage improvement and scaling up related knowledge (fig). The flood resilient multi-layered farming with

appropriate crop combinations reduced the input cost by 30-35% among 265 households. More than 2000 farmers used short term weather and agro- advisory in agricultural practices reducing input cost by 10-30%. The use of gradient based cropping system reduced crop losses by 30-33% and thus enhancing the gross income of farmers by 66%. The total annual turnover of such social enterprise during 2018-19 was around Rs 52,000 for rendering different services, and 29 self-managing community institutions extended knowledge about technologies to 1091 households.



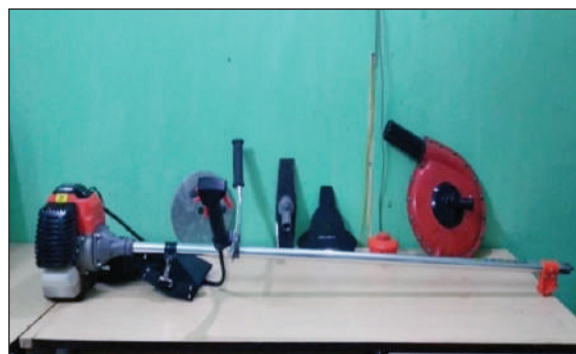
Adoption of multi layered farming system for improved farm productivity in flood affected village Rakhukhore, Gorakhpur, UP

- c) In order to address the livelihood issues of animal-human conflict affected tribal population in the fringe areas of National parks, **WWF-India** has developed S&T based alternative livelihood opportunities. Conservation issues in protected areas of Corbett landscape of Uttarakhand were addressed through value addition and skill development in food processing sector through 6 Self Help Groups (SHGs) in 6 villages of Ramnagar and Kotabag blocks of Nainital district. Corbett Gramin Mahila Sangathan (CGMS), an SHG federation consisting of 75 rural women was formed to provide sustainability to the initiative. CGMS got the certification from Food Safety and Standard Authority of India (FSSAI) for quality and standards. Total revenue of Rs. 2.50 lakh was earned by the women from sale of various food products till end of December 2019.

A handicraft-based enterprise development for women artisans belonging to Tharu tribal community in Dudhwa Tiger Reserve in Uttar Pradesh was also supported. The traditional looms used for weaving were upgraded for increased productivity with reduced drudgery by introducing Garari system (Pulley & ratchet) in the looms along with

rope rolling system and installation of two pairs of paddles in the loom for simultaneous work by two weavers on a single loom. A fiber glass shuttle was made which was found to be lighter than the original wooden or iron shuttle to operate. These interventions reduced inconvenience caused to the women by reducing their day to day drudgery and increased efficiency of operations. Tribal Co-operative Marketing Federation of India (TRIFED), placed an order to THGU for products worth Rs. 9.00 lakh for three years from 2018 to 2020.

To address forest fire issues, user friendly tools and equipment were developed for forest fire management at the community level(Fig). Two devices were locally designed, developed and field tested in Pilibhit Tiger Reserve in Uttar Pradesh. A sprayer was modified with high end engine of 50 cc (2 strokes) for spraying water and blowing leaf litters for cleaning and developing fire lines. A high-end blower-cum-cutter was developed for cutting grasses and shrubs.



User-friendly tools and equipment developed for forest fire management

3.6.2 *TIME-LEARN Program for Mountain Community*

Technological Interventions for Mountain Ecosystem: Livelihood Enhancement through Action Research & Networking (TIME-LEARN) for North-Western Himalayas address mountain specific challenges with innovative technology development/ demonstration initiatives for mountain community. Under this action research program, in Himachal Pradesh, Y S Parmar University of Horticulture and Forestry, Nauni, developed effective alternative to chemical pesticides. Farmers from six villages in Mandi district were trained for preparing botanical formulations using locally available plant material. Farmers growing tomato, capsicum, cauliflower, peas and exotic vegetables reported 10% enhanced yield and better quality when compared to use of chemical fertilizers and pesticides. Technology package resulted in 20-30% reduction in production cost and 20-30% increase in the profit margins per unit area of the land.

Another project in Uttarakhand by field-based S&T capable NGOs like Development Alternatives, New Delhi in collaboration with HESCO, Dehradun developed following

packages on resource efficient multi-hazard resistant construction technologies for the disaster-prone areas:

- Improved Random Rubble Masonry for foundations and walls till sill level
- Masonry construction with corner reinforcement and horizontal bands for earthquake resistance and ductility.
- Locally produced concrete blocks as masonry units for wall using a well graded cement concrete mix.
- Locally produced stabilized compressed earth blocks for masonry.
- Pine wood shingle roofing on timber under-structure.
- Pre-cast RCC plank and joist roof system
- Precast RCC door window frames.

3.6.3 *Scheme for Young Scientists and Technologists (SYST)*

The SYST was evolved during 2019-20 through identification of thrust areas, which are currently pertinent and futuristic for societal development.:

Artificial Intelligence and IoT for Societal Application in

- Agriculture
- Rural Development
- Disaster Management
- Health

Hybrid Solar PV Technologies with Wind Generators

Robotics for Societal Application

Agricultural Tools and Agriculture Produce

Nutritional Supplements and Value Added Food Products for Human and Animals

Plant Based Health Products

Scientific Validation and Upscaling of Traditional Knowledge Systems

Cost Effective Health and Hygiene Aids

Effective Indigenous Methods of Disease Identifications and Monitoring

Natural Resource Based Livelihood Systems

Strategic Agricultural Practices

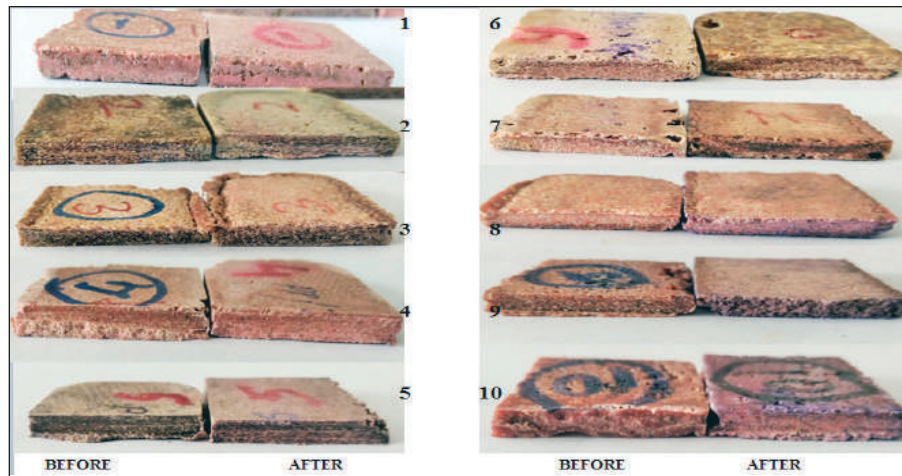
Captive Cultivation & Breeding

Environment Sustainability

Accordingly, an overwhelming response was received against the 'Call for Proposals' with 839 proposals received under the identified thrust areas. In current financial year, 60 proposals were recommended for support. In last five years, 77 young women scientists and 99 young male scientists have been oriented towards socially relevant research through SYST.

Significant achievements for the projects funded under SYST are as given below:

- a) ***Green Cutting Fluid for Manufacturing Sector:*** Cutting fluids from non-edible oils for use in the metal cutting and shaping operations in the manufacturing sector were prepared from four different oils (*Neem, Karanja, Jatropha and Castor*). More than 2000 formulations were prepared and tested for their stability for 5 days under factory environment and most stable formulation was selected for further experiments to test other physiochemical properties. The viscosity of the formulation was found to be higher than the conventional machine oil. This indigenous, environment friendly green cutting fluid leads to reduction in dependency on petroleum based products and is expected to reduce occupational hazards such as respiratory diseases, skin diseases and cancers caused by exposure to cutting fluids among the industry workers.
- b) ***Hybrid Nanocomposites from Wood Dust and Plastic:*** Wood based industries in *Dimapur* and other districts of Nagaland generate enormous waste in the form of wood dust. National Institute of Technology (NIT), Nagaland developed wood polymer hybrid nanocomposites using wood dust and waste plastic (Fig). Depending on the composition and lignin content, the developed wood composite blocks showed comparable mechanical properties such as tensile strength which was found in the range of 5.6-28.7 MPa as compared to market based similar product that showed less than 25 MPa under standard conditions. Due to the use of waste raw materials and value additions with newer properties in the product, cost of the composites compared to market based products will be lower. The composite showed great possibility to use the developed material as self-cleaning construction materials for outdoor applications thus creating an opportunity to generate wealth from waste.



Wood Polymer Composite (WPC) sample blocks before and after dipping in water for 28 days

- c) Smart Walking Stick and Umbrella for Elderly: Sensor and light integrated walking stick and umbrella for elderly was developed based on user feedback at old age homes (Fig). Walking stick was designed based on usability issues, stress-discomfort and pain point locations. For the re-design, anthropometry data was collected from Indian elderly about gluteal furrow, hand breadth without thumb at metacarpal, maximum grip diameter, fingertip depth, etc. The stick has features to send an alert to relatives/friends in case of a fall, alarm to commute an emergency situation and could also be used as a torch in case of darkness.

The umbrella was also designed using techniques of design thinking as used for walking stick. The user feedback was carried out on 19 primary and secondary users on a 7 point like rating scale. During the field trials 78% users approved the umbrella prototype for reducing the stress on shoulders compared to conventional umbrellas and 95% were happy with lighting and emergency alarms.



Walking Stick Prototype for Elderly



Umbrella Prototype for Elderly

3.6.4 Technological Interventions for Addressing Societal Needs (TIASN)

TIASN programme involves technology development and adaptive R&D for the benefit of society. Grant-in-aid is provided to R&D Institutions, Universities, and NGOs in the area of Agriculture, Health, Nutrition and activities related to Non-Farm sector. DST supported 7 projects in 2019-20 and some of the noteworthy achievements are given below:

- a) **Cost Effective Treatment of Psoriasis:** A nano carrier based drug delivery system was developed by Indo Soviet Friendship (ISF) College of Pharmacy, Moga, Punjab for Clobetasol propionate. Developed nanosystem displayed various advantages over conventional carriers, including increased solubility, permeability, storage stability, half-life, tissue-targeted delivery and reduced adverse effects. Effectiveness of the clobetasol propionate was enhanced by increasing its penetration through scaly keratinized barriers of stratum corneum. Developed systems showed 85% decrease in average Psoriasis Area and Severity Index (PASI) score as compared to marketed formulation which showed only 50% decrease in average PASI score. Nanosystems further showcased ~40% more retention in skin and 80% decrease of drug availability in systemic circulation as compared to marketed gel.

The overall treatment cost and time reduced to almost half with better penetration, retention, patient compliance and therapeutic effectiveness as compared to conventional dosage form (Table 1) thus reducing the cost of psoriasis treatment to half.

Table: Cost benefit analysis of psoriasis treatment

Cost of conventional formulation (Topinate gel 0.05% clobetasol propionate 30 gm)	Application frequency (1gm/sq. cm. of affected area)	Cost of conventional formulation (90 days of treatment)	Cost of nano formulation (0.05% clobetasol propionate 1gm)	Application frequency (1gm/sq. cm. of affected area)	Cost of nano formulation (42 days of treatment)
Rs 87 per pack	3 times a day	Rs783	Rs 10.42	1 time a day	Rs 437.64

- b) **Millet based Oral Rehydration Fluid for Diarrheal Condition:** Oral rehydration fluid was formulated with roasted foxtail millet flour, electrolytes such as sodium chloride (NaCl), potassium chloride (KCl), trisodium citrate dehydrate and fungal alpha amylase enzyme at Periyar University, Salem, Tamilnadu. Formulation was found nutritionally better when compared with glucose based Oral Rehydration Solution (ORS) to address dehydration during diarrheal disease. The developed ORS was low in viscosity and osmolality, which suits well to the children under the age group of 3 years. Clinical trials revealed that frequency and consistency of stools reduced to normal state and ORS intake

levels were reduced from 100-200ml/day to 50-100ml/day compare to control group. These formulas were found to be an excellent source for homemade fluid for diarrheal and nutritionally superior to ORS of World Health Organization.

3.6.5 Technology Intervention for Disabled and Elderly (TIDE)

The Technology Interventions for Disabled and Elderly (TIDE) programme provide scientific solutions for creating inclusiveness and universal accessibility for Divyangjan and Elderly by developing tools, technologies and techniques, that are affordable and adaptable to Indian built environments. The TIDE Programme thus complements the Accessible India Campaign (AIC) – Suganya Bharat Abhiyan and the assistive devices developed under the TIDE programme cuts across all the three verticals of Accessible India Campaign.

A two-day Conclave and Expo on “Assistive Technologies and Divyangjan” was also organized for the first time in the India International Science Festival (IISF) 2019 with more than 100 participants comprising of researchers, users, industry, practioners, NGO’s and policy makers. Deliberations were heldfor innovative approaches to solve the problem and creation of Disability Cells in all the State Science and Technology Councils.

While the major initiatives of the Government look at framing policies and providing rehabilitation services, the TIDE Programme had a wider perspective of scientific R&D of assistive technologies for providing greater autonomy to Divyangjan and Elderly through application of Science and Technology. Some of the ready to commercialize assistive technologies developed under the Programme during the year 2019-2020 are given below:

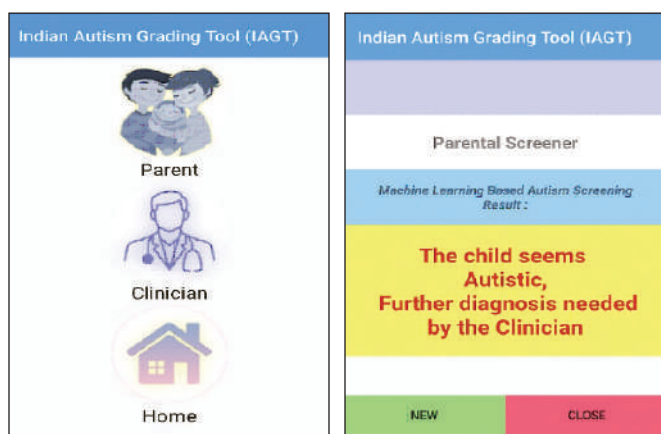
Speech-Input Speech-Output Communication Aid (SISOCA)

helps in improving intelligibility of dysarthric speech by correcting articulatory errors of cerebral palsy speakers. The device acts (fig) as an interpreter that recognizes disordered speech and produces its intelligible equivalent. SISOCA includes (i)

Assessment of the articulation errors made by the CP speakers and modeling errors, (ii) Speaker-dependent speech recognition system that converts unintelligible speech into text, (iii) Error correction system to correct the errors in the recognized text, with the assessment knowledge, using weighted finite state transducers (WFSTs), and a (iv) Text-to-speech synthesis system to synthesize the error corrected text into intelligible speech using a normal speaker’s voice. SISOCA involves no keyboard or visual intervention and the technique adopted is language-independent. The tool developed as a portable mode of AASC device using Raspberry Pi works not only for isolated words but also for phrases.



Text to Indian Sign Language Converter is a web based tool/app that converts educational texts in Hindi or English into sign language for communication and education of hearing impaired. The software takes English/Hindi text as input and passes it to generate lexical items as tokens. These lexical items are mapped to Hamburg sign language Notation System (HamNoSys) with the use of word to HamNoSys database. These HamNoSys words are converted to Signing Gesture Markup Language (SiGML) which is played by Signing Avatar. The Web and Mobile based application uses 3D Animation and follows ISL grammar rules. The tool support Speech to ISL Sign generation and is capable of Automatic Hindi Transliteration. This tool could be used in public places (such as railway stations) to convert announcements into sign language so that people with hearing impairment can get the information. It is first system of its kind which is available on web for conversion of English text/ Hindi text to Indian Sign Language where animations are generated in real time with the use of avatar. The tool could be accessed on web <http://www.islfromtext.in> or on Android Smartphone using the Android Application –Sanket (from Google Play Store)



Indian Autism Grading Tool (IAGT) has two interfaces (Fig). The first interface contains parental questionnaire for initial screening and the responses are processed with machine learning method and guide the parents to further reference. The second interface is CARS (Childhood Autism Rating Scale) based clinical diagnostic and grading tool. It has the multi-choice options for the clinicians to select their clinical observations for diagnosing ASD. The tool can grade the severity of the autism based on the machine learning method which can interpret all the

information and give the accurate results. The tool was developed in native languages rather than the translated version of western tools with the consideration of Indian socio-cultural settings.

DST in collaboration with DoEPwD and its autonomous R&D Institutions is in the process of developing new technologies including commercializing few technologies developed under TIDE Programme for the benefit of Divyangjan.

3.6.6 Science & Technology for Women Scheme

Science & Technology for Women Scheme was initiated in 1982 for empowering women through inputs of S&T for strengthening, their position in the society. This scheme aims to promote research, development and knowledge generation *w.r.t.* various stages of life of women. This is done through adaptation of technology for gainful employment, reduce their drudgery and provide better working scenario. It also looks into challenges to improve the

quality of life and provide better health through nutrition and other interventions of S&T. Some noteworthy achievements of the scheme are given below:

The scheme has been evolved with new thrust areas viz. Livelihood Status, Health, Nutrition and Sanitation, Entrepreneurship and Employment, Women Safety & Occupational Hazards and Indigenous Technological Knowledge taking into consideration the complete life cycle of women.

National Women Empowerment Atlas – S&T Perspective

To capture the spatial distribution of S&T factors influencing women empowerment, a national women empowerment atlas from S&T perspective was initiated for the first time in joint collaboration with the National Atlas & Thematic Mapping Organisation (NATMO) and Kirori Mal College, University of Delhi. The Atlas would visualize the gender gap in S&T domain at different spatial hierarchical level through maps, data and text. Various layers like livelihood, health, nutrition, sanitation; entrepreneurship, employment; Women in Science & Technology; Indigenous technical knowledge, women safety and occupational hazards, etc. It would provide ready reference material for policy makers, decision makers and planners.

Achievements during the year are as follows:

- (i) Dairy based agricultural activities, value added milk products and food preservation interventions to build capacity of identified rural women was taken up NDRI, Karnal. Thirty training programmes for more than 400 women beneficiaries were organized in two villages each from Sonipat and Panipat areas of Karnal district.
- (ii) Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore developed ready to eat flakes from foxtail millet with further value addition using medicinal ingredients namely flax seeds and Ashwagandha. Data related to socio-economic background, anthropometric measurement, dietary lifestyle pattern and family history of the selected women subjects were collected from five women institutions to capture the effects millet flakes. Stress assessment tool by ISMA, 2013 was used to assess the stress level of subjects. Awareness and dissemination regarding the health benefits of the developed flakes was done in 25 villages.
- (iii) G. B. Pant National Institute of Himalayan Environment and Sustainable Development, Himachal Pradesh & Jagriti, NGO developed post-harvest technology for wild Rosehips for creating sustainable livelihood option among rural women in Kullu Valley (Fig). Value added products like tea, oils and oil based personal care products were also developed. 24 SHGs of women were formed and more than 200 women were trained in making value added products from wild rosehips like rosehip mint tea, rosehip oil, etc. A brand "Mountain Bounties" for rose hip oil was established through this initiative.



Products from wild rose hips on display



Women plucking & cleaning wild rose hips

- (v) The Punjab State Council of Science and Technology (PSCST), Chandigarh implemented a project **Technological Empowerment of Women on Energy Generation from Rural Biomass** in Kandi region, lower Shivalik foothills, for value added products of biomass/waste. Intervention aimed at mapping of agricultural & forest waste, and disseminating the technology packages through capacity building programs for income generation and addressing – waste disposal without pollution & energy generation. The technologies include fuel pelletization and awareness about nutrient rich fodder production. The raw material used in the manufacturing of the fuel pellets are Lantana, pine leaves, paddy straw, paddy husk, wheat stalk and other agricultural and industrial byproducts which are a major cause of air pollution in the region. A fuel palletization machine was fabricated and installed at a demonstration site in Talwara block of Hoshiarpur district.

3.7 Special Component Plan For Scheduled Castes (SCSP) & Tribal Areas Sub Plan (TSP)

The Scheduled Castes (SC) and Scheduled Tribes (ST) comprise about 16.6% and 8.6%, respectively of India's population (2011 census) which is more than 25 % of the total population. The socio-economic deprivation and disadvantages suffered by SC and ST led to adoption of a multi-pronged approach for the holistic development of these communities. Various Schemes and Programmes under the Development Action Plan for Scheduled Caste (DAPSC) and Tribal Sub-Plan (TSP) address the vulnerability issues by taking into account the *growing aspirations* and *improved quality of life*. The Scheduled Caste Sub Plan (SCSP) and Tribal Sub Plan (TSP) Schemes of DST focus on innovative S & T projects directed towards addressing the basic day-to-day needs of the people that increase the adaptive capacity and resilience to emerging problems of livelihood systems and bring into practice innovative approaches towards creating opportunities for *sustainable development*. The Schemes also has components for Science, Technological and Human Capacity Building of SC and ST

communities including opportunities for Research and Development in frontier areas of Science and Engineering. Various components under the SCSP and TSP Schemes of the department are given below. **Innovation Technology Development and Deployment:** The prime objective of the schemes is to empower the SC & ST Communities through promotion of research, development and adoption, transfer and dissemination of proven technologies to solve the problems of economically weaker Scheduled Caste (SC)/ Scheduled Tribe (ST) communities, especially in rural areas through application of Science and Technology.

Science and Technology Institutional and Human Capacity Building: The main objective is augmentation of S&T human resources by creating a pool of talented students in Sciences for future research activities in the country through various fellowships and creation of sophisticated R&D infrastructure in knowledge institutions for enhancing research capabilities

Science and Engineering Research Board (SERB): The Empowerment and Equity Opportunities for Excellence in Science (EMEQU) scheme implemented by SERB is aimed at providing research support to researchers belonging to the Scheduled Caste and Scheduled Tribe in undertaking research in frontier areas of science and engineering

I. INNOVATION TECHNOLOGY DEVELOPMENT AND DEPLOYMENT:

1. Scheduled Caste Sub Plan: Several projects in diverse technology areas like agriculture (including fisheries, animal husbandry, horticulture technologies etc.), forestry, alternate livelihoods, post-harvest technologies, natural resource management, health and sanitation, occupational hazards, rural industry and micro enterprise, sustainable agricultural practices etc. were supported during the year. The projects completed during the year directly benefitted 6000 people and there has been a significant improvement the socio economic conditions of people at localized level. The technological interventions also helped in overcoming the social discrimination problems in certain areas. Few glimpses of achievements and details of projects supported during 2019-2020 under these schemes are given below.

1.1. Sixty (60) SC women were benefited in a project “*Dehydration and value addition of flowers and foliage for making floral craft*” implemented at Salogra village near Solan in Himachal Pradesh. A floral craft laboratory for dyeing and bleaching technology of dry flowers, agricultural crops/waste and other wild native flora was developed. Value added products like flower arrangements, greeting cards, flower sticks, wall pictures, pot-pourri, and gift items like maize spathe dolls and pine cone birds etc were prepared for improved income generation.

1.2. In another project “*Introduction and demonstration of S&T based intervention for improved agriculture and rain water conservation*” 1960m of bunding channels and 5 rain water pits were constructed in drought affected Virpur, Gamda and Talabpada villages

of Talwara block in Rajasthan for improved agriculture and rain water conservation by small and marginal SC farmers. Awareness created for 500 women on S&T based agriculture practices and mixed cropping system in these villages

1.3. A Project on “Empowerment of scheduled caste fisher folk through entrepreneurial capacity building of self-help groups in marine sector” implemented in Vypin and Paravoor blocks in Ernakulam district of Kerala” benefitted 100 fisherwomen. Entrepreneurial Capacity Building of the newly formed Self Help Groups of SC beneficiaries was done in appropriate technologies such as cage culture, fish feed production etc. Enterprises were created in value addition, dry fish products, fish processing, ready to eat and ready to cook fish products. The interventions are proposed to be extended to other fishing communities in other districts of Kerala.



Fig 1. Entrepreneurial capacity building of self-help groups in marine sector

1.4. A project on “Promotion of Agri-Horti based livelihood among Scheduled Caste community Jhansi and Datia districts of Bundhelkhand Region” has been implemented with the objective of providing S&T solutions to address issues of SC community through advancement of alternative land use systems with 500 farmers belonging to Scheduled Castes in 20 villages.



Fig 2. Agri-Horti Model in Arid Regions of Bundhelkhand

The key deliverables of the project included demonstration of farm diversification models such as agri-horti model, horti-pastoral model and improvement of seed varieties that lead to improvement in farm productivity (20% increase), income (30% increase), enhanced climate resilience and nutrition diversity. The technologies that promoted include ridge and furrow method of cultivation, trellising, poly-mulching, raised bed sowing and the use of pro-tray nurseries. Farmers were also trained on crop planning using crop rotation plan to get continuous harvest, to meet the market demand as well as to maintain farm diversity. More than 1,500 farmers were trained on various improved technologies and appropriate farming models and 80 percent of these farmers have adopted climate resilient and resource efficient farming practices. For ensuring sustainability of interventions, 1,200 farmers were linked to farmers' producer organisation for improved forward and backward linkages. Linkages have also been established with government departments for access of government schemes and agri-advisory services. The models developed in this project can be replicated in other for semi-arid geographies

1.5. A total of 2000 SC farmers has been trained in *standardization of large-scale microbial technology of agro waste using microbiological and composting techniques*. The interventions include microbe-mediated bioconversion involving bacterial and fungal strains using locally and easily available ingredients along with other agricultural residual biomass.



Fig 3. Large scale wind-row composting production of compost from agro waste

On-farm composting technology bioconversion and bio fortification of raw compost was demonstrated through interactive participatory training cum learning sessions on microbial among the farmers, agri-activists and the scientists in ten villages of four districts in Uttar Pradesh under the project scale-up, fortification and dissemination of microbial agro-waste bioconversion technology.

1.6. Science Technology and Innovation (STI) Hubs: The STI Hubs will develop, nurture and ensure the delivery of appropriate and relevant technologies for inclusive social and economic development of the Scheduled Caste and Scheduled Tribe population in the country. The STI hubs look at harnessing and leveraging frontier technologies

available with other knowledge institutions like Agricultural Universities, IITs, NITs, KVK's, central scientific departments for creating livelihoods and employment, promote equitable economic growth, reduce drudgery and promote efficient and effective use of local and natural resources. The STI hubs address the weakest linkages between the natural resource endowment and livelihood systems for ensuring greater sustainability with visible impact. The STI Hubs will create mechanisms for Sustainable Rural Livelihoods based on scientific evidences and fill the vital gaps in the techno-economic interface through Technology Intervention Models. Two STI Hubs were established during 2019-2020. The STI Hub established at Babasaheb Ambedkar Marathwada University (BAMU), Aurangabad focuses on

- o KUSHAL (Knowledge Upgradation through Skilling Human Abilities and Livelihood)
- o CSTURI (Computer Skill Training Under Reform Intervention) &
- o HARIT (Herbal Agriculture Reform Intervention and Training)

2. Technological Interventions for Tribal Empowerment: The S&T interventions had directly benefitted 7500 households and in addition to improved socio economic status there had been a significant improvement in skills, building on local innovation & local knowledge. The interventions also promoted alternative livelihoods (wherever the present occupation is dwindling) through innovative community-based approaches, local (natural) resource management and technological (designing strategies through participatory research approach) options. Broadening the impact of S & T based activities by promoting replication and scaling up of successful approaches lead to empowerment and technical capacity building of tribal populations. Some of the significant outcomes under the scheme during 2019-20 are as follows.

1.1. 200 beneficiaries had adopted modern technologies of muga culture in selected villages of Lakhimpur, Dhemaji, Kamarup and Golapara of Assam under the project "*Improved sustainable technologies of Muga culture for elevation of cocoon production*" in the tribal belt of Assam are being adopted in 4 districts".

The improved technologies being used are (a) selection of High yielding host plants (b) Pruning pollarding of host plant at proper height for higher leaf yield and uniform growth of the host plant (c) using agronomical inputs like fertilizer and manure at proper time (d) Preparation of vermi compost, green manure (green gram, black gram and lentil etc), for improving the soil health, soil moisture conservation (e) Disease and pests management for muga host plant (f) Implementation of new mounting and spinning device.(g) Muga Silkworm grainage technology (h) Muga Silkworm post cocoon technology (i) Product diversification



Fig 4. Silk worm Seed Production, Harvesting of Cocoons & Cocoon Stiffing

1.2. A project on *“Organic garbage recycling for the generation of livelihood and zero solid waste”* was implemented in Meghalaya and more than more than 6,000 households were benefitted where a technology has been developed for converting the organic waste from homes into value added products like animal feed and compost using simple techniques of segregation and recycling of resources. *“Mass propagation and cultivation of high yielding sea buckthorn cultivars for livelihood improvement in tribal areas of Himachal Pradesh”* is being implemented in Lahul block, in Lahul-Spiti district covering 200 tribal marginal farmers, women self-groups and youth. The project evaluates and select 2-3 high yielding forms of seabuckthorn out of the 10 Russian seabuckthorn varieties, which are in the 4th year of growth under field conditions and develop the capacity for future mass propagation to integrate into the alley cropping systems/ agro-forestry systems in Lahaul. Rural micro entrepreneurship to overcome the issue of *“Livelihood through skill up gradation using scientific approach”* has been imparted to 200 youth in Kadayalumodu Panchayat of Melpuram Block in Kanyakumari District, Tamil Nadu. Training in employment creation for local market based skill development (like computer application and hardware maintenance, AC mechanic & refrigerator, motor winding) has been given. *“Livestock Rearing Issues of Tribal Farmers of Khed Block of Pune District in Maharashtra”* for increasing Milk Production has addressed in Rajgurunagar block. Services like preventive health, selection and popularization of green fodder development practices as per livestock requirement and minimizing the cost of cattle feed, execution of stall feeding method, strengthening health practices and solving health related issues timely through networking with veterinary services, improving hygiene, developing management skills through systematic training programmes and building capacity programmes had been provided to 100 farmers.

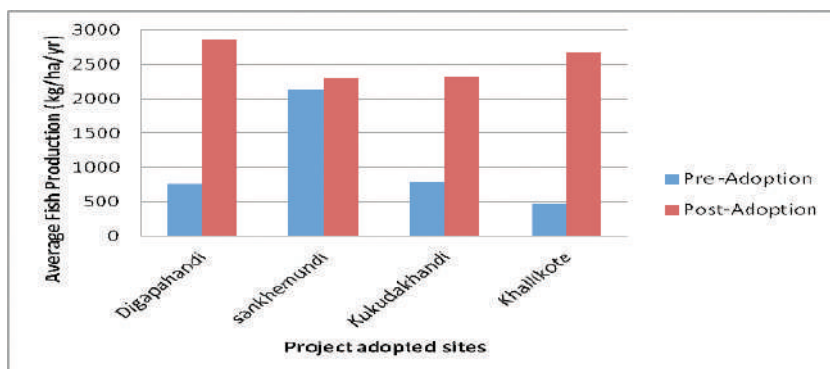
1.3 A project on *“Carp Seed production and integrated fish farming technology for livelihood development of Phailin affected tribal farmers of Ganjam district, Odisha”* has been implemented in four Community Development (C.D) Blocks viz., Kukudakhandi (Village: Nuapada), Digapahandi (Village: Sindhukhali and Ambapur), Sanakhemundi (Village: Daseipur) and Khallikote (Village: Sujanasahi), from Ganjam district covering 213 beneficiaries. Four Fibre Reinforced Plastic (FRP)

carp hatchery units are installed and operated under the project. Total 20.5 lakhs of carp spawn were produced through induced breeding programmes in the established hatcheries.



Fig 5. FRP Ranks, Spawn Harvest from Hatchery and Egg Collection

Fish harvest were done in different villages and productions achieved were 1.8-2.9 t/ha/yr with survivability range of 33% to 68% from a pre-adoption level of 0.6-1.1 t/hr/yr. Plankton productivity of ponds was increased from 0.8-1.8 to 1.8-2.4



ml/50 litre of water with adoption of better management practices (BMP), which contributed to 2.53-3.18 times higher fish production from ponds. Six training programmes on fish rearing and breeding were conducted in collaboration with State Fisheries Department, Ganjam in adopted blocks of the district. Two research papers; one book chapter; three research abstracts; one booklet; one crop calendar and one leaflet were published from the project. Ambapur village got awarded for its excellence in aquaculture adoption in the National Workshop on “Aquaculture as a Livelihood Option for Tribal Farmers of India” held at Kausalyaganga, Bhubaneswar during 18-19 February, 2019.

1.4. “Treerich Biobooster (TRB)” a bio-Product alternative to traditional potting mixture (sand: soil: FYM) is developed from coconut fibre waste is developed under a project “Transfer of products/technology on biobooster” as an alternate source of livelihood support to Irular tribes in forest fringe villages of Coimbatore, Tamilnadu. A prototype disc making machine has been installed at Institute of Forest Genetics and Tree Breeding (IFGTB), Coimbatore for demonstration and production of Treerich Biobooster (TRB) to the WSHGs that slowly reduced their dependence on forests. TRB

has been extensively field tested on forest species as well as vegetative crops. The germination of vegetable crops in TRB enriched with flower compost and vegetable compost is found to be 89% and 84%. Respectively when compared to 44% in normal potting medium. Training on the development of TRB was given to WSHGs of the Irular tribes who inhabiting the forest fringe village in Coimbatore District.

255 tribal women were trained on development of TRB and the product was demonstrated to more than 2500 people at various forums. TRB demonstration was given to, 500 farmers from various districts of Tamil Nadu and 75 farmers from VVK and KVK, Thrissur, Kerala. TRB product demonstration was given to 311 Irular tribes of 35 settlements of Coimbatore district at their premises. There has been an increase in income from Rs.150/- per day to Rs.300/- per day due to adoption of technology and the socio-economic studies of 82 households studied during their project periods revealed that the HDI before and after training was 0.680 and 0.841, respectively. A "Home Garden Kit" consisting of an ecofriendly cloth bag with TRB, Tulsi sapling (medicinal plant); Sorgha maram (vastu tree) sapling; Bhendi sapling; Bhendi seeds, organic insecticide along with user pamphlet was developed for distribution for commercial purposes.



1.5. The STI Hub established at Sidho Kanho Birsha University, Prulia for the benefit of ST population through implementation of various technologies for Land and Watershed Management, Aquaculture, Water Purification Technologies, Cultivation of Aromatic Plants, establishment of units for production of aromatic oils etc

1.6. A programme has been initiated by ICPS Division to train SC and ST students in advanced technologies like Artificial Intelligence, Sensors, Data Science, Computer Networks, Cyber Security and Block Chain Technologies. 1140 ST students will be trained during the current year through 38 training programmes and 33 workshops will be conducted for 1090 ST students. It is also proposed to create awareness and impart training on ICPS technology at School level (class 6 to 8) in 11,500 schools covering 115 aspirational districts across the country. During the current year, awareness has on ICPS technology was imparted to students in 11 aspirational districts under ST Category and 4 aspirational districts under SC Category. 300 Students and

2 teachers from each of the school will also be trained in the emerging technologies. It is proposed to train 3450000 students in 115 aspiration districts of India.

II. SCIENCE & TECHNOLOGY INSTITUTIONAL & HUMAN CAPACITY BUILDING:

1. INSPIRE FELLOWSHIPS: Innovation in Science Pursuit for Inspired Research (INSPIRE) aims at creating excitements of creative pursuit of science and attract talent to the study of science at an early age and thus build the required critical human resource pool for strengthening and expanding the Science & Technology system and R & D base through its various components like INSPIRE Scholarship, INSPIRE Fellowship and INSPIRE Faculty. The details of the fellowships disbursed under INSPIRE under SC Category and ST Students is given below.

<i>Scheduled Caste Sub Plan</i>			
<i>Sl. No.</i>	<i>Name of the Component</i>	<i>Number of Beneficiaries</i>	<i>Total Amount Disbursed</i>
1.	Scholarship (SHE)	234	Rs.1,95,00,000
2.	INSPIRE Fellowship	95	Rs.4,09,32,571
3.	INSPIRE Faculty Fellowship	23	Rs. 3,80,28,475
<i>Tribal Sub Plan</i>			
<i>Sl. No.</i>	<i>Name of the Component</i>	<i>Number of Beneficiaries</i>	<i>Total Amount Disbursed</i>
1.	INSPIRE Fellowship	31	1,22,83,823

2. INSPIRE AWARDS-MANAK (Million Minds Augmenting National Aspiration and Knowledge) is a national programme to promote 'Original ideas' having potential to address societal needs through Science & Technology especially in context of National flagship Programmes such as Swachh Bharat, Digital India, Swasth Bharat, Make in India, Energy, Environment, Sanitation etc. Under the Scheme, 10 Lakh ideas will be targeted from 5 Lakh schools across the country, in a financial year. Of the 3,92,486 ideas and innovations received by the Department, 42,143 were selected for INSPIRE-MANAK Award and provided with a financial support of Rs 10,000/- each for participation at District Level Exhibition and Project Competition (DLEPC). Out of total 42,143 selected students, 7300 awardees are from SC and 3442 awardees are from ST category.



Fig 8. Glimpses of 7th National Level Exhibition and Project Competition

III. SCIENCE & ENGINEERING RESEARCH BOARD (SERB):

1. Around 230 scientists were supported through projects worth Rs.52.85 Crore in the “Empowerment and Equity Opportunities for Excellence in Science” Scheme. The scheme provides research support to scientists belonging to SC/ST categories

3.8 Drug & Pharmaceutical Research

Drugs and Pharmaceuticals Research Programme aims to synergise the strengths of publicly funded R&D institutions and Indian Pharmaceutical Industry, to create an enabling infrastructure to facilitate new drug development in all systems of medicines and both for human and veterinary purposes.

- 1. Drug Development Unit and Training Centre for Neurological Disorders (a capacity building program) has been established at Post Graduate Institute of Medical Education and Research (PGIMER), Chandigarh.** This center aims to (i) Develop world class facility to develop the drugs acting on CNS or neurological disorders specially for neurodevelopment and neurodegenerative disorders (2) Develop the training center for the early faculties, residents, students and researchers in the field in drug development for capacity building (3) Develop in silico facility to develop and prepare the libraries of new chemical entity (NCE) and (iv) Develop in vitro facility to prepare the primary cell culture to check the activity of NCE. This facility will work and support in education and training to the nearby institutions like Punjab University, IISER, NIPER, IMTECH and CSIO for the particular proposals on neurological disorders.
- 2. National Center for Pharma Co-Engineering to Fight Against Neglected Diseases has been established at National Institute of Pharmaceutical Education and Research (NIPER) Guwahati. The established facility aims (1) To adopt innovative methodologies/strategies to match the drug solubility, permeability, stability, safety, and efficacy related requirements of different pharmaceutical units of the North-east region in particular & Nation in general (2) To work at the interface of pharmaceutical engineering and technologies to develop safer and effective deliverables (3) To provide facility and build-up capacity of faculties, researchers, trainees, and industry motivated aspirants of North-east (4) To translate pharmaco-engineering approaches into translational health science & technologies.**
- 3. DST has also established a National Centre for Screening of Natural Products for Parasitic Diseases at Jawaharlal Nehru University (JNU), New Delhi.**

3.9 Good Laboratory Practice (GLP)

Good Laboratory Practice (GLP) programme is a quality system under which non-clinical health and environmental safety studies are conducted on various chemicals viz. Industrial Chemicals, Pharmaceuticals (Human and Veterinary), Agrochemicals, Cosmetic

Products, Food/ Feed additives, Medical Devices, etc. The National Good Laboratory Practice Compliance Monitoring Authority (NGCMA) was set up under the administrative control of Department of Science and Technology (DST) in August, 2002 to provide GLP certification to the test facilities, which are involved in conducting safety studies on such chemicals in accordance with Organization for Economic Co-operation and Development (OECD) Principles of GLP. India is a full adherent to OECD Council Acts related to Mutual Acceptance of Data (MAD) since March 3, 2011, which ensures that the data generated by the GLP certified Test facilities in India is acceptable in the 36 member-countries of the OECD and other countries, thus removing the technical barriers to trade.

As on date, there are 50 GLP certified test facilities in the country. Some of the major achievements of the Indian GLP programme during the financial year 2019-20 are given below:

- **Grant of GLP Certificate:**

- o Cadila Pharmaceuticals Ltd., Ahmedabad
- o Diligence Bio Private Limited, Pondicherry
- o Vipragen Biosciences Private Limited, Mysore
- o Accutest Biologics Private Limited, Navi Mumbai
- o Ana Laboratories, Mumbai

Periodic surveillance(s) and re-certification(s) of certified test facilities were done as per the laid down procedures of NGCMA.

- **Joint-inspection and Study Audits with United States Food and Drug Administration (USFDA):**

- o Vimta Labs Limited, Hyderabad.

- **Training Courses/ Capacity Building Programmes:**

- o National Workshop Series on GLP Sensitization for Faculty & Scientists at NIPER, Guwahati
- o Train the Trainer Programme on GLP for faculty and Sensitization Workshop on GLP for students at Amity University, Manesar
- o Training Course on GLP for Study Directors of GLP Test Facilities at New Delhi
- o Training Course for Study Directors of GLP Test Facilities at New Delhi
- o Sensitization Workshop on GLP at New Delhi

- o Training Course for QA Personnel of GLP Test Facilities at New Delhi
- **Interactions with OECD Working Group on GLP:**
 - o Representative of NGCMA, India attended the 33rd meeting of OECD's Working Group on GLP held during March 5-7, 2019.
 - o Representative of NGCMA, India attended the 14th OECD Training Course for GLP Inspectors held at Cape Town during October 7-10, 2019.
 - o The On-Site Evaluation of Indian GLP Programme is due in 2020 and NGCMA is in process of preparing for the same.
- **Impact Analysis of National GLP Programme:** An Impact analysis study of the National GLP Programme is being conducted to assess the industrial, societal and governmental benefits after India attained full adherent status to Mutual Acceptance of Data in the OECD. The report of the impact analysis study would be presented to the Government of India and OECD Secretariat, which would go a long way in assessing the success of the National GLP Programme while understanding the challenges faced and guiding future course of action.
- **Digitization of the National GLP Programme:** The GLP Division and its documentation is being digitized to reduce the time required for processing of GLP Applications & for harmonization of processes.
- **Revision of Working Documents of NGCMA:** A committee for revision of working documents of NGCMA has been constituted with the approval of Secretary, DST & all documents of NGCMA are being revised.

3.10 Patent Facilitation Programme (PFP)

Patent Facilitating Centre established by DST at Technology Information Forecasting and Assessment Council (TIFAC), New Delhi with four-fold objectives of creating IPR awareness and deeper understanding of patents and IPR in the country, facilitating filing, obtaining and maintaining patents on sustained basis, providing patent information as an input to R&D and handling IPR policy matters. In addition, Department has been forefront to create awareness and training IPRs and patent filing with the help of Patent Information Centre created in States.

3.10.1 IP/Patent Facilitation

Department through PFC helps in filing and prosecuting patent and other IPR applications in India and in other countries on behalf of academic institutions and government R&D institutes, some of these applications also routed through the Patent Information Centres (PICs) in States. These patent and IP applications are drafted and filed through patent

attorneys on the panel of PFC. The cost of filing these patents is borne by PFC and patent/IP applications are filed in the name of inventing institute/s. PFC & PICs conducts through patentability assessment in house for all the invention disclosure received by it. PFC & PICs has assessed the patentability of more than 100 new inventions and is in process of next step for filing patent applications w.r.t. patent eligible cases. During this period 9 patents were granted in India. PFC facilitated filing and prosecution of these patents.

S. No.	Patent No.	Grant Date	Applicant	Title
1.	312609	10/05/ 2019	National Institute of Technology, Calicut	A novel method for the preparation of chitin/pva/peg crosslinked hydrogel for biomedical application
2.	315834	11/07/2019	1.Cochin University of Science and Technology (CUSAT), Kochi 2.Raman Research Institute, Trivandrum	Optical limiting ferromagnetic Nanoparticles and device thereof
3.	315898	12/07/2019	Dolphin (PG) Institute, Dehradun	Column reactor for the Synthesis of cyclic carbonate of polyols via carbamide process
4.	316377	18/07/2019	Indian Institute of Technology Kanpur	Dielectric resonator
5.	316472	19/07/2019	Indian Institute of Technology Delhi	Electro-oculogram (EOG) based Multimode controller system
6.	322060	30/09/2019	Postgraduate Institute of Medical Education and Research (PGIMER), Chandigarh	D-peniciline nanoparticle and process of synthesis
7.	322666	14/10/2019	Malaviya National Institute of Technology, Jaipur	Natural ventilation system for building through solar and/or wind energy
8.	323734	25 /10/ 2019	Indian Institute of Technology Delhi	System and method for Accessing data using wireless communication
9.	325256	18/11/2019	Department of Science and Technology DST, New Delhi	A torch oscillation system

3.10.2 Training Programmes and workshops

PFC organised 5 two days advanced training programme for Patent Information Centres (PIC) in states and University IPR Cell (IPCU) Officials as per details given below, in all total of 250 scientists benefitted from these programme which includes researchers in addition to PIC and IPCU officials:

- i. First two days training programme at Rajiv Gandhi Science & Technology Commission, Govt of Maharashtra, Bombay was held on 11-12 June, 2019 for IPR Cells in Universities of Maharashtra.
- ii. Second two days state level IPR workshop was held at Goa University, on September 26-27 along with Goa State Council of Science & Technology.
- iii. Third two days Training Programme on Intellectual Property Rights was held on 14th-15th October 2019 at ICSSR, NEHU, Shillong along with State Council of Science Technology and Environment (SCSTE), Meghalaya. PIC officials from North East states attended the programme.
- iv. Fourth two days workshop on Intellectual Property Rights (IPR) workshop for Women Researchers in Sciences was held at BISR, Jaipur on 29th- 30th November, 2019 organised along with PIC Jaipur.
- v. Fifth two days Training on IPR specially for patents and patentability assessment was organized at Hyderabad in association with Patent Information Centre (PIC) at Telangana State Council of Science and Technology.

3.10.3 Annual Review/discussion meeting of the PICs:

Department has organized the Annual Review meeting of the Patent Information Centre (PICs) during the 12th -13th August'2019 at Solar Observatory, Kodeikenal hosted by Tamilnadu Council for Science & Technology, Chennai

It was found that PICs in States are doing well for safeguarding the IPRs. Patent Information Centres (PICs) in States have filed 1013 Patent application and around 115 Patent were granted, 159 Geographical Indicators were filed 16 were registered during the last three years. Many more success stories may be seen in time to come.

3.11 Technical Research Centre

This initiative was launched as a follow-up of the budget announcement made by the Hon'ble Finance Minister of India in his Budget Speech in FY 2014-15. Five Technical Research Centres (TRCs) were established with a mission to provide techno-legal-commercial and financial support to scientists, entrepreneurs, and business fraternity to achieve translation of research into products and processes for greater economic and societal benefits in 5 DST institutions namely, Sree Chitra Tirunal Institute for Medical Sciences and Technology (SCTIMST), Trivandrum; International Advanced Research Centre for Powder Metallurgy and New Materials (ARCI), Hyderabad; Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bengaluru; Indian Association for the Cultivation of Science (IACS), Kolkata; and S.N. Bose National Centre for Basic Sciences, Kolkata during FY 2015-16.

Some of the achievements under TRC during the reported period are given below:

3.11.1 Sree Chitra Tirunal Institute for Medical Sciences and Technology

- Under this TRC, three new R&D projects in the hard issue devices segment were initiated. The total number of projects being executed in the segment has risen to 38.
- Expression of interest was sought from Indian Medical Device industries for identifying industrial partners for ten R&D projects. Industrial partners were identified for five projects and the process of technology transfer has been initiated for these.
- The Industry Institute Partnership Cell (IIPC) carried out ten training programs for the medical device industry and R&D personnel (out of these, three programs specifically targeted participants from SC/ST segment).
- The following technologies were transferred to medical device companies and start ups.

Technology	Industry Partner
Left Ventricular Assist Device	Meril Lifesciences, Vapi, Gujarat
Lint free absorbent wound dressing	Phraction Scientifics Pvt Ltd Pattanamthitta, Kerala
Testing device for Tuberculosis diagnosis	Agappe Diagnostics Limited, Agappe Hills, Pattimattom, Ernakulam, Kerala
PT/INR monitoring device	Agappe Diagnostics Limited, Agappe Hills, Pattimattom, Ernakulam, Kerala



Hon'ble President of the Institute, Dr. VK Saraswat handing over the Certificate of Technology Transfer of PT/INR Monitoring Device (left) and TB Screening Device (right) to M/s. Agappe Diagnostics, Kochi



Hon'ble President of the Institute, Dr. VK Saraswat handing over the Certificate of Technology Transfer of LVAD to M/s. Meril Lifesciences Pvt. Ltd, Gujarat (left). Exchange of MoA for codevelopment of Implantable cardioverter defibrillator with M/s. Shree Pacetronics, Indore (right)

3.11.2 International Advanced Research Centre for Powder Metallurgy and New Materials (ARCI), Hyderabad

- Under this TRC, in the energy storage programme, $\text{LiNi}_{0.5}\text{Mn}_{0.3}\text{Co}_{0.2}\text{O}_2$ (NMC532)/graphite based prismatic cells (3.6 V, 20 Ah) have been fabricated with commercial materials. A module of 48V, 1 kWh was assembled in 14S1P configuration and integrated to an electric scooter and on-road demonstration was carried out with industry collaboration. A mileage of 50 km/charge was obtained at 25 km/h top speed. A fast formation protocol (<24 h) was derived for the NMC cells. The cylindrical cells showed a capacity of 2 Ah at 0.5 C rate. LiFePO_4 /graphite based prismatic cells (3.2 V, 15 Ah) were fabricated and a module of 12 V, 150 Wh was assembled for offline demonstration of solar street lamp (ITIL-ARCI Collaboration). A lighting time of 26 h/charge was achieved with the battery module. Technology for cost-effective production of Lithium Titanate as anode material has been demonstrated.



E-scooter with NMC/graphite module of 48V, 1 kWh

- An assembly line for fabrication of 1000F supercapacitors has been commissioned.
- Module for hybrid operation with lead acid battery-powered two-wheeler has been conceptualized with a view to enhance battery life.

- Supplied 6kg of indigenously developed lithium titanate anode material and activated porous carbon to VSSC for making LIB and supercapacitor cells, respectively.
- 15 kgs of lithium iron phosphate and 1 kg of Nb-doped Lithium iron phosphate supplied for fabrication of high power batteries.
- Overall, the TRC accomplishments include one technology transfer, funding from one public sector company, forging of collaborations with more than 20 companies, filing of 10 Indian/International patents and 65 publications in reputed international journals and importantly training of the Human resources (Ph.D) in these thrust areas.

3.11.3 Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bengaluru

- Under this TRC, three novel antimicrobial assets were transferred to a drug development company as an out-licensing deal. The company will continue to work with JNCASR's inventors to further develop and test the assets in order to exploit them commercially.



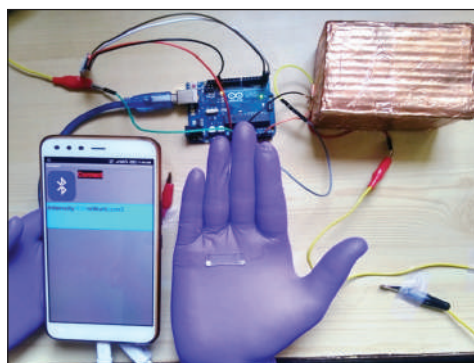
Execution of IP Licensing Agreement for Three IP Assets in the Antimicrobial Resistance Space

- Entered into a collaboration agreement with Tata Steel Limited to convert heat generated at iron/steel plants into electricity by deploying new devices with safe and efficient thermo-electric materials.
- To develop integrated, industrial-scale solution to convert carbon dioxide from industrial sources into valuable products like methanol and carbon monoxide.
- JNCASR partnered with Bangalore International Airport Limited to develop a scientific solution based on micro-physical processes and modeling, to be deployed at national and international airports for predicting onset of radiation-fog for efficient flight management systems.

- A study that provided one of the first direct evidences of interlink among chromatin, nuclear architecture, chromatin state, and the process of autophagy, via the Stable PC4 Knockdown HEK293 Cell Line(s) has been licensed to an industrial partner.
- JNCASR was instrumental in creation of yet another start-up company HBAROMEGA Pvt. Ltd. - a start-up with expertise in screening and evaluating solar panels.

3.11.4 Indian Association for the Cultivation of Science (IACS), Kolkata

- Technology for various pest management mediated by pheromone nanogels was developed in Technical Research Centre (TRC). A sponsored research project has been initiated with ATGC Biotech Pvt. Ltd., Hyderabad, also. Biotechnology Industry Research Assistance Council (BIRAC) has funded a start-up project based on technology developed by TRC entitled “Management of crop diseases via drone assisted detection of pheromones and kairomones in a cotton farming land”
- Demonstrated by fabricating laboratory scale prototype for transparent photodetector, interfaced with mobile using appropriate electronics to displays the intensity of light.



Interfacing of the transparent photodetector with mobile

- Other new projects initiated having translational potential include i) Understanding chaos: Realization of Chua’s circuit with analog electronics; ii) Electro spun polymer nanofibers for amplified fiber optics, sensing and lab on a chip integration; iii) Sustainable catalytic degradation of lignocellulosic biomass and organic pollutants.
- One patent (Application number: 201931017619) entitled: “Transparent and Flexible Nano-structured Wire Networks with Seamless Junctions for Photodetector Applications” has been filed.

3.11.5 S.N. Bose National Centre for Basic Sciences

- A non-invasive breath analysis system and process-based detection of peptic ulcer disease, no ulcerous dyspepsia and Helicobacter Pylori infection.
- Flexible paper-based highly sensitive sensor for ammonia gas detection by visual effects (color change).

- Low cost portable thermal analyzer (working range 30°C - 400°C).
- Development of Non-Contact Optical Device for Clinical Diagnostics of Anaemia, Jaundice and Oxygen Deficiency (AJO Device) at Resource Limited Point of Care Setting.
- High sensitivity (better than 1 ppm) and high selectivity hazardous gas sensor for unheated operation with remote read-out capability.
- A device for detection of adulteration of milk using spectroscopic method.
- The following technology were transferred to the company:

S. No.	Technology	Industry Partner
1.	Non-invasive Quantitative Estimation of Bilirubin in Blood	M/s. EzeRx Health Tech Private Limited
2.	Non-invasive detection of Oxygen deficiency in blood	M/s. EzeRx Health Tech Private Limited



Technology transfer through NRDC held on 27th August 2019 at Technology Bhawan, DST, New Delhi. 2019



Prototypes on 27th August 2019 at Technology Bhawan, DST, New Delhi. 2019

3.12 Exhibitions and Fairs

The Exhibition Cell is concerned with the work relating to organizing exhibitions, participation in science exhibitions at national and international level. In addition, it has also been assigned responsibility of coordinating the work related to participation of Department of Science & Technology along with its organisations in the exhibitions.

The aim of Exhibition Cell is organising exhibitions to bring awareness among students,

scholars and general public about different Government policies, schemes, scientific innovations, milestones in the field of Science & Technology.

The activities of Exhibition Cell, DST during 2019-2020 were as under:-

- i. Organised India International Science Festival (IISF) – 2019 in association with Ministry of Earth Sciences, Departments of Bio-Technology, Scientific & Industrial Research & Health Research along with Vijnana Bharati (VIBHA) and NGO at Kolkata during 5-8 November 2019.
- ii. Participated in Pride of India Exhibition at the 107th Indian Science Congress (ISC) – 2020 held at University of Agricultural Sciences, Bengaluru, during 3-7 January, 2020.
- iii. In association with Subordinate Offices/Aided Institutions under DST, participated in 23rd National Science Exhibition during 28-31 August 2019 at Kolkata, 5th Smart Cities India 2019 Expo during 22-24 May 2019 at New Delhi.
- iv. The Cell also coordinated with subordinate offices and autonomous institutions working under the Department for participation in a number of exhibitions in various states.



Hon'ble Prime Minister of India inaugurating the 5th India International Science Festival on 05.11.2019 over Video Conferencing at the Biswa Bangla Conference Centre, Kolkata



Science Village - 5th India International Science Festival, Kolkata



Dr. Harsh Vardhan, Hon'ble Minister Health & FW, Earth Sciences and Science & Technology inaugurating the DST Pavilion at Pride of India Expo during 107th Indian Science Congress held from 03.1.2020 to 07.1.2020 at UAS, Bengaluru.



Smt. Anju Bhalla, Joint Secretary (Admin.), Department of Science & Technology at the DST Pavilion at Pride of India Expo during 107th Indian Science Congress held from 03.1.2020 to 07.1.2020 at UAS, Bengaluru.

AUTONOMOUS INSTITUTES

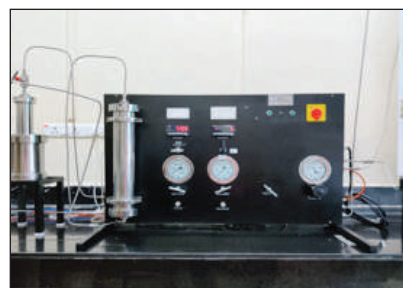
The Department of Science and Technology nurtures 25 Autonomous Bodies (ABs). These include 16 research institutions, 4 specialized knowledge and S&T service organizations and 5 professional bodies. These institutions, with long and cherished history and their variety of activities, occupy a very important place in the S&T eco-system of the country. Activities and achievements of autonomous institutes during the year under report are briefly described below:

4.1 Maharashtra Association for the Cultivation of Science (MACS)-Agharkar Research Institute (ARI), Pune

The institute focusses on Biodiversity and Palaeobiology, Bioenergy, Bioprospecting, Developmental Biology, Genetics and Plant Breeding and Nanobioscience.

Some Major Accomplishments:

- Biofortified wheat variety MACS 4028 (*T. durum*) is notified for rainfed timely sown condition of Peninsular Zone. Due to its better nutritional quality (protein 14.7%, zinc 40.3 ppm & Iron 46.1 ppm), Department of Agricultural Research and Education, ICAR notified MACS 4028 biofortified wheat as a mission to tackle the hidden hunger in the rural areas of India in the Government sponsored “Kuposhan Mukh Bharat”. This variety has also been chosen for UNICEF funded project to alleviate malnutrition in the country.
- MACS 4058, a new durum wheat variety, was identified for timely sown restricted irrigated conditions of peninsular zone. It gives an average yield of 29.6 q/ha and a potential yield of 37.1 q/ha, has protein content 12.8%, zinc 37.8 ppm and iron 39.5 ppm, shows seedling resistance to leaf, stem and yellow rust of prevailing pathotypes.
- ARI developed an efficient and clean microbial process for sustainable recovery of energy from lignite via biomethanation route in collaboration with ONGC Energy Centre, Delhi. The specially developed microbial consortium yielded 217 ml methane from 1 g lignite under simulated *in situ* conditions (900 psi, 68 °C). The process is ready for implementation in the field. Biomethanation of lignite at 68 °C under 900 psi pressure



- An easy to use, specific, sensitive, on-site, nano-gold immunodiagnostic assay for Human Invasive Aspergillosis, (an opportunistic fungal infection) was developed for improved human health care in resource poor settings.
- Biodiversity of Western Ghats, North-Western Himalayas, wetlands and rice fields is being extensively investigated for taxonomic and industrial applications. Several genera and species of plants and diatoms (9), fungi (6), yeast (1), and bacteria (3) were identified and reported. ARI also reported a novel bacterium, *Isoptericola oleotrophicus* sp. nov. (PW21) for efficient containment of terrestrial oil spills.
- ARI identified a novel molecular component of a neuronal circuit that regulates gonad maturation during development in *Drosophila*. Autophagy reporters and mitochondrial reactive oxygen species sensors for germline stem cells in *Drosophila* were generated and characterized. Research in zebrafish identified Ccn2a as a protective secreted molecule in intervertebral tissue (IVT).
- 240 quintals of wheat breeder seed and 376 quintals of soybean breeder seed was distributed to public and private seed multiplying agencies and farmers during the year 2019. The total estimated area under cultivation of ARI's wheat and soybean varieties for current year is 2,88,000 hectares (Wheat 2,50,000 hectares; Soybean 38,000 hectares). The area under cultivation of grape variety ARI 516 is continuously increasing and has reached up to 100 acres in Maharashtra, Punjab, Karnataka, Telangana, Tamil Nadu and West Bengal.

Important Output Indicators:

Sr. No.	Parameters	Output
1.	Papers in refereed journals	57
2.	Books	2
3.	Chapters in Books	6
4.	Papers in Conferences	6
5.	Number of Ph.Ds. produced	3
6.	Foreign Patents filed	2
7.	Indian Patents filed	2
	Indian Patents granted	1
8.	Number of Technology leads awaiting transfer	3
9.	Research Manpower trained (other than Ph.Ds)	47
10.	Technical Manpower trained	26

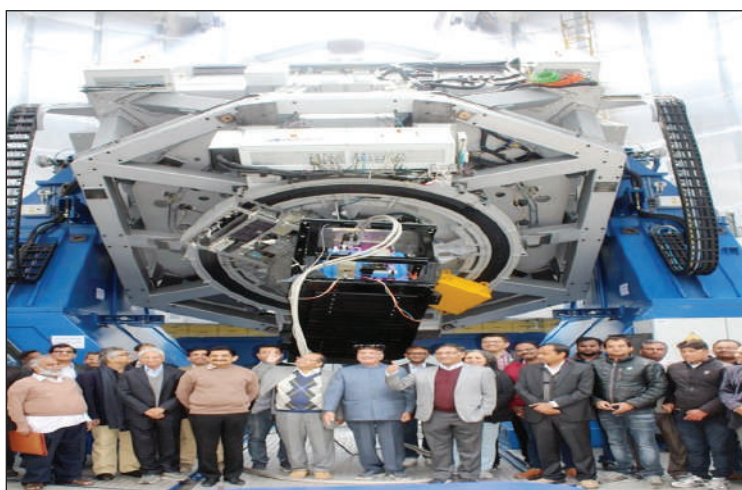
4.2 Aryabhata Research Institute of Observational Sciences (ARIES), Nainital

The Institute focuses on research in the areas of Astronomy, Astrophysics and Atmospheric

Sciences. The Institute operates a suite of optical telescopes and advanced instruments to study the Earth's atmosphere, Sun, Planets, Stars and Galaxies.

Major Accomplishments:

- Test runs carried out with India's largest aperture telescope, the 3.6m DOT located in Devasthal. Backend instruments such as 4K X 4K imager, ARIES Devasthal Faint Object Spectrograph Camera (ADFOSC) and TIFR-ARIES Near Infrared Spectrometer (TANSPEC) were mounted on the telescope and several scientific and technical runs were conducted. The first light images with TANSPEC were taken on 12 April 2019 followed by subsequent sky tests upto 15 May 2019.
- The work on Globular Cluster NGC 4147 based on the photometric observations acquired with the 4K X 4K Imager on 3.6m DOT and 42 periodic variables in the region of NGC 4147 were identified, 28 of which have been detected for the first time. The only known variables in NGC 4147 were RR Lyrae. With much better plate scale and the large aperture telescope, it has been possible to identify more RR Lyrae and other variable stars in the crowded central region of the globular cluster NGC 4147.
- ARIES scientists contributed towards the multi-wavelength study of the first ever detection of TeV photons from a long Gamma Ray Burst GRB 190114C.
- The components of 4m ILMT was made ready for commissioning expected in Spring 2020.
- Operationalization of ARIES ST Radar (ASTRAD) with all 588 TRMs (12 clusters).
- A regional air quality model (WRF-CO2) is successfully set up for CO2 over the greater Asian region and compared well with observational data.



DST Secretary Prof. Ashutosh Sharma visited ARIES and Devasthal campus during April 2019.

Important Highlights of Major Programmes:

- The two major observational facilities, 3.6m DOT and ST Radar, in astronomy and atmospheric sciences were made operational.
- Balloon-borne measurements of temperature, water vapor, ozone and aerosol backscatter provided unprecedented insights into the Asian summer monsoon anticyclone thermal structure. Surface observations of formaldehyde and glyoxal using MAX-DOAS and investigation of the absorption characteristics and source processes of aerosols confirms the influence of biomass burning and indicating the efficient vertical transport over this region.
- I-TMT Science and Instruments Workshop (October 2019) and 4th International Global Atmospheric Chemistry - Monsoon Asia and Oceania Networking group (IGAC-MANGO) (November 2019) were organized.

Important Output Indicators:

S.No.	Parameters	Output
1.	Papers in refereed journals	38
2.	Papers in Conferences	3
3.	Number of Ph.Ds. produced	7
4.	Research Manpower trained (other than Ph.Ds)	5
5.	Technical Manpower trained	53
6.	B.Tech/ UG projects guided	29
7.	M.Tech/M.Sc./M.Phil projects guided	40

4.3 Birbal Sahni Institute of Palaeosciences (BSIP), Lucknow

BSIP carries out research on both fundamental and applied aspects of Palaeosciences, including allied earth system sciences with an integrated, multi-disciplinary approach. The science & research activities focus on understanding origin and evolution of lifeforms (Flora & Fauna) through time, recent and past climatic & ecosystems changes including vegetation dynamics and paleobiogeography, past civilizations & human history and exploration of fossil fuels. The main area of focus involves diversification of Precambrian life, diversity, distribution and inter-basinal correlation of Gondwana and Cenozoic Floras, Coal/Lignite quality, basin evolution & sea level change, past civilizations & culture and interaction between climate and vegetational changes in Quaternary Period.

Major Accomplishments:

- Ancient DNA study on skeletons of Roopkund Lake situated in Himalayan region revealed Mediterranean history of migrants in India.

- DNA analysis of Harappan skeleton from Rakhigarhi, Hisar, Haryana reveals no ancestral linkage to Steppe pastoralists or Iranian Farmers.
- Multiproxy analyses of modern dung samples of endangered megaherbivores from India (Yak, Rhino, Sangai and hog deer) revealed the dietary preferences of these faunal species in relation to the vegetation and ecology of the region. It helped in understanding the extinction of megaherbivorous animals such as woolly rhino and mammoth despite having diets very similar to the surviving yak and bison based on their similar palynodata.
- The regional tree-ring width chronology of *Pinus wallichiana* from Northwest Himalayan region revealed a marked warming trend at beginning in the late twentieth century and persisting through the present. The periodicities observed in the reconstructed temperature are likely associated with the Atlantic Multidecadal Oscillation and El Niño–Southern Oscillation.
- Palynological and organic geochemical study of Gurha Lignite/shales pointed to presence of gymnosperm vegetation cover and marine influence Bikaner-Naguar basin during early Paleogene and also revealed the potential for oil/gas hydrocarbon generation.

Important Highlights of Major Programmes:

- BSIP organized International symposium on Fossil Algae.
- Under distinguished Lecture Series, Prof. Christopher Fielding University of Nebraska-Lincoln, USA, discussed causes & effects of end-Permian mass extinction from southern latitude perspective and highlighted terrestrial end-Permian mass extinction event which occurred ~370 Kyr before the marine extinction event in the latest Permian. Also, Highlighted new generation of facies models in fluvial systems and their deposits based on peak discharge variability. More than 80 persons including scientists, professors, and research scholars attended the event.
- BSIP also organized 6th Asian Dendrochronology Conference attend by 62 researchers. In addition, workshops on Quantitative Wood Anatomy, Tree-ring and R environment and Dendrogeomorphology towards forest, natural hazards and risk were organized.

Important Output Indicators:

S. No.	Parameters	Output
1.	Papers in refereed journals	96
2.	Chapters in Books	02
3.	Papers in Conferences	45
4.	Number of Ph.Ds. produced	01
5.	Research Manpower trained (other than Ph.Ds)	20
6.	Technical Manpower trained	01



Why did woolly rhino, mammoth go extinct? (PLoS One - 2019)

- Yak Dung analysis helped to map out the different plants and trees in the western Himalaya.
- Giant mammoth and woolly rhino which used to live with the yak during the transition of Pleistocene-Holocene epoch were not able to adapt to the climatic and thus went extinct

4.4 Bose Institute (BI), Kolkata

Bose Institute pursues research for augmentation of fundamental knowledge-base and developing solutions to national problems in the areas of healthcare, food security, environmental pollution and climate change. Research is pursued in areas such as understanding stress response and disease biology, anthropogenic activity-induced environmental changes, bioremediation of environmental pollutants and geomicrobiology, fundamental understanding of subatomic particles, development of detectors/sensors- from cosmic rays to biomolecules and the dynamics of atmospheric pollutants, especially in the Himalayan region.

Major Accomplishments:

Plant Molecular Biology

- Elucidation of the earliest ancestor of the Green Sulfur Bacteria (*Chlorobia*) and discovery of crypto-aerobic microbial life in anoxic (sulfidic) marine sediments.
- Development of inter-specific hybrid lines between cultivated Indian sesame and wild sesame to improve the oil quality of cultivated sesame.
- Establishment of WUSCHEL as marker for shoot morphogenesis in tobacco and Beta.
- Rice Trithorax factor ULTRAPELATA 1 specifically binds to the putative polycomb responsive elements "GAGAG" to regulate the cold induced transcription.
- Secreted ribonucleases from *Ustilago maydis* scavenge extracellular RNA.
- The ongoing research on understanding the role of microRNAs in plant defense response against pathogen revealed that miR6024 overexpression in tomato plants accelerates plant cell death in response to a pathogen attack and facilitates necrotrophic pathogenesis. Implying, miR6024 is an essential component of plant immune response signaling.

- Development of *Alternaria brassicicola* tolerant *Brassica juncea* lines through conditional expression of ABA-auxin crosstalk factor ARF10.
- Enhancement of ABA sensitivity through conditional expression of ARF10 gene in *Brassica juncea* exhibit fertile plants with tolerance against *Alternaria brassicicola*.

Microbiology

- Development of chromosome-based bioreporter strain to monitor environmental pollutants.
- Microbial diversity and *in silico* functional metagenomic analysis of Hilsa gut microbiota.
- Study of novel bioactive compounds and polyketide synthase gene clusters from mangrove plant associated microbes by culturable and non-culturable procedures.
- Classification of the Ring Hydroxylating Oxygenase (RHO) enzyme system to explore the evolutionary mechanism using various bioinformatics tools including docking, MD simulation etc.
- Exploration of host-pathogen interaction by *in silico* analysis of human-bacteria protein-protein interaction network for better understanding of pathogenicity and drug design.
- Elucidation of the earliest ancestor of the Green Sulfur Bacteria (*Chlorobia*) and discovery of crypto-aerobic microbial life in anoxic (sulfidic) marine sediment.

Biophysics

- Adapted and optimized computational protocols to quantify the contributions of some specific amino acid residues of proteins/peptides to determine their capacity to penetrate into the membrane; particularly the role of charged residues were underscored. Even the roles of cholesterol molecules to influence the membrane fusion were demonstrated.
- Long noncoding RNA target prediction tool has been developed.
- A new version of Long noncoding RNA database has been developed which hosts information on lncRNAs harbouring SNPs in breast, cervical and ovarian cancer patients.

Biochemistry

- The domain structure and the folding-unfolding mechanism of a staphylococcal cyclophilin have been demonstrated.
- An internal region that preserves the structure, function, stability and shape of a staphylococcal cyclophilin has been identified.
- Identification of a paralogous family of vesicle-mediated protein transport machinery

component in the human enteric pathogen *Giardia lamblia* that do not have any human counterparts.

- Novel membrane-bending proteins of the human pathogen *Giardia lamblia* with unusual lipid-binding domain.
- The oligomeric plasticity and inter-molecular cross-talk between heat shock proteins of *Sulfolobus acidocaldarius* protect stress-induced protein aggregation and membrane destabilization.
- Diversity and distribution of Antibiotic resistome in the Sundarban mangrove ecosystem.

Molecular Medicine

- Elevated histone H3 acetylation and the loss of the Sp1-HDAC1 complex de-repress the GM2-synthase gene in renal cell carcinoma.
- *Ricinus communis* L. fruit extract inhibits migration/invasion, induces apoptosis in breast cancer cells and arrests tumor progression in vivo.

Biophysics

- Tumor suppressor p53-mediated structural reorganization of the transcriptional co-activator p300.
- The three dimensional cryo-EM density map of the p300-p53 complex was constructed. Characterization and stability study of different gaseous detectors for ALICE and CBM experiments.
- R&D of straw tube detector and low resistive RPC detector, measurement of spark probability of MPGD.
- The only cosmic ray extended air shower (EAS) array in Eastern part of India, was commissioned and taken data continuously for last two years in the Darjeeling campus of Bose Institute
- BI demonstrated the tuning of light-matter coupling in exciton-plasmon (2D-0D) hybrid system. We have shown for the first time the switching between the optical emissions due to the transitions of exciton and trion in WS_2 .
- Characterization of the hot and dense quark gluon plasma (QGP) medium produced in heavy ion collisions, by studying jet modifications in presence of the medium using ALICE detectors and using the framework of theoretical models EPOS and JEWEL.
- Understanding the dynamics of particle production in small systems (proton-proton collisions) at LHC energy through study of jet properties.

- Development of a water based cooling system for the Muon Detector (MUCH) for the mini-CBM experiment at GSI, Germany.
- Data quality assurance and calibrations of the LHC data obtained by Photon Multiplicity Detector (PMD) in the ALICE experiment at CERN, Geneva. Signatures of new resonances observed in the context of the decades old cosmological lithium problem from the first Indian experiment at CERN-HIE-ISOLDE, Geneva, Switzerland. The analyzed data on the excited states of ^{16}O from this experiment provided the ratio of ^{12}C to ^{16}O abundances, impacting stellar nucleosynthesis in massive stars.

Environmental Sciences

- A 15 year long-term study shows that Sundarban mangrove forest acts like an umbrella consuming polluted acid vapours arriving from massive biomass burning over Eastern Ghat regions (Jhum Cultivation) and inhibits their further advection towards further north of West Bengal including Kolkata.
- Sources were identified and quantitatively estimated their strength for the extremely carcinogenic Polynuclear Aromatic Hydrocarbons in the atmosphere of Kolkata and the exposures to the people of different ages and occupation.
- Models have been developed to quantitatively predict the deposition flux of nutrients on the Himalayan soil when rain rates and aerosol pollutions are known.
- Bose Institute has been selected as the Nodal for making action plans for air pollution for the state of West Bengal under National Clean Air Programme (NCAP), Govt of India.

Important Output Indicators:

S.No.	Parameters	Output
1.	Papers in refereed journals	175
2.	Papers in Conferences	3
3.	Number of Ph.Ds. produced	31
4.	Number of Technology leads awaiting transfer	1
5.	Research Manpower trained (other than Ph.Ds)	22
6.	Technical Manpower trained	07
7.	M.Tech/M.Sc./M.Phil projects guided	11

4.5 Centre for Nano and Soft Matter Sciences (CENS), Bengaluru

The centre focusses its R&D activities in the areas of Nano Science and Nanotechnology; Nano-Soft composites; Soft matters such as liquid crystals, polymers, gels, membranes etc.

Major Accomplishments:

The topics under which research work was carried out during 2019-20 and the results are published in peer-reviewed reputed journals are as follows.

- Unusual thermal behaviour in liquid crystal chiral dimers exhibiting photoluminescence.
- Highly efficient and sustained electrochemical hydrogen evolution by embedded Pd-Nanoparticles on a Coordination Polymer - Reduced Graphene Oxide Composite.
- Highly sensitive, fast response and recovery times in a humidity sensor using TiO₂ slanted nanorods.
- Tunable structural colours exhibited using TiO₂ nanorods and thin films prepared by e-beam glancing angle deposition (GLAD).
- Chemical nature of the intergrowth nanostructures of a series Sb-doped SnTe by variable-energy X-ray photoelectron spectroscopy at synchrotron, which is well known to probe buried interfaces and embedded nanostructures.
- Studies on the degradation of both the polymorphs of Cs₃Sb₂I₉ (dimer and layer forms) in water, light, and elevated temperature – the well-known factors causing degradation in perovskites using X-ray diffraction and thermogravimetric analysis bring out clear understanding of the stability of this material for its efficient use in photovoltaics.
- An efficient tuning of photonic band gap by utilising the combination of electric and optical fields in a 3D soft photonic crystal based on blue phase liquid crystal is achieved.
- Hexagonally ordered gold nanostructure arrays with closed and opened interstices is fabricated in a single substrate using colloidal lithography, inclined reactive ion etching and inclined sputtering techniques, which exhibit tunable plasmonic resonances at different regions of the substrate.
- An optical storage device by doping photo-sensitive achiral non-linear mesogen into a room temperature nematic liquid crystal is fabricated successfully.
- To find an alternate to expensive conducting substrates such as ITO and also to overcome the issue of non-uniform electric field in metal mesh electrode, a hybrid electrode is fabricated, in which, a thin conducting layer of oxide (AZO or ITO) is coated over metal mesh.
- Crystalline phase distribution maps in gold microcrystals using synchrotron measurements.
- Translucent- transparent switching glass by refractive index matching using micro fluid.

- Fabrication of USB power enabled transparent heaters using Hybrid metal-oxide coated on Al-mesh TCEs.
- First time Coating of conducting SnO₂ film on Al-mesh@glass substrate was optimized by a solution method.
- A new kind of switching glass developed based on microfluidic toggles between opaque and transparent states in select areas.

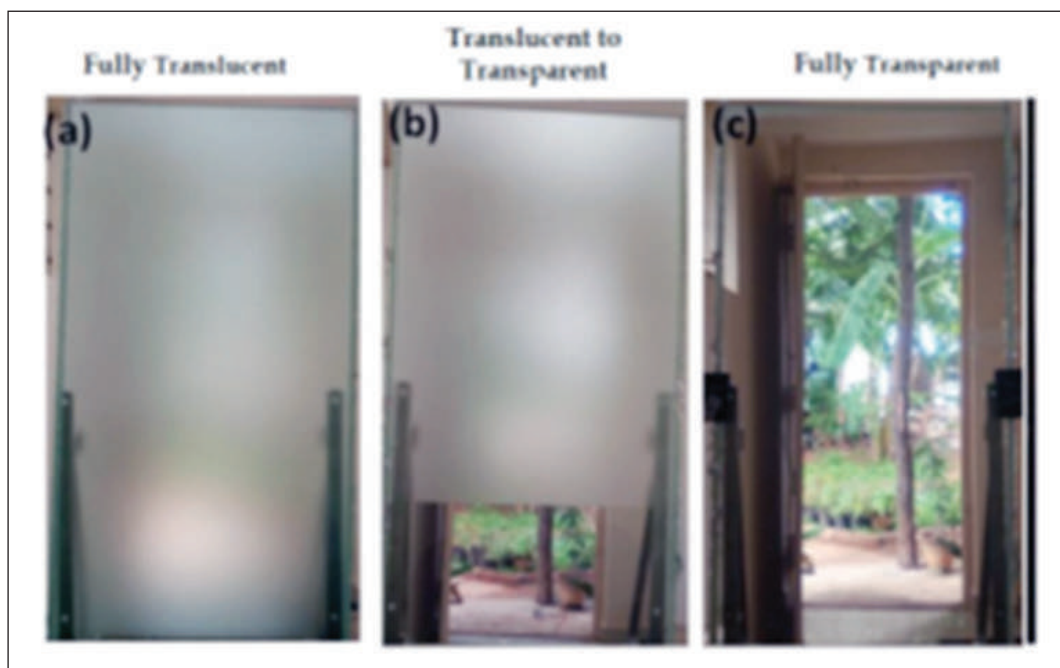


Fig. Switching Glass

- Demonstration of activation of as-synthesized MoO₂ electrocatalyst for efficient hydrogen evolution in acidic medium by cycling of potential.
- A bifunctional electrocatalyst based on earth abundant transition metal phosphites has been developed for performing oxygen evolution reaction and oxygen reduction reaction in alkaline medium.

Important highlights of major research programme:

- Highly functional liquid crystals and coordination polymers have been designed, synthesized and characterized. The latter's usages in different sensing application have been demonstrated.
- Studies on humidity sensing and breath analyzing applications of TiO₂ slanted nanorod arrays.

- Self-cleaning structural colors by TiO_2 /Tinanostructures.
- Grain boundary assisted bipolar resistive switching in solution-processed NiO.
- Imprinting directional microstructures by gelating the twist bend nematic phase.
- Estimation of the dynamic scaling exponents of thin films of nickel octabutoxy phthalocyanine at air-solid interface.
- Production of large area (1 sq.ft.) and low-cost Transparent conducting glasses made of metal nanomesh coated with metal oxide overlayer (300 no. in quantity) and exploring its market feasibility and identifying potential customers.
- Fabrication of prototypes (Transparent EMI shields, Transparent defogger/defroster, Transparent heaters, Polymer Dispersed liquid crystal (PDLC) based switching glasses, etc.) using above hybrid electrodes.
- First time Coating of conducting SnO_2 film on Al-mesh@glass substrate was optimized by a solution method.
- A new kind of switching glass developed based on microfluidic.
- Arriving at the highest achievable 2D raman intensities in twisted graphene.
- The gold nanorods doped in a TGB phase-the liquid crystal analogue of Abrikosov phase gives rise to enhanced thermal range of TGB phase with an influence on photonic band gap.
- The large aspect ratio (~ 250) CNT favours the smectic phase over the reentrant nematic.
- Nickel cobalt phosphite (NCP) decorated with carbon nanotubes for bifunctional oxygen electrocatalysis.
- Electrochemical activation of MoO_2 films towards highly efficient catalyst for hydrogen evolution from water in acidic medium .
- Graphene and MoS_2 dispersions for lubricant applications in industrial oils.

Important Output Indicators:

S.No.	Parameters	Output (as on 31.12.2019)
1.	Papers in refereed journals	47 (Average IF: 3.84/paper)
2.	Patents filed / granted	8 (incl. 2 PCT Application)
3.	Books/Chapters in Books	4
4.	Papers in Conferences	2
5.	Number of Ph.Ds. produced	4

S.No.	Parameters	Output (as on 31.12.2019)
6.	Number of Technology leads awaiting transfer	1
7.	Research Manpower trained (other than Ph.Ds)	49
8.	Other Products/ Indicators (* Lectures given at schools/colleges under popularization of science / V4 Programme)	Under V4 Programme and ROIS Programme of CeNS, overall, 5572 students of different school/colleges of the Country have been benefitted during the period of the report.

4.6 Indian Association for the Cultivation of Science (IACS), Kolkata

Applied and Interdisciplinary Sciences, Biological Sciences, Chemical Sciences, Materials Sciences, Mathematical and Computational Sciences and Physical Sciences are some of the major areas of R&D at the IACS.

Major Accomplishments:

- Polydisulfide scaffolds as drug delivery vehicle.
- New antibacterial material based on polyurethane.
- Morpholino-based antisense reagents for the treatment of Duchenne muscular dystrophy (DMD).
- Delivery efficacy of ThioRNA-based antisense drug “Dircapersen” for the treatment of DMD.
- GRAPHENE OXIDE DOPED POLYANILINE NANOTUBES (Patent No: 317597 dated 05/08/2019) has been granted to IACS.
- Triboelectric Nanogenerator for Mechanical Energy Harvesting.
- Perovskite Nanocrystals for Energy Harvesting.
- Transparent, Flexible Silicon Nanostructured Wire Networks for High-Performance Photodetector Applications.
- Self-Powered and Broadband Photodetectors with Gallium Nitride.

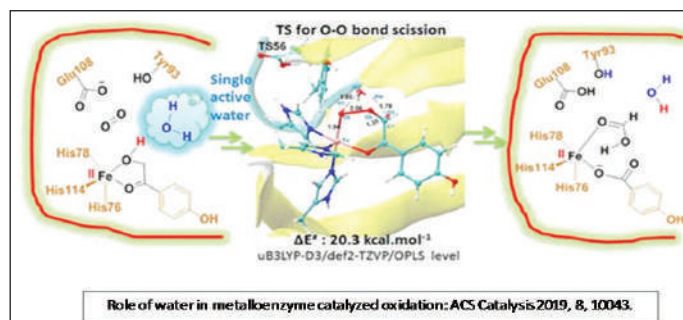
BIOLOGICAL SCIENCES:

- Fluorescent Switch for Sensing Acid and Base Vapors.
- Atomically precise Cu-nanoclusters from Bulk Scale Synthesis to Catalytic Reduction.

- Understanding of perinuclear Nonmuscle myosin II found in primary mouse tumorigenic cells” highlighted in PNAS as “Meddling with Myosin’s mechanobiology in cancer.
- Contributions in the area of DNA repair and genome stability for understanding genomic alterations in carcinogenesis and neurodegeneration.
- Construction of in house point FRAP system.
- Discovery of novel immune response in zebrafish system.

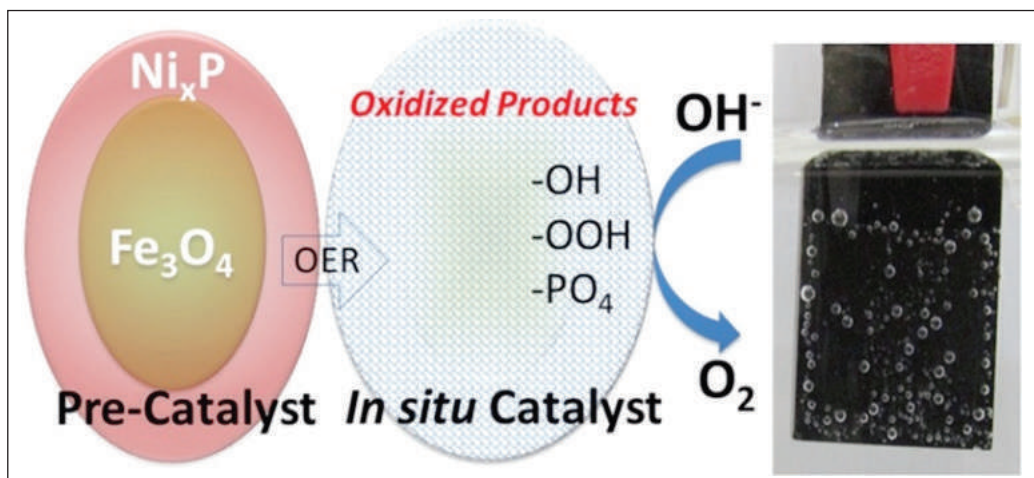
CHEMICAL SCIENCES:

- Biologically active natural and non-natural compounds.
- Asymmetric N-heterocyclic carbene catalysis via ion-pair interaction.
- Environmentally benign ways of C-H functionalization using visible-light and air.
- DNA-based logic devices for DNA-based computation.
- Identification of the reactive intermediate, for degradation of neurotransmitters by heme-bound amyloid beta peptides associated with Alzheimer’s disease.
- Advanced photochemical oxidation, optimized conditions for complete oxidative removal of cyanide ions from an industrial effluent (water).
- Understanding the role of spin-orbit coupling in transition metal complex facilitated oxidation with dioxygen as terminal oxidant.
- Computational Design of a potentially sustainable Hydrogen Storage material.
- Multi-scale molecular dynamic probing of the processivity and directionality of kinesin.
- Understanding of the role of fungicides in the genotoxicity.
- Catalytic oxidation of inert organic compound with oxygen.
- Computationally Driven Design of Singlet Fission in Organics .



MATERIALS SCIENCES:

- Nanomaterials base light harvesting systems.
- Nanoparticles for cytosolic delivery via direct membrane penetration.
- Cost-effective and stable photoelectrodes for PEC water splitting.
- Broadband (UV-Vis-NIR) and Self-powered Photodetectors.
- Transition metal decorated on graphene (diamagnetic graphene).
- Modifying perovskite grains with poly(vinylidene fluoride) in the interfacially engineered perovskite solar cells with power conversion efficiency of 12 %, at ambient condition.



Working principle of designed nanoparticle as electro-oxidation catalyst

MATHEMATICAL AND COMPUTATIONAL SCIENCES:

- Stiffness of the local environment and mechanical stress for studying intercellular cooperativity can guide the tissue structure
- Cell adopts redundant pathways via interaction with cortex and nucleus to place the centrosome in the perinuclear region.

PHYSICAL SCIENCES:

- Organic dual spin valves with well-resolved four resistive-states.
- New energy materials based on multiferroic family R,YCrO_4 ($\text{R}=\text{Sm,Gd}$ and Ho).
- Study of the influence of spinless impurities on a frustrated magnet featuring a spin-

density phase, which shows a novel way of controlling the phase diagram of a many-body system using disorder.

- A model of Fermionic dark matter is proposed, having both UV and IR freeze-in mechanism.
- A large effect on bottom mass Yukawa coupling is seen when including soft supersymmetry breaking non-holomorphic trilinear terms within the minimal supersymmetric standard model, for interesting collider signatures at the Large Hadron Collider of CERN, Geneva.

Important Output Indicators:

S.No	Parameters	Output
1.	Papers in refereed journals	339
2.	Books	05
3.	Papers in Conferences	37
4.	Number of Ph.Ds. produced	52
5.	Foreign Patents filed	01
	Foreign Patents granted	01
6.	Indian Patents filed	03
	Indian Patents granted	03
7.	Number of Technologies/Designs and other intellectual products commercialized	02
8.	Research Manpower trained (other than Ph.Ds)	39
9.	B.Tech/ UG projects guided	06
10.	M.Tech/M.Sc./M.Phil projects guided	05

Indian Institute of Astrophysics (IIA), Bengaluru

IIA focusses its Research and development on Astronomy and Astrophysics, Atomic Physics, Laser Physics and Astronomical Instrumentation development of facilities.

Major Accomplishments:

- IIA was involved in search for an electromagnetic counterparts of gravitational wave sources using the 0.7m robotic telescope at IAO, Hanle, the study of stellar populations in the Magellanic Clouds, study of radio loud quasars in the SDSS survey, study of the energetic type IIP supernova SN 2017gmr.
- The 2m Himalayan Chandra Telescope (HCT) was used in an international study that detected the catastrophic disintegration of P/2016 G1 (PANSTARRS), an active asteroid and suggested that G1 was hit by a small object which caused its (partial or total)

disruption, and that the ring corresponds to large fragments ejected during the final stages of the crater formation.

- Precise photometric studies using the 2m HCT and 1.3m JCBT provided updated and improved understanding of the properties of five close-in exoplanets.
- Enhancement of the element Li in some stars is one of the unsolved problems in astrophysics. In a recent study, IIA scientists speculated that the origin of Li enhancement may lie at Red Giant Phase tip during He-flash rather than by external source of merging of sub-stellar objects or during luminosity bump evolution. Strong evidence that the Li enhancement is associated with stars in the core He burning phase, which pass through a particular evolutionary phase known as He-flash was found based on astro-seismic studies. This provides a strong constraint on theoretical models which try to explain the Li enhancement in stars.
- Shock breakout was detected by IIA in the peculiar Type II supernova SN 2018hna. This is the second supernova with a blue supergiant progenitor in which shock breakout has been recorded.
- The gamma ray properties of Narrow Line Seyfert Type-I galaxies challenges our current notion of them hosting low mass black holes. To resolve this tension a team of scientists estimated the black hole masses of more than 500 sources using different methods and suggested that NLS1s host high mass black holes and their available black hole mass values are underestimated influenced by their observed relatively small emission line widths.
- IIA scientists were part of a discovery paper on an extremely large (≈ 115 kpc in diameter) HI ring, located around a massive quenched galaxy, AGC 203001, but off-centred with respect to it (using the Giant Metrewave Radio Telescope). Such an extended HI structure is very rare with only one other case known so far.
- The trajectories of particles around spinning black holes were studied with an aim to apply it to oscillations seen in black hole binaries. The black hole mass distribution in the Universe was constructed to extract parameters using theoretical models given the data gathered from tidal disruption events. It has been suggested that primordial black holes could trigger the formation of high red shift super-massive black holes.
- IIA organized an international conference on “150 years of periodic table: Chemical elements in the Universe” in which more than 100 researchers from national and international institutions participated.



International conference on “150 years of periodic table: Chemical elements in the Universe”

- A machine learning software was developed to distinguish stars from quasars using photometric data.

Important Highlights of Major Programmes:

- The payload operation centre of UVIT at IIA is monitoring the operations of Ultra Violet Imaging Telescope (UVIT), on-board AstroSat and is responsible for the processing and delivery of data products. In the last one year UVIT produced excellent scientific results both in galactic and extragalactic astronomy. Study of star clusters using UVIT provided important insights on the formation mechanism of Blue Straggler stars. UV study of star formation in a nearby dwarf irregular galaxy, IC 2574 provided evidence for that the role HI shells in triggering star formation.
- Design study of the dome and building for the National Large Solar Telescope continued even while awaiting the final approval of the project.
- India Thirty Meter Telescope delivered components such as actuators, leaf springs, software are all successfully qualified. The construction of the India-TMT Optics Fabrication Facility building is completed. Various tools and metrology stations being developed by Information Technology and Communications Complex.
- For the establishment of National Large Optical-IR Telescope the design of the primary mirror optics is proceeding. The development of the prototype segmented mirror telescope is progressing well.

- Indian Spectroscopy and Imaging Space Telescope (INSIST) is the proposed next generation space telescope by India in UV and optical wavelengths. IIA is the PI institution and it is in the pre-project phase, with initial seed funding from ISRO. Scientists and Engineers in IIA are leading the efforts related to the optical, mechanical design and development of science cases and requirements.

Important Output Indicators:

S.No.	Parameters	Output
1.	Papers in refereed journals	98
2.	Papers in Conferences	21
3.	Number of Ph.Ds. produced	10
4.	Research Manpower trained (other than Ph.Ds)	30
5.	Technical Manpower trained	15
6.	B.Tech/ UG projects guided	20
7.	M.Tech/M.Sc./M.Phil projects guided	18

Indian Institute of Geomagnetism (IIG), New Mumbai

Areas of Focus: Geomagnetism and Allied Fields

Major Accomplishments:

- The Van Allen Probes have observed both symmetric and asymmetric bipolar electric field structures in the Earth’s inner magnetosphere. In general, the symmetric bipolar structures are identified as electron-phase space holes, whereas the asymmetric structures are interpreted as electron acoustic double layers (EADLs). The simulation shows that the localized depletion and enhancement in the electron populations act as a perturbation to excite the symmetric bipolar electron acoustic solitary waves, which later evolve into the EADLs. The ponderomotive force is found to be the main driver behind the transformation of the symmetric electron acoustic solitary waves to EADLs via formation of the electron acoustic shocks.
- The airglow imager that was operated in campaign mode from the Magnetic Observatory campus of Silchar will be shifted to its new permanent housing in the form of a raised structure. This instrument was deployed during December 2017 as part of IIG’s Coupled Lithosphere-Atmosphere-Ionosphere-Magnetosphere system (CLAIMs) scientific program. Analysis of few nights of airglow observations using the all-sky imager had led to some interesting results on mesospheric bores and gravity wave propagation over the north-eastern region.
- The tests carried out with the front end optical assembly by IIG of the newly designed Fabry Perot Interferometer (FPI) have been satisfactory and the fabrication of the

mechanical components of the Interferometer is currently being undertaken. Once it is set up, the FPI will yield useful measurements of thermospheric temperatures and winds, crucial and important parameters for understanding the day-to-day variabilities of many of the equatorial upper atmospheric phenomena.

- Depth to the top of different density interfaces within the Kutch rift basin was calculated by IIG using the spectral analysis of the Bouguer anomaly data. Three density interfaces were obtained for both the blocks: the deepest interface at 10.3 km (Eastern Block) and 10.5 km (Western Block) were interpreted as the top of the high velocity, high conductivity mafic body, intermediate interface at the 3.6 (Eastern Block) and 3.1 km were interpreted as the bottom of the high velocity limestone strata (Jhumara and Jhurio formations) while the density interface at 1km (Western Block) depth in the western block and 1.5 km in the eastern block is interpreted to represent the top contact of the high velocity limestones with the low velocity Mesozoic sediments. Combined 2D forward modelling of two profiles in the Wagad Uplift (Kutch Rift basin) delineated the presence of Upper/Middle and Lower Jurassic sediments corresponding to sandstone, limestone, shale etc., in the subsurface above the basement. Mafic/Ultramafic intrusions of variable thickness observed along these profiles suggest that the region has undergone magmatic activities in the past, which is in tune with the previously inferred three stage evolutionary model and previous studies.

Important Highlights of Major Programmes:

- One-dimensional fluid simulation is used to investigate the generation of electron acoustic solitary waves (EASWs) in three-species plasma. An un-magnetized collisionless plasma consisting of cold electrons, hot electrons, and ions is considered. The Gaussian perturbations in the equilibrium electron and ion densities are used to excite the waves in the plasma. This simulation demonstrates the generation of a series of EASW pulses in this three-species plasma through the process of wave breaking. The behavior of the ponderomotive potential, frequency, and force associated with electrons and ions is investigated during the process of the wave breaking. It is observed that the ponderomotive potential of the hot electron, which is the driving species for the electron acoustic waves, peaks at the time of wave breaking.
- Palaeo-environmental evolution of the sediments in DVP is studied using a multiproxy approach involving mineral magnetics, geochemistry, grain size distribution, carbonate data and geochronology. In this study IIG illustrate magnetic grain size properties of the sediments collected from 3 m thick section of Jawale, Pravara valley. Hysteresis loop, FORC and major element experiments were performed on sediments in order to study the grain size variations. Ratios of hysteresis parameters M_{rs}/M_s versus H_{cr}/H_c (Day plot) indicate that the magnetite/maghemite particles in the sediments are fine to medium grained, occupying mainly the PSD range. The hysteresis loop of the samples showed the characteristics of so-called pseudo-single-domain (PSD) magnetic grains in the studied

samples. All of the hysteresis loops are narrow (indicating a relatively small coercive force), and the ferromagnetic components, indicated by the corrected hysteresis curves, are saturated in a low level of applied field (200–300 mT). FORC diagrams can be used to identify and discriminate between the different components in a mixed magnetic mineral assemblage. FORC diagrams of samples show wide vertical distribution with open contours which may indicate PSD behavior.

- Simultaneous observations of rising and falling tones which IIG name as bifurcation of Electromagnetic Ion Cyclotron (EMIC) waves are reported. These observations are from THEMIS E satellite in the dayside magnetosphere. Three EMIC events that occurred on 6th April 2015, 29th June 2007 and 13th April 2015 are presented. Bifurcations are observed in proton as well as in helium bands. Looking into the fine structures of the dynamic spectra and applying bandpass filters for desired frequencies, IIG have shown that the wave amplitude and phase for rising and falling tones nearly match at the bifurcation. Frequency sweep rates, wave normal angles, ellipticity for all the events are calculated and found to have similar characteristics. A good cross-correlation between rising and falling tones is found. The study of bifurcation will provide a new understanding of wave-particle interactions and the overall behavior of EMIC waves.
- Global Navigation Satellite System (GNSS) measured Total Electron Content (TEC) is now widely used to study the near and far-field coseismic ionospheric perturbations (CIP). The generation of near field (~500–600 km surrounding an epicenter) CIP is mainly attributed to the coseismic crustal deformation. The azimuthal distribution of near field CIP may contain information on the seismic/tectonic source characteristics of rupture propagation direction and thrust orientations. However, numerous studies cautioned that before deriving the listed source characteristics based on coseismic TEC signatures, the contribution of non-tectonic forcing mechanisms needs to be examined. These mechanisms which are operative at ionospheric altitudes are classified as the i) orientation between the geomagnetic field and tectonically induced atmospheric wave perturbations ii) orientation between the GNSS satellite line of sight (LOS) geometry and coseismic atmospheric wave perturbations and iii) ambient electron density gradients. The combined effects of these mechanisms were not quantified. A 3D geometrical model, based on acoustic ray tracing in space and time is developed to estimate the combined effects of non-tectonic forcing mechanisms on the manifestations of GNSS measured near field CIP. Further, this model has been enhance a proper perception among the researchers about the tectonic source characteristics tested on earthquakes occurring at different latitudes with a view to quickly quantify the collective effects of these mechanisms. It is presumed that this simple and direct 3D model would induce and derived based on the corresponding ionospheric manifestations.

Important Output Indicators:

S.No.	Parameters	Output
1.	Papers in refereed journals	48
2.	Chapters in Books	1
3.	Papers in Conferences	85
4.	Number of Ph.Ds. produced	12
5.	Indian Patents filed	1
6.	Research Manpower trained (other than Ph.Ds)	55
7.	Technical Manpower trained	15
8.	M.Tech/M.Sc./M.Phil projects guided	50
9.	Scientific Outreach Programmes organized	26
10.	Popular Science Articles published	30
11.	Number of persons who attended various science outreach programmes/conferences etc.	1600
12.	Scientific Lectures/Training Programmes organized	60
13.	Number of students trained	50
14.	Number of school/college/university teachers trained	23

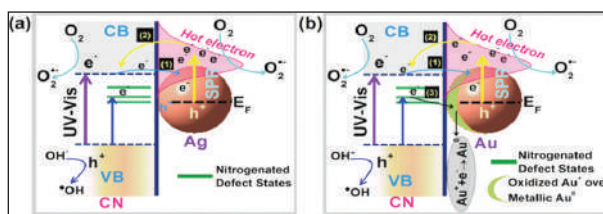
Institute of Advanced Study in Science and Technology (IASST), Guwahati

Areas of Focus: Basic and applied plasma physics, advanced material sciences, mathematical and computational sciences, biodiversity and ecosystem research and traditional knowledge based drug development and delivery.

Major Accomplishments:

- IASST conducted studies on vortex observation in dusty plasma flow, synthesis of metal oxide nanocomposites with tunable band gap in liquid plasma discharge and gas phase synthesis of nano dust powder in radio frequency discharge

- A symmetric pair of vortices was created in a dusty plasma supersonic flow past an obstacle. This is the first successful observation of vortex pair in dusty plasma similar to its hydrodynamic counterpart.
- Photocatalytic roles of silver (Ag) and gold (Au) nanoparticles (NPs) on graphitic carbon nitride (CN) nanosheets, thoroughly investigated, under UV (250-380 nm), UV-vis (256-600 nm), and green laser (532 nm). IASST established that under UV light, Ag and Au NPs capture photogenerated electrons from CN and function as cocatalysts.



The synchronicity of bandgap excitation and plasmonic activation under UV-Vis light for (a) AgCN and (b) AuCN.

- Förster resonance energy transfer-mediated globular protein sensing platform developed using polyelectrolyte complex nanoparticles
- Isolated purified and characterized two molecules (verbascoside and isoverbascoside) from the herb *Premna herbacea*, which were effective against type 2 diabetes.
- A bacterial inoculum *Micrococcus luteus* could enhance yield of scanted rice in small size plot and farm field by 12.6 to 63% respectively observed.
- IASST demonstrated for the first time the anti-cancer efficacy of the fruit extract of common castor plant, *Ricinus communis* L. fruit extract (RCFE) which can be proposed as a potent candidate for the treatment of breast cancer.
- Developed sustainable and environment friendly carbon and non-carbon based hybrid nanomaterials as sensor for carcinogenic material used in cosmetics, plasmonic photocatalysts, PEMFC etc.
- Sediment characteristics, carbon stock, heavy metal and pollution status were carried out in the Ramsar declared tropical freshwater wetland Deepor Beel. The higher carbon stock of $2.5 \pm 0.7 \text{ kgm}^{-2}$ indicates Deepor Beel is a potential carbon sink.
- A cost-effective and environmentally sustainable process developed for phycoremediation of oil field formation water for its safe disposal and reuse. This technology has potential to solve the formation water problem being faced by the oil industry.

Important Output Indicators:

S.No.	Parameters	Output
1.	Papers in refereed journals	67
2.	Chapters in Books	05
3.	Papers in Conferences	62
4.	Number of Ph.Ds. produced	07
5.	Foreign Patents filed	01
6.	Indian Patents filed	06
7.	Number of Technologies/Designs and other intellectual products commercialized	01
8.	Number of Technology leads awaiting transfer	04
9.	Research Manpower trained (other than Ph.Ds)	46
10.	Technical Manpower trained	05
11.	B.Tech/ UG projects guided	21
12.	M.Tech/M.Sc./M.Phil projects guided	22
13.	Extramural Project	22

Institute of Nano Science and Technology (INST), Mohali

Area of Focus: Various areas of nano science and technology with major thrust on the following areas: Electrochemical devices for Energy Conversion and Storage, Smart materials for packaging, Terahertz Spectroscopy Imaging, Topological materials, Nanotechnology based technology in Agricultural, Nanomedicine for Theranostics, imaging and its Applications, etc.

Major Accomplishments:

- Developed a cost-efficient and scaleable method for graphene based integrated on-chip microsupercapacitor, a miniaturized electrochemical storage device. A simple electrochemical method followed by laser-irradiation technique was exploited to develop metal-free energy storage devices. A graphene film, which is highly conducting, robust and can readily be integrated with energy conversion technologies developed.
- INST developed a simplified process to treat Paracetamol Industrial Effluents.
- INST has organized an open day for school, college students and the general public its premises with an objective to get science out of the textbook and help to develop a genuine interest and stronger skills in science.
- Organized a special workshop titled “Advanced Techniques in Nano Science and

Technology (ATNST 2019)” for ST researchers during 03rd to 08th December 2019 for the purpose of raising the awareness of M.Sc and Ph.D. students belonging to the ST-category.

- INST, Mohali provides opportunity for candidates belonging to Scheduled Tribe (ST) to bring highly motivated and bright Scheduled Tribe (ST) candidates for engagement of Research Internship in various research projects in the field of Nanoscience and Nanotechnology. A financial support of Rs. 10,000 p.m is given for the fellowship for doing internship at INST for a duration of 03-06 months.
- The flagship Outreach programme, which was launched in 2014 was continued and INST scientists reach out to the tribal population by visiting remote places in various states, in addition to the training provided through workshops and conferences organized at INST.
- Collaboration was established under INST industry collaborative programme (a) IISER for sharing of animal facility to do research work on applications of Nano Science and Technology. (b) With Rajib Gandhi Centre for Biotechnology, Trivandrum relating to the study that involves development of prototype for local delivery of anti-cancer drug for containments of oral cancer. (c) Collaborative programmes was initiated with Tata Steel also.

Important Output Indicators:

Sr.	Parameters	Output
1.	Papers in refereed journals	100
2.	Books	02
3.	Chapters in Books	03
4.	Number of Ph.Ds. produced	02
5.	Indian Patents filed	03
6.	Number of Technology leads awaiting transfer	03
7.	Technical Manpower trained/guided	03
8.	M.Tech/M.Sc/M/Phil/UG Projects guided	20

International Advanced Research Centre for Powder Metallurgy and New Materials (ARCI), Hyderabad

Areas of Focus: Automotive Energy Materials, Solar Energy Materials, Nanomaterials, Engineered Coatings, Ceramic Processing, Laser Processing of Materials, Fuel Cells, Carbon Materials.

Major Accomplishments:

- ARCI handed over the know-how document for 'Ceramic Inserts for Anti-mine boots' to user agency for productionisation.
- Know-how for 'Easy to clean coating for PV panels' handed over to sponsoring organization, NTPC, New Delhi.
- ARCI demonstrated solar receiver tube absorber coating for Industrial process heat applications.
- ARCI developed Li-ion batteries demonstrated on solar street light and e-scooter applications.
- Conformally cooled core pin for Pressure die casting (PDC), Metallic Bipolar Plates for PEM fuel cells and hair transplantation tools were developed.
- Silicon Carbide (SiC) mirrors and cold-fingers were supplied to IIA, Bangalore for integration with ARCI supplied SiC mirror substrates.
- ARCI conducting filed test for (a)Erosion resistance coatings on helicopter compressor blades; (b) Laser cladding based refurbishment technology for helicopter pinion housing; (c) Tungsten based components by spark plasma sintering route with nano additives; (d) Laser surface treated piston rings.
- ARCI demonstrated good antibacterial properties for Sol-gel based antibacterial coatings on non-woven scrub pads.
- Prototype of antifogging and antireflective dual functional coatings on optical lenses undergoing validation at industries.

Important Highlights of Major Programmes:

- Towards electric mobility- Li-ion battery pack comprising 26650-cylindrical cells (3.6V,2.3 Ah) developed
- 50 Whr Zinc-Air battery demonstrated.
- Demonstrated high performance in 12V/120A prototype alternators with indigenous Fe-P soft magnetic materials.
- A process to fabricate thermoelectric module using PbTe and Mg₂Si_{1-x}Sn_x compounds usable up to 400°C has been established.
- A 200 W automotive exhaust thermoelectric generator has been designed and tested for its performance.

- Prototype of 1 Nm³/hr PEM based water electrolyser developed and integrated with 1 kW fuel cells.
- Demonstrated 5kW PEMFC system for Stationary Applications using hydrogen generated at BARC's Electrolyser plant.
- Developed prototype of medium temperature solar selective absorber coating on 30m length SS tube.
- Wear resistant plates were supplied to Thermal Power Plant for field testing
- Advanced coating technologies such as High Velocity Axial Flow plasma have been established.
- Advanced intermetallic based oxide dispersed materials showed promising results for turbine blade application studied.
- Metallic bipolar plate designs optimized.
- Automated assembly line for 100 kW of fuel cell stacks per year has been conceptualized
- Initiated to low expansion-glass ceramic (LEGC) facility.

Important Output Indicators:

S.No.	Parameters	Output
1.	Papers in refereed (SCI) publications	143
2.	Books & Chapters in Books	3
3.	Papers in Conferences (with or without proceeding)	76
4.	Number of Ph.Ds. produced (including employees and Fellows)	04
5.	Foreign Patents filed	8
6.	Indian Patents filed	10
	Indian Patents granted	12
7.	Number of Technologies Transferred/applications developed/products supplied	21
8.	Number of Technology leads awaiting transfer	28
9.	Research Manpower trained (other than Ph.Ds)	21
10.	Technical Manpower trained	123
11.	B.Tech/ M.Sc projects guided	79
12.	M.Tech/ projects guided	46
13.	Number of Fellows Pursuing Ph.D	51
14.	Number of Project Scientists Pursuing Ph.D	17

Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bengaluru

Areas of Focus: Chemistry and Physics of Materials, Engineering Mechanics, Evolutionary and Integrative Biology, Geodynamics, Molecular Biology and Genetics, Neurosciences, Theoretical Sciences and New Chemistry.

Institutional recognitions: UGC on 24th May 2018 graded JNCASR as Category-I Deemed to be University as per the provisions of the UGC regulations. As per normalized Nature Index 2018, JNCASR featured 7th in the list of the Top 10 academic institutions in 2018. In the latest release of Nature Index 2019 young Universities- JNCASR stands 40th among top 100 young universities; 17th among top 50 young universities in chemistry, and recorded 61.6% increase in international collaboration

Major accomplishments:

JNCASR made major progress in research, which were published in some of the high-impact science journals. Few of our research achievements during the period are listed below: -

- In the area of cancer research, understanding regulation of autophagic processes through which human cells can become resistant to radiation, such as that used in cancer therapy. Recently, a key protein was found, called positive co-activator 4 (PC4), whose absence can lead to increased autophagy, allowing cells to withstand high radiation. These novel findings can be valuable in developing future autophagy inhibitor-based cancer therapeutics.
- The remotely sensed indices used in wildlife studies result in utility of NDVI in mapping foraging behavior of elephants. This may also have implications for studies on other herbivores.
- An open-source App “RhythmicAlly” was developed which allows subjective marking of phase on actograms, provides high interactivity with graphs, and facilitates visualization and storing of data for a batch of individuals simultaneously.
- EACC, a novel small molecule was found to inhibit late autophagy, without perturbing the general endolysosomal traffic. This is useful for studying autophagy-specific SNAREs, which has been difficult to do, so far, due to a lack of autophagy-specific inhibitors.
- Photocatalytic hydrogen evolution is a promising and sustainable alternative to generating hydrogen for solar energy conversion. The regulation of charge transfer in conjugated microporous polymers for the photocatalytic production of hydrogen was discovered by our Scientists.

Important Highlight of Major Programme:

- A total of 50 students joined different degree programmes at JNCASR through admissions in August 2019, in addition to the 07 students who joined through the mid-year admissions earlier in January 2019. The current student strength of the Centre is 339.
- The Centre received 23 applications for the visiting Fellowships 2019-20 in different disciplines. Of these, 13 were selected under Physical Sciences, 3 were selected under Biological Sciences and 1 was selected under Engineering Science category.
- Student Buddy Programme, which is an outreach programme bring, 35 students and 2 teachers from Jawahar Navodaya Vidyalaya -Bengaluru Urban, Bengaluru to JNCASR.
- A total of 257 students and 20 teachers from six colleges visited JNCASR campus and different labs (Biology, Chemistry, Physics & Engineering) during July to September 2019.
- Science outreach programme at Gangolihat, Uttarakhand (May 6-8, 2019).
- The JNCASR has obtained 8 patent grants (7 from Indian Patent Office and 1 from Japanese Patent Office) and filed 7 patent applications (5 - Indian Provisional Patent Applications, 1 - National Phase Patent Application under PCT in Australia and 1 - International Phase Patent Application under PCT) during April to December 2019.

Important Output Indicators:

S.No.	Parameters	Output
1.	Papers in refereed journals	205
2.	Papers in Conferences	7
3.	Number of Ph.Ds. produced	28
4.	Foreign Patents filed	2
	Foreign Patents granted	1
5.	Indian Patents filed	5
	Indian Patents granted	7
6.	Number of Technologies/Designs and other intellectual products commercialized	5
7.	Number of Technology leads awaiting transfer	40
8.	Research Manpower trained (other than Ph.Ds)	84
9.	Technical Manpower trained	4

Raman Research Institute (RRI), Bengaluru

Areas of Focus: Astronomy & Astrophysics, Light & Matter Physics, Soft Condensed Matter and Theoretical Physics.

Major Accomplishments:

- Timing and spectral analysis of X-ray emission from high mass X-ray binaries (stellar systems in which an ordinary star is orbiting a neutron star) has furthered our understanding of the magnetic field geometry, beaming pattern and the composition of the medium surrounding the neutron star.
- Demonstrated that a collection of Rb atoms at room temperature can serve as a near-ideal phase-sensitive amplifier for signals across frequency domains separated by several orders of magnitude.
- Worked out the structure and characteristics of the Sorkin-Johnston vacuum for a massive scalar field in the 2D causal diamond.
- Recent theoretical research focused on (a) finding solutions to the question - Is there a unique nonequilibrium steady-state in hybrid devices of topological superconductors and normal metal wires? and (b) providing physical perspectives on classical cloning that could be experimentally tested.
- Liquid crystal blue phases that are stable over a wide range of temperatures are highly desired for applications in tunable photonic band gap materials. RRI developed a novel technique for designing stable-induced blue phases in liquid crystal.
- Using a newly developed framework for Causal Set Markov Chain Monte Carlo simulations, RRI theoreticians and collaborators have for the first time implemented causal set dynamics that is restricted to 2 and 3-dimensions.
- Recent research on qualitatively assessing the extent to which a non-maximally entangled state is away from a maximally entangled state for a two qubit entangled state has revealed significant differences in theoretical estimates obtained using different entanglement measures thus highlighting the need for appropriate quantifiers.
- Axonal beading – formation of a series of swellings along the axon – and retraction are commonly observed shape transformations that precede axonal atrophy in Alzheimer's, Parkinson, and other neurodegenerative conditions. Hence elucidating the mechanisms behind these shape transformations could lead to better prevention and treatment strategies. RRI along with collaborators has shed light on the role of microtubules and membrane tension in axonal beading, retraction and atrophy.
- Have provided a novel interpretation of slit-diffraction that sets the stage for extending

the scope of application of diffraction interferometry to modern problems like quantum information processing (QIP). Such a formalism provides an alternative to the implementation of higher-dimensional QIP using the orbital angular momentum of light.

Important Highlights of Major Programmes:

- The **Nano-biophysics laboratory** has (a) measured, using the home-built nanopore platform, DNA plasmids folds with clear distinction between its various polymer conformations. (b) measured, using home-built electro-fluidic devices, alcohol dependent changes in red blood cells.
- An **X-ray polarimeter, POLIX**, made at RRI will be key payload on a dedicated satellite of ISRO named XPoSat. All the mechanical components of the Qualification Model (QM) of POLIX have been assembled and sent to ISRO for mechanical qualification tests. All mechanical components of the Flight Model (FM) of POLIX have been fabricated and assembly work for the four proportional counter detectors is ongoing. All the electronics for POLIX including five types of PCBs for detector control and nine types of PCBs for signal processing and telecommand/telemetry/housekeeping have been designed. Fabrication of the QM and FM electronics consisting of 69 space qualified PCBs are under fabrication. QM electronics for the detector units have been fabricated and tested.
- During 2019, Quantum Information and Computing laboratory (QuIC) at RRI continued making advances in free space QKD as part of its ongoing project called “Quantum Experiments using Satellite Technology” in collaboration with ISRO. One of the main achievements was the development of an indigenous end to end QKD simulator which has been named qkdSim which is aimed at simulating QKD with imperfections, an essential aid to the experimentalist. Research has also started on integrated photonics based QKD, as a part of DST’s India Trento Programme on Advanced Research (ITPAR).

Important Output Indicators:

S.No.	Parameters	Output
1.	Papers in refereed journals	80
2.	Papers in Conferences	03
3.	Number of Ph.Ds. produced	07
4.	Indian Patents granted	01
5.	Research Manpower trained (other than Ph.Ds)	89
6.	Technical Manpower trained	29

Sree Chitra Tirunal Institute for Medical Sciences and Technology (SCTIMST), Trivandrum

Areas of Focus: Biomaterials Research and Development, Biomedical Product Development, Technology Transfer and Industrial Linkages, Quality Management Systems, Testing and

Technical Services, Research in cardiac and neurosciences, and Patient Care and Public Health.

Major Accomplishments:

- US patent awarded for **FIBRIN WAFER/DISC AS A BIOLOGICAL CARRIER FOR SUSTAINED DELIVERY OF CURCUMIN (Patent No. 10,004,698)**. Curcumin mediates its anti-proliferative and apoptotic effects on cancer cells, including cancer stem/progenitor cells and their progenies, through multiple molecular mechanisms. The product claims immobilization of curcumin with human fibrin clot which is converted to a lyophilized wafer. Upon suspending the wafer in tissue culture medium, sustained release of curcumin is achieved in an active form without any metabolism of the drug. The released drug demonstrated the ability to arrest the proliferation of human cancer cells and endothelial cells and induced cell death in culture. The use of the drug incorporated fibrin wafer/disc enables availability of the drug in the local milieu in a soluble and effective manner.
- SCTIMST was awarded with the National Intellectual Property Award 2019 instituted by the Nation IP office, Department of Industrial Policy and, Ministry of Commerce, Government of India, in the category, “Top Indian R & D Institution / Organization for Patents & Commercialization. The award is to recognize enterprises for their creations and commercialization of IP which have contributed to harnessing the country’s intellectual capital and creating IP eco-system that boosts creativity and innovation.



- The following technology transfer agreements were signed

Technology	Industry Partner
Bioactive bone cement based on calcium sulfate	Prevest Denpro Ltd, 38, Industrial estate, Digiana, Jammu
Calcium phosphor silicate composite	Prevest Denpro Ltd, 38, Industrial estate, Digiana, Jammu
SCTAC2010 Albumin conjugated with drug	Eightoaksbio Private Limited, 7/361, Palatty, Angamaly South PO, Ernakulam



Exchange of Technology Transfer agreement for SCTAC2010 (technology of an anti-cancer formulation) between SCTIMST and EIGHTOAKS BIO Pvt. Ltd, Ernakulam

- Efforts for test manufacturing/ preclinical trials/clinical trials activities being undertaken by SCTIMST and the industry partners for the following products:
 - Extracellular matrix scaffolds from mammalian cholecyst/jejunum/urinary-baldder-
 - Rapid diagnostic kit with antibiogram for urinary tract infections
 - Beta Tricalcium Phosphate
 - 60% synthetic Hydroxyapatite and 40% Beta Tricalcium Phosphate
 - Poly Vinyl Alcohol sponge.
 - Injectable hydrogel for potential applications in cartilage repair and growth plate defects.
 - PT/INR monitoring device

- viii. Testing device for Tuberculosis diagnosis.
- ix. Lint free absorbent wound dressing
- x. SCTAC2010 Albumin conjugated with drug
- SCTIMST created facility in the Interventional Radiology Department for 'fenestrated endovascular aortic repair' by 'tear' in the large blood vessel called aorta, using the minimally invasive technique.
- SCTIMST established Molecular Genetics and Neuroimmunology Unit (MGNU) for the diagnosis of genetic causative factors in a variety of diseases, such as channelopathies, cardiomyopathies, neuromuscular disorders, movement disorders, hereditary ataxias and pediatric genetic syndromes, where underlying mutations in more than 1000 genes are known. The unit has been equipped with the most advanced facilities required to perform the genetic diagnostic tests like Real Time Polymerase Chain Reaction (RT-PCR), Sanger sequencing and Next Generation sequencing (NGS).

Important Output Indicators:

S.No.	Parameters	Output
1.	Papers in refereed journals	220
2.	Average IF per paper	3.67
3.	Chapters in Books	4
4.	Papers in Conferences	202
5.	Number of Ph.Ds. produced	13
6.	Foreign Patents filed	2
	Foreign Patents granted	1
7.	Indian Patents filed	17
	Indian Patents granted	8
8.	Number of Technologies/Designs and other intellectual products commercialized Agreement Signed	7
9.	Number of Technology leads awaiting transfer	16
10.	Research Manpower trained (other than Ph.Ds)	415
11.	Technical Manpower trained	232
12.	M.Tech/M.Sc./M.Phil/ B.Tech/ UG projects guided	48

S N Bose National Centre for Basic Sciences (SNBNCBS), Kolkata

Areas of Focus: Physics of nanomaterials including application-specific materials and nano devices; Advanced computational materials science including soft condensed matter, ionic liquids and biomolecules; Interface of biology and condensed matter physics; DNA-protein and nanomaterials interactions; biomolecular recognition; etc.

Important Highlights of Major Programmes:

- Two Technologies have been transferred for ‘Non-invasive Quantitative Estimation of Bilirubin in Blood’ and “Non-invasive detection of Oxygen deficiency in blood” on 27th August, 2019.



- A new technique has been invented to pave way for generation-next computing. (Spintronics pave way for gen-next computing <https://www.deccanherald.com/national/north-and-central/spintronics-pave-way-for-gen-next-computing-733668.html>) The research featured in the Nature India.
- Implemented three international and two national collaborative projects.
- Ph.D. programme conducted in collaboration with university of Calcutta and Jadavpur University.
- **Technical Research Centre**

Innovation/Deliverable	Sector
1. A simple diagnostic methodology for <i>non-invasive</i> detection of infection in real-time using human breath analysis.	Health care
2. Pico-calorimeter for biochemical and small volume analyzer for DSC/microscope attachment	Value added product to an existing sector of economy
3. Prototyping thin film devices using functional oxide patterned films.	Value added product for an existing sector of economy
4. Flexible paper-based highly sensitive sensor for ammonia gas detection by visual effects (color change).	Environment
5.(a) Hybrid Nanocomposites and (b) porous metal-organic framework compounds for CO ₂ and toxic gases removal	Environment
6. Hand held device for detection of adulteration of milk	Food safety

Important Output Indicators:

S.No.	Parameters	Output
1.	Papers in refereed journals	205
2.	Papers in Conferences	14
3.	Number of Ph.Ds. produced	16
4.	Indian Patents filed	4
	Indian Patents granted	4
5.	Research Manpower trained (other than Ph.Ds) PDRA	28
6.	B.Tech/ UG projects guided	3
7.	M.Tech/M.Sc./M.Phil projects guided	61
8.	Completed M.Sc. under IPhD	7

Wadia Institute of Himalayan Geology (WIHG), Dehradun

Areas of Focus: Geodynamics evolution of Himalaya using different proxies. and study of Habitants through time. Assessment and monitoring of National Resources and Hazards

Major Accomplishments:

- Strengthening of glacial and seismic monitoring network in Himalaya with special emphasis on NE and Himachal Himalaya along with Ladakh
- New initiative taken to study the impact of black carbon on glaciers.
- Initiated an awareness program on natural disaster in remote localities of Himalaya.

Important Highlights of Major Programmes:

- Deep mantle rocks from Indo-Myanmar range of Nagaland have evolved from a mid-oceanic ridge to a supra-subduction zone setting.
- Decadal scale climatic record for 900 years, generated from NE Himalaya, reinforces a strong climate-society interlinkage during past millennial.
- Historical and present seismicity catalogues of the Garhwal Himalaya suggest that Mid-Crustal Ramp of the Main Himalayan Thrust (detachment) is seismogenically active.
- Identified Ice dams and related Glacial Lake Outburst Floods in Karakoram region having 146 events with 30 major disasters.
- Remote sensing data in Sikkim Himalaya show that Glaciers were retreated significantly between 1991 and 2015. Glacial lakes have grown in size and numbers with a significant increase in snow line altitude.

- Recorded the Emission of Black carbon (EBC) concentration from $0.01 \mu\text{g m}^{-3}$ to $4.62 \mu\text{g m}^{-3}$ with a diurnal variability of $0.10 \mu\text{g m}^{-3}$ to $1.8 \mu\text{g m}^{-3}$ based on measurements at high altitude site Chirbasa (3600 m, amsl), near Gangotri Glacier.

Important Output Indicators:

S.No.	Parameters	Output
1.	Papers in refereed journals	65
2.	Chapters in Books	4
3.	Number of Ph.Ds. produced	9
4.	Research Manpower trained (other than Ph.Ds)	115
5.	M.Tech/M.Sc./M.Phil projects guided	32

National Innovation Foundation (NIF), Ahmedabad

Areas of Focus: Incubation and promotion of technological grassroots innovations including those which stem from children creativity and to add value to India's outstanding traditional knowledge base. To promote innovations and celebrate creativity of common people, through INSPIRE Awards - MANAK, Festival of Innovation and Entrepreneurship (FINE), Biennial National Grassroots Innovation awards and Dr APJ Abdul Kalam IGNITE Competition for school children.

Major Accomplishments:

- In addition to development of many grassroots innovation based technologies, a unique patent granted indigenous veterinary medicine to control endoparasite infestation among livestock was developed into a commercial product 'Wormivet'.
- For INSPIRE Awards - MANAK competition 2019-20, a flagship scheme for student innovations jointly implemented by NIF and DST, a total of 3.92 Lakh student ideas and innovations were mobilized from all 37 States & Union Territories of the country. Of these, a total of 42,143 student ideas were shortlisted for District Level Exhibition and Project Competition (DLEPC) and Financial support for development of prototypes. In addition, hundreds of District level exhibitions and State wise exhibitions were organized and mentoring / incubation activities for students are being executed.
- NIF has organized the 2nd ASEAN India Grassroots Innovation Forum in Philippines during November 2019 with the objective to strengthen Science, Technology and Innovation based co-operation between India and ASEAN Member States (AMS) and the forum witnessed significant participation in all activities from a majority of the AMS. Adjudicated by a jury comprising of members from 8 different countries, the 1st Prize in both student and grassroots Innovation Competitions was won by Innovators from India.

- The Hon'ble former President of India, Shri Pranab Mukherjee, gave away the 'Dr. APJ Abdul Kalam IGNITE Awards 2019' for technological ideas and innovations to 21 creative children from 9 States / UT's for their 18 distinct ideas and innovations.

Important Highlights of Major Programme:

- Over 5000 innovations and traditional knowledge practices from grassroots innovators and knowledge holders were received.
- Nearly 48,000 Science and Technology based Innovations were received from children for participation in the annual Dr APJ Abdul Kalam IGNITE Competition.
- Two new grassroots innovation based enterprises were recognized as Start-Up by Department for Promotion of Industry and Internal Trade (DPIIT).
- A polyherbal acaricidal technology developed and standardised by NIF was launched for benefit of livestock farmers. This medication has already been found effective in the farmers field in States of Maharashtra, Haryana and Himachal Pradesh. With a continued focus on livestock, validation activities were undertaken for treatment of livestock ailments through collaborative research program with 6 veterinary universities and 4 livestock research institutions.
- With the objective of strengthening social dissemination of grassroots innovations, implementation along with requisite training for many livelihood generating innovative technologies was undertaken in various parts of country, North East region in particular. Training was also given to farmers for preparing herbal formations using local bio-resources for reducing chemical load and cost of cultivation in farming.
- A total of 14 innovators from 6 states were provided financial support for scaling up production of quality seeds / planting material of 18 plant varieties for diffusion studies in different agro-climatic zones. Additionally, 21 plant varieties of rice, wheat, banana, cauliflower french bean and casuarina and 13 plant protection leads were validated at 9 agricultural universities.

Important Output Indicators:

S.No	Parameters	Output
1.	Papers in refereed journals & Conferences and Books/Monographs	6
2.	Indian Patents filed	119
3.	Indian Patents granted	47
4.	Applications under PPV&FR Act 2001	3
5.	Certificates of Registration of plant varieties from PPV & FR Authority	4

S.No	Parameters	Output
6.	Number of Technologies/Designs and other intellectual products commercialized	13
7.	International Conferences Organized	1
8.	Scientific Outreach Programmes organized	130
9.	Scientific Lectures/Training Programmes organized	34
10.	Number of students trained	50
11.	Number of school/college/university teachers trained	2000
12.	Number of Innovators trained	25
13.	Number of Innovations Registered	53000
14.	National Missions Led and Coordinated	4



Young innovator Syeeda Banoo from Kargil, Union Territory of Ladakh receiving the Dr APJ Abdul Kalam IGNITE Award 2019 at the hands of Bharat Ratna Shri Pranab Mukherjee, the Hon'ble Former President of India for her innovative "Perspiration absorbing shoe"



Women are being trained to make low-cost sanitary napkin pads in Tuensang, Nagaland. In the North East India, NIF has facilitated setting up of Sanitary Napkin Making Units in Sikkim, Meghalaya, Assam, Nagaland and Manipur in line with its commitment to promote women empowerment through dissemination of technological innovations in the region.

Technology Information Forecasting and Assessment Council (TIFAC), New Delhi

Area of Focus: Technology foresight exercises, vision 2035, nurturing innovation, supporting MSME cluster, capacity building, electric mobility, collaborative linkages etc.

Major Accomplishments:

- Global Technology Watch Group reports of three sectors viz. Water, Sustainable Agriculture

and Manufacturing prepared. TIFAC submitted the final report on Technology Needs Assessment to MoEF&CC. In addition, draft policy on Scientific Social Responsibility has been prepared, in coordination with DST.

- Six new MSME clusters namely: Apparel manufacturing cluster, Kolkata, Fisheries & Spices Cluster, Manipur, Chanapatana Toys Cluster, Karnataka, Katkhal Sital pati cluster, Assam and Sal/Areca nut Leaf Plate Manufacturing Cluster, West Bengal taken up towards technology gap identification, technology mapping and formulating technology interventions action plan.
- Study on '*Spatial Information System on Biomass Potential from crop residues over India using GIS techniques*' with National Remote Sensing Centre, Hyderabad, to facilitate site suitability for bioenergy plants was undertaken.
- A study on '*Characterisation of major agro-residues biomass in India*' launched in partnership with CSIR-IIP-Dehradun & CSIR-NIIST- Thiruvananthapuram for identified crops from each of the different agro-climatic zones.
- Under TIFAC Internship programme, '*Assessment of Bioethanol potential of selected crops in selected districts of India*' was carried out.
- A study was undertaken on the opportunity Charging of Electric Bus and Electric Road Technologies. Simulation models have been developed for analysis of opportunity charging of electric buses and dynamic wireless power transfer
- During the period 09 Indian Patents have been granted to respective applicant. PFC facilitated filing and prosecution of these patent
- Technology Roadmap on '*Water Sector*' and on '*Habitat*' is being prepared and would be released shortly.
- Under India-IIASA Programme, two studies namely Development of GAINS model for Indian Cities with NEERI, Nagpur and Conservation of Agro-Biodiversity and Ecosystem Management with ISEC, Bangalore completed.
- Technologies available globally for Climate Change mitigation and adaptation purposes were identified for six sectors: Enhanced Energy Efficiency, Sustainable Agriculture, Sustainable Habitat, Water, Manufacturing and Green Forestry. The technologies suitable to Indian Context for all those six sectors were selected following MCDA technique.
- Under TIFAC-SIDBI Technology Innovation Programme (Srijan), two Innovative products developed and commercialized viz (a) Extraction of advanced highly dispersible grade silica from rice husk ash generated for application as filler in tyres to reduce the rolling resistance of vehicles and (b) Automatic compact Poori Making Machine integrating both dough and disc making

- Technology Foresight reports on Natural Resources and Environment Security, Securing Society and Infrastructure and Essential Oil completed.
- Technology Gap Analysis Study carried out for Saree Cluster in and around Varanasi. The study highlighted major technical issues and challenges in Saree manufacturing and suggested appropriate actions towards resolving the same.
- TIFAC Scientist visited Sweden as a part of a delegation from the Office of the PSA. This team visited various pilot implementation sites (eRoadArlanda, Line 16, Electric Bus Opportunity Charging in Gothenburg City, and also had detailed discussions with various stakeholders like Elways, ABB, Volvo, Electreon, RISE etc.). TIFAC also worked on mathematical models for comparative analysis of the technology options and forecast their future evolution. It is planned extend this analysis tool further to include a life-cycle analysis and grid impacts.
- PFC conducted five (5) two days advanced training program for Patent Information Centers (PIC) in states and University 250 scientists benefitted from these program. Completion of one year training on IPR by 103 KIRAN-IPR trainees in 11th batch.

Important Output Indicators:

S.No.	Parameters	Output
1.	Papers in refereed journals	2
2.	International Conferences Organized	3
3.	Scientific Outreach Programmes organized	10
4.	Popular Science Books/Newsletters published	7
5.	Number of persons who attended various science outreach programmes/conferences etc.	213
6.	Scientific Lectures/Training Programmes organized	16
7.	Number of students trained	290
8.	Foresight Reports and Analyses Prepared	9
9.	Policy Report Prepared	1

North East Centre for Technology Application and Reach (NECTAR), Shillong

NECTAR focusses on providing last mile guidance and support to north-eastern States in technology applications for socio-economic activities.

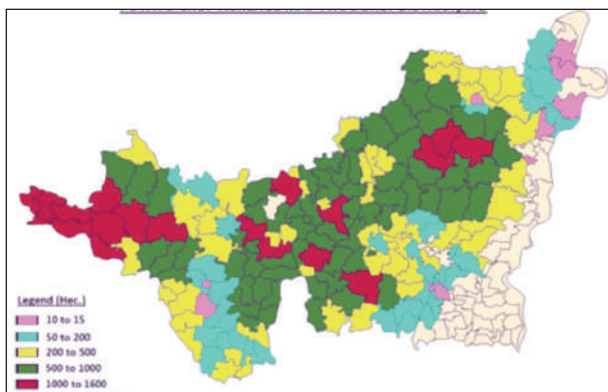
Important Highlights of Major Programmes:

- Organized 1st Brain storming Conclave at Guwahati on Science & Technology Intervention by NECTAR involving more than 100 stakeholders for identification of issues and technology implementation proposals for North East Region.

- Project 'Bamboo Sanitary and Electrical Product Prototypes' implemented by M/s San Eco Vision P. Ltd., at Agartala with objectives to develop manufacture and market of bamboo eco-friendly low cost and high value bamboo household sanitary and electrical prototype.
- Project 'Demonstration of bamboo poly house without nuts and bolts-a new patented technology for NE Region' implemented by M/s Green Bam Infra Tech Pvt. Ltd. at Sibsagar Assam with objective to demonstrate a bamboo poly house with minimum use of steel using a new GBIT patented technology of bamboo connections which eliminates the use of nuts and bolts for bamboo-bamboo connections and hence increase the life and durability of the structure. One Inclined roof type of polyhouse structure will be installed of size 500sq. meters at Sibasagar, Assam where prototype test, market test & certification process will also be done.
- Technological solution and effective training was provided by NECTAR to state police forces engaged in counterinsurgency operation in Dima Hasao district of Assam to carry the 3D Digital Terrain Maps in Android mobile with GIS analysis.
- Bamboo based Kitchen cum Store for Midday Meal Program under SSA in Manipur on partnership of NECTAR DST-Govt. of Manipur (Education Department) taken up in second phase of the project with total 2500 numbers of structures to be implemented. It will not only generate the employment but also optimal usage of Bamboo resources in India.
- Science & Technology Application/intervention for Development of North East Region. NECTAR is the leading Centre to foster, nurture and ensure the delivery, sustenance and use of technology applications for public and social good; and to reach and expand the benefits of technology among people, communities, institutions and governments for equitable and inclusive social and economic development of the North Eastern Region of our country.
- NECTAR has accomplished a Technology Outreach program launched for North Eastern Students by conducting a scientific study on damage analysis of Potato crop under "Pradhan Mantry Fasal Bima Yojana (PMFBY)" using Remote Sensing Technology (RST) for about 12510 sq km area. The project was taken up to provide industrial exposure to North eastern students on remote sensing and GIS applications technology for crop analysis based on satellite image data.



Bamboo based Kitchen cum store for Midday Meal Programm



Potato Crop Acreage Map of Hooghly district and Technology Outreach program to NE Students

Important Output Indicators:

S.No.	Parameters	Output
1.	National Conferences Organized & sponsored	04
2.	Number of persons who attended various science outreach programmes/conferences etc.	10
3.	Number of students trained	03
4.	Foresight Reports and Analyses Prepared	01

Vigyan Prasar (VP), Noida

Areas of Focus: Science and Technology Communication and Popularization.

Major Accomplishments:

- Vigyan Prasar uses multiple approaches to deliver value-added scientific and technological information / learning meant for a wide array of stakeholders. Vigyan Prasar established network of science clubs, science communications and training, gender and technology communications, EDUSAT network, Ham Radio communication, published popular science books / resource material and monthly magazine 2047 developed audio and video programme for radio and television. Vigyan Prasar maintained web portal which is repository of science communication and content.

Important Highlights of Major Programmes :

- Bilingual newsletter 2047 published in time every month
- India International Science Festival (IISF) successfully organized at Kolkata during 5-8 November, 2019

- 9 new books published
- 7 monthly newsletters in Urdu “*Tajassus*” published
- Massive outreach campaigns on Annular Solar Eclipse were organized in Tamil Nadu, Kerala, Kolkata and Puducherry
- VP participated in Guadalajara Book Fair, Mexico as part of Guest of Honor Country with National Book Trust (NBT)
- More than 190 programmes telecast at DD Science during the period
- A number of promos produced for cross channel publicity

Important Output Indicators:

S. No.	Parameters	Output
1.	Papers in refereed journals	06
2.	Books/Monographs	09
3.	State of the Art reports published	04
4.	Scientific Outreach programme organized	20
5.	Popular Science Books Newsletters published	19
6.	Scientific lectures training programme organized	15
7.	No. of students trained	911
8.	No. of school, colleges, universities teachers trained	20
9.	Compendia of historical data compiled	01
10.	National Mission lead and coordinated	03

Indian National Academy of Engineering (INAE), Gurugram

A brief overview of the major activities/achievements of Indian National Academy of Engineering (INAE) is as under:

(i) Engineers Conclave 2019

INAE launched an annual mega event of engineers as “Engineers Conclave” in 2013 organized jointly with major engineering organizations/ Strategic Departments of the Govt. of India on rotation basis with the objective of providing a platform for engineers from allied fields to meet, deliberate and recommend right engineering solutions to pertinent issues of national engineering importance. The seventh Engineers Conclave 2019 (EC-2019) was organized jointly with Bharat Electronics Limited (BEL) on Sept 19-21, 2019 at BEL, Bangalore. The two themes of EC-2019 were “**Defence Technology & Innovation**” coordinated by BEL and “**Transformation of Rural India Using Digital Technologies**” coordinated by INAE. The

Engineers Conclave 2019 was inaugurated by the Chief Guest, Hon'ble Raksha Mantri Shri Rajnath Singh Ji.



Hon'ble Raksha Mantri Shri Rajnath Singh Ji Delivering the Inaugural Address during the Engineers Conclave 2019.

(ii) Building up the young engineering Students

INAE had created a **Youth Forum** in the year 2017 with the objective of facilitating the engagement of Indian youth in engineering activities at national level. The third **INAE Youth Conclave** was organized at Indian Institute of Technology, Delhi on Aug 9-10, 2019. The engineering model and idea presentations by the engineering students were based on five topics of national importance namely (a) **Health is Wealth** (b) **Digital Revolution** (c) **Environment Protection** (d) **Lab to Market** and (e) **Waste to Wealth**.

Important Highlights of Major Programmes:

- The Thirteenth National Frontiers of Engineering (NatFoE -13) Symposium was organized by INAE jointly with IIT Bhubaneswar from May 31, 2019 to June 1, 2019 at IIT Bhubaneswar. The aim of the Symposium was to provide cross-disciplinary exchange of ideas and transfer of new techniques leading to new collaborative research activities in the following four thematic areas: - Augmented Reality and Virtual Reality; Smart Grid; Advances in Materials and Manufacturing Technology and Next Generation Transportation Systems.

- INAE has launched an INAE Digital Platform with the objective of digitalizing the functioning of technical activities undertaken by the Academy. Twenty-two modules have been developed, which include comprehensive online systems, for accepting nominations and applications for INAE Awards, INAE Schemes, Joint INAE - AICTE Schemes and Abdul Kalam Technology Innovation National Fellowship and their subsequent processing which are invited online in a phased manner.
- **3rd INAE-NAEK Workshop** :3rd INAE-NAEK (National Academy of Engineering Korea) Workshop on “**High Temperature Materials and System Engineering for Aerospace, Power Generation and Defense Industry**” was held during 15-17th July 2019 at Hyderabad. The workshop was jointly organized by INAE and Mishra Dhatu Nigam Limited, Hyderabad wherein twenty-four topics of mutual interest to India and Korea were covered.

Important Output Indicators:

S.No.	Parameters	Output
1	Books/Monographs	1
2	International Conferences Organized	1
3	National Conferences Organized	13
4	State-of-the-art-Reports Published	1
5	Journals Published	1
6	Popular Science Books/Newsletters published	1monthly e- Newsletter
7	Number of persons who attended various conferences etc.	150 - (average per event)
8	Number of students trained	47
9	Number of school/college/university teachers trained	15

Indian National Science Academy (INSA), New Delhi

Areas of Focus: Promoting science in India and harnessing scientific knowledge for the cause of humanity and national welfare.

Major Accomplishments:

- Achieved all its objectives fully in respect of its mandate of inter-facing with international scientific bodies.

Important Highlights of Major Programmes:

- Identified eminent Indian scientists for Fellowship of INSA; full support to Research Professors, Senior Scientists, Honorary and Visiting Scientists, various other programmes

such as INSA Medal for Young Scientists, Summer training for students and teachers; and Teachers Award.

- Indian National Science Academy (INSA) is a National body of Indian Science devoted to the pursuit of identifying, nurturing excellence in Science; assisting the government with aspect of policies on science. INSA has been mandated by the Government of India to represent it in all International science fora. The Academy recognizes Indian scientists excelling in their work by electing them as Fellows covering all sciences, engineering, medicine, agriculture, and interdisciplinary research. During 2019, 29 Fellows and 3 Foreign Fellows were elected to the Fellowship making a total of 945 Fellows. The INSA Medal for Young Scientists was given to 31 young researchers. This included a medal for exceptional research in the History of Science. INSA also recognized, 12 outstanding and creative teachers with INSA Teachers Award.
- INSA conducts the entire selection process of INSPIRE (Innovation in Science Pursuit for Inspired Research) Faculty Fellowship Award, for DST. During 2019, 99 young scientists from 2062 applicants, were short listed as INSPIRE fellows.
- INSA pursues several programmes to promote international relations. These can be broadly placed in two categories, viz., i) activities in pursuance to adherence to ICSU now renamed as International Science Council (ISC) and, ii) bilateral exchange/collaboration programmes with academies of other countries. INSA thus represents India in all scientific unions affiliated to ISC and deals with all the logistics of Indian adherence, through pan-Indian advisory committees for each union. As a part of bilateral exchanges, during 2019 due to INSA's efforts, total 11 Indian scientists (4 new and 7 on-going) were elected in various executive positions of ISC and unions affiliated to it; 26 scientists /researchers were supported to attend various ICSU/non-ICSU sponsored international conferences; 37 scientists were supported to work in laboratories overseas. INSA actively participated in the programs of Inter Academy panel (IAP), Association of Academies, and Societies of Sciences in Asia (AASSA) and participated in several meeting on Sustainable Development Goals and Science, worked with Commonwealth and other Academies on statements on Climate Change, Ocean Health and like.
- Under the Science Promotion Programme, INSA Research Professorial Chairs were merged with the newly initiated scheme of INSA Distinguished Professors. The INSA Distinguished Professors are expected to participate in outreach programmes for school and college students. The Academy supports Senior Scientists, Honorary Scientists, and Young Scientists Awardees for advanced research in their specialized disciplines. During the year, five scientists were supported with INSA Distinguished Professor, 85 scientists were supported with INSA Senior Scientist position and 25 scientists were supported with INSA Honorary Scientist position. INSA provided partial support to 50 Conferences/ Symposia/ Workshops.

- INSA through its History of Science programme supports the development of monographs, discussion meetings and publishes the Indian Journal of History of Science (IJHS). The program under the guidance of the Indian National Commission for History of Science offered 12 new projects and reviewed 13 ongoing studies.
- Under Science and Society Programme, INSA support the Academy sponsors lecture-cum-interaction meeting by the INSA Fellows / Young scientist awardees/ Teacher awardees / INYAS members at schools/colleges in remote and during 2019, 25 lectures were held. In addition, 45 scientific lectures were delivered during the Anniversary General Meeting in eight different symposia and 5 award lectures delivered under at local chapters.

Important Output Indicators:

S.No.	Parameters	Output
1.	Books/Monographs	4
2.	International Conferences Organized	2
3.	National Conferences Organized	1
4.	Journals Published	3
5.	Scientific Outreach Programmes organized	66
6.	Popular Science Books/Newsletters published	4
7.	Number of persons who attended various science outreach programmes/conferences etc.	2000
8.	Scientific Lectures/Training Programmes organized	32
9.	Number of students trained	2459
10.	Number of school/college/university teachers trained	102
11.	Foresight Reports and Analyses Prepared	3

The Indian Science Congress Association (ISCA), Kolkata

Major activities of ISCA during the year ynder report are as following:

- Holding of 107th Indian Science Congress Session at University of Agricultural Sciences, Bangalore, inaugurated by Hon`ble Prime Minister of India.
- Publications including ISCA bi-monthly journal Everyman's Science.
- Augmentation of 25 ISCA Chapter Activities.
- Publication of Annual report
- Organising Seminars, Symposia, Discussions, Workshop etc.
- Young Scientists Award' Programme

- Best Poster Presentation Awards Programme
- Science Awareness Programme for Popularisation of Science
- Advancement and Promotion of Science and Technology through
- National/International Symposia, Follow-up of Recommendation(s)
- Involving Young Scientists International Collaboration on Exchange Programme
- Fellowship (FISCA) to members
- Infrastructure Development

Important Highlights of Major Programmes

- Organized 107th Indian Science Congress (ISC) during 3-7 January 2020, at University of Agricultural Sciences, Bangalore, inaugurated by Hon`ble Prime Minister of India on 3rd January 2020. Nobel Laureates and more than 15,000 scientists/ research /students attended the ISC. The focal theme of 107th Science Congress was “Science and Technology: Rural Development”. Children Science Congress, Women Science Congress and Science Communicators Meet were also organized.



Hon`ble Prime Minister delivering the inaugural address at 107th Indian Science Congress



Hon'ble Prime Minister launched Indian Science Technology and Engineering Facilities Map (I-STEM) Portal

Important Output Indicators:

S.No.	Parameters	Output
1.	Papers in refereed journals	8
2.	International Conferences Organized	1
3.	National Conferences Organized	20
4.	Journals Published	1 (6 issues)
5.	Scientific Outreach Programmes organized	25
6.	Number of persons who attended various science outreach programmes/conferences etc.	30
7.	Scientific Lectures/Training Programmes organized	10
8.	Number of students trained	>800
9.	Number of school/college/university teachers trained	>300

The National Academy of Sciences (NASI), Allahabad

The Academy continued to promote Science & Technology by regularly organizing several activities with the help and support of its Fellows and Members. During the year of the report, the following activities were undertaken. Area of focus of the NASI are Promotion & Popularization of Science & Technology to aid & advise in Policy Making

Major Accomplishment:

Publications

- NASI published the Proceedings of NASI, Sec. A & B, each in IV parts and National Academy Science Letters in VI parts, in collaboration with the Springer Nature.
- National Academy Science Letters received Impact Factor (IF) as 0.331 in 2019 from Thomson Reuters; about 525 papers were received from thirty countries/regions.
- PNASI, Sec. A received Impact Factor (IF) as 0.681 in 2019 from Thomson Reuters; and about 385 papers were received from twenty five countries/regions.
- The PNASI, Sec. B received Cite Score as 0.62 in 2019 from Scopus; and about 425 papers were received from thirty seven countries/regions.
- Two special publications were released on 5th Oct. 2019 at New Delhi on the occasion of the "Closing Ceremony of the Anniversary Celebrations of 'Ba & Bapu' and Prof. Meghnad Saha". These were the collection of the Lectures delivered (in the memory of these three great personalities of the world) by the distinguished persons in different parts of the country.

Science Communication Activities

- The highlights of these activities were Children Science Meet, Summer & Winter Schools, Teachers' Training Workshops, Scientific Writing Contest, Vigyan, Jal & Health Chaupals, Seminars, and celebration of the National Technology Day, the National Science Day, the National Constitution Day, the National Mathematics Day and the World Environment Day etc. The Academy also encouraged the teachers for out-of-the-class science activities by recognizing their talent and giving away NASI-Science Teacher's Awards to them.
- NASI's 21 Chapters spread across India, organized hundreds of science communication activities in and around their respective regions throughout the year. More than 50,000 students and teachers benefitted from these activities. A series of workshops (3 this year) on Scientific Paper Writing were also organized.
- Science Education Programmes in joint collaboration with other Academies.

Activities under Scheduled Tribe Sub-Plan Programmes

- An innovative programme launched two years back under this head for improving the

socio-economic status of the Scheduled Tribes of about 21 regions of the country, has been well received by the tribal community.

S&T Entrepreneurship development

- Training programs for entrepreneurs – To inculcate the spirit of entrepreneurship in the youth and in line with the **National Mission Programmes of Skill Development and Start Up India**, NASI organised programmes with ‘Hands-on training’ at **Lucknow** and **Mahendragarh** this year.
- Awareness and Training – on Nutrition, Safe drinking water, Health & hygiene etc. A mixed participation of rural and urban population was ensured. This was included in the spirit of “**Swasth Bharat Mission**”.
- Safe drinking water and pollution abatement - especially for the rural areas and municipal workers. This was included in the spirit of “**Swachh Bharat Mission**”. Vth Brain Storming on Safe Water & Sanitation was organised at MPCOST Bhopal in Sept. 2019; a large number of scientists, municipal workers, researchers and others attended the brainstorming sessions.

Sensitization Programmes for Women Researchers/Scientists

- The Academy organized **28 workshops on Technological Empowerment of Women** in different parts of the country during the last 5 years; and **3 this year**. More than 50,000 women scientists/researchers were sensitized under this programme.

Annual Session/Symposia/Seminars & Scientific Discussions

- On Dec. 21-23, 2019, 89th Annual Session of NASI and a **Symposium on ‘Science and Technology based Entrepreneurship Development’**, was held at NAARM, Hyderabad. More than 600 researchers and scientists participated in each of these events. Other seminars/symposia were also organised by NASI, as the **Birth Centenary celebration of Prof. Vikram A. Sarabhai** at I.I.Sc., Bangalore on 16th Nov. 2019, attended by Dr. K. Sivan, Chairman, Space Commission, India; and 4 former Chairman of the Space Commission, as well as several other distinguished scientists.

Important Output Indicators:

S. No.	Parameters	Output
1.	Papers in refereed journals(by Chairs, NASI-Senior Scientists & researchers, including Ganga researchers)	180
2.	Books/Monographs	03
3.	Chapters in Books(by NASI-Senior Scientists & researchers)	14
4.	National Conferences Organized	16

S. No.	Parameters	Output
5.	State-of-the-art-Reports Published	03
6.	Journals Published	Total 14 issues (PNASI-A & B; & Sci. Letters & Spl Issues)
7.	Scientific Outreach Programmes organized	More than 80
8.	Popular Science Books/Newsletters published	2
9.	Number of persons who attended various science outreach programmes/conferences etc.	1.5 lac
10.	Scientific Lectures/Training Programmes organized	65
11.	Number of students trained	525
12.	Number of school/college/university teachers trained	230
13.	Data Bases Compiled(on Tribal Population/area/products etc.)	21



A view of the 89th Annual Session of NASI, and the Symposium on Entrepreneurship Development

Indian Academy of Sciences (IASc), Bengaluru

The Academy was founded in 1934 by Nobel laureate Sir Prof C V Raman. The Academy strives to meet its objectives through promotion of original research and dissemination of scientific knowledge to the community via a variety of activities that include scientific meetings, discussions, seminars, symposia and science education courses and workshops.

Major Accomplishments:

Over 1613 peer-reviewed articles in 18985 pages have been published in 12 thematic journals and the entire contents are available for free access on the webpages of the academy. The free access journals during the year had around 35.28 lakh downloads of refereed articles. Individuals/universities/other institutions received print version of the journals. 4 thematic special publications and 3 books were published. Under the Summer Research Fellowship programme, 1752 students and teachers availed 2 months' Fellowship and worked with Fellows and other mentors spread across 249 research institutions of the country. 4 Lecture Workshops and 4 Refresher Courses were held.

Important Highlights of Major Programmes:

- Publication of scholarly journals:** The Academy publishes reputed international scientific journals that contain high quality papers and articles by scientists from India and abroad. The number of journals currently published by the Academy is 13 (including Current Science), covering all major disciplines in science. The entire contents are available in a free access platform (<http://www.ias.ac.in/journals/overview>). Over 30,000 print versions of these journals were circulated to individuals/universities/institutions. 10 journals of the Academy are being co-published with Springer Nature it provides access to the journals' content worldwide on its journal platform SpringerLink. The Current Science Association works with the Academy in bringing out the multidisciplinary journal Current Science.

The Table below indicates the journal-wise details of articles published during the year.

Sl.no	Name of the Journal	Manuscripts received	No. of articles published	No. of pages published
1.	Bulletin of Materials Science	1638	277	2478
2.	Conference Series	22	22	160
3.	Dialogue	8	8	142
4.	J. of Astrophysics & Astronomy	279	50	584
5.	Journal of Biosciences	1097	146	1426
6.	Journal of Chemical Sciences	1299	120	1355
7.	J. of Earth System Science	760	237	3642
8.	Journal of Genetics	700	114	1290
9.	Pramana - Journal of Physics	1030	201	2038
10.	Proc. Mathematical Sciences	539	84	1254
11.	Resonance	292	106	1514
12.	Sadhana	1878	248	3102

- The academy annually elects distinguished scientists of the country to its Fellowship. It also elects Honorary Fellows, working in institutions outside India, who are distinguished for their contributions to science. 32 outstanding scientists from India and one foreign scientist were inducted into the Academy Fellowship and Honorary Fellowship respectively (with effect from 1 January 2020).
- The Associateship programme was introduced in 1983 to identify and encourage promising young scientists. The Associateship is tenable for a minimum period of 3 years or a maximum period of 6 years. During July 2019, 25 promising young scientists were selected.
- Towards attempts to improve the state of higher education and teaching of science in the country, major activities are implemented under this programme. Under the Summer Research Fellowship (SRFP) and Focus Area Science Technology (FAST-SF) programmes, 1752 students and teachers availed of a 2 months' Fellowship and worked with Fellows and other mentors spread across 249 research institutions in the country. Five Summer Schools of one-month duration were held, in each of these school's 30 students were participated. 4 lecture workshops and 4 refresher courses were held in various science subjects.
- The Academy annually holds scientific meetings, symposia and public lectures and encourages other similar activities to provide means of exchange of scientific knowledge among scientists and to bring new knowledge to the attention of the scientific community. During the year, the Academy held two meetings; the 30th Mid-Year Meeting was held (28-29 June 2019) Indian Institute of Science, Bengaluru and the 85th Annual Meeting was held (8-11 November 2019) at University of Hyderabad. 32 scientific talks by Fellow/ Associates, 2 Symposia on topical interest were held. Four discussion meetings on various scientific themes and seven public lectures were organized during the year. A centenary national conference on statistical science was held commemorating the birth centenary of well-known statistician Professor C.R. Rao during 12-13 December 2019.
- The Jubilee Professorship was instituted during the Platinum Jubilee Year of the Academy in 2009. Eminent scientists from any country and from any scientific discipline are invited to occupy the Jubilee Professorship. Prof. Ken Ono from the University of Virginia was the Jubilee Chair Professor for the year 2019. Prof. Ono visited India in December 2019 and delivered scientific lectures at various places.
- New records were added to the repository of publication of fellows, bringing the total to 16355 articles.

Important Output Indicators:

Sl.No.	Parameters	Output
1.	Papers in refereed journals	1613
2.	Books	3
3	National Conferences Organized	3
4.	Journals Published	13
5	Scientific Outreach Programmes organized	6
6	Original Science Communication Content Designed (Articles/ Face-to-Face)	80
7	Popular Science Books	2
8	Number of persons who attended various science outreach prog/ conf etc.	Over 3400
9	Scientific Lectures/Training Programmes organized	15
10	Number of students trained	1752
11	Number of school/college/university teachers trained	120
12.	Data Bases Compiled	6
13.	Foresight Reports and Analyses Prepared	2

SCIENCE AND ENGINEERING RESEARCH BOARD

The Science and Engineering Research Board (SERB), a body of Department of Science and Technology (DST), empowered through an Act of Parliament, has taken significant steps in R&D management. The competitive mode of funding schemes has been strengthened with more operational flexibility and brought new vista to R&D landscape of the country. The SERB (Board) interventions are primarily focused to expand the research base in the country without compromising the quality of research. Investing in young minds and in new areas of science had turned out to be the prime priorities of the Board.

The Board, chaired by Secretary, DST, comprised of 16 members including six Secretaries to the Government of India, met three times in the reporting period and has taken key decisions. Some of the decisions taken by the Board are given below:

- The Investigators who submit R&D proposals should run a plagiarism check before submitting the proposal to SERB. They should explicitly mention that a plagiarism check was done and a report on this effect should also be submitted along with the grant application.
- The Board restructured the PACs under Life Sciences into three thematic areas, namely, Biomedical and Health Sciences (BHS), Organismal and Evolutionary Biology (OEB) and Interdisciplinary Biological Sciences (IBS).
- Initiation and Implementation of the following new and re-formulated schemes:
 - i. SERB-TETRA: The Board approved a new Scheme titled “SERB-TETRA” (Technology Translation Award) to challenge scientists executing SERB grants to establish an effective, functional and synergistic working collaboration with an industry partner to elevate their breakthrough results and technologies to Technology Readiness Level (TRL) level 5 and beyond. TETRA Support will help entities having successful ideas to kick start new venture processes. With a seed capital, flexible working spaces and interaction between mentor and start-up entrepreneurs, the SERB-TETRA will expand the scope by providing numerous networking opportunities, followed by presenting the finished prototype to an audience of large investors, established MSMEs and private companies, and public sector enterprises.
 - ii. SERB-SUPRA: SERB has re-developed a newly approved scheme titled “SERB-

SUPRA (Scientific and Useful Profound Research Advancement)” that seeks to explore new scientific breakthroughs, with long-term impact on our fundamental scientific understanding, and offer disruptive technologies at the cutting edge. SERB-SUPRA is a scheme beyond normal core grants and purposefully designed for high quality proposals consisting of new hypothesis or challenge existing ones, and provide ‘out-of-box’ solutions. Transformative and disruptive concepts based on innovative and unproven hypotheses, possessing a high degree of uncertainty, yet having conviction to produce a lasting impact across discipline boundaries, qualify for support under SERB-SUPRA. SUPRA was chosen as a flagship S&T programme under Hon’ble Prime Minister’s 100 days of governance agenda.

- iii. Since the approval of the Scheme by the Board, SERB SUPRA logo and Brochure were prepared; online package was designed and installed with the help of CDAC, Noida and SUPRA Programme Advisory Committee and Screening Committee had been constituted. A call for application had been given through the SERB online portal (www.serbonline.in) and close to 1600 applications were received in broad areas of STEM.
- iv. SERB-STAR: Science and Technology Award for Research (SERB-STAR) is a prestigious award instituted by SERB to recognize and reward outstanding performance of Principal Investigators (PIs) of SERB Projects. SERB has been supporting basic research in frontier areas of science and engineering through its various programs and schemes. The number of researchers under the ambit of SERB has increased over the years and they contribute significantly towards the progress of science and engineering in the country through their research endeavour. SERB-STAR is an initiative to acknowledge such exemplary contributions in research and also to motivate the PIs of ongoing projects for outstanding performance.
- v. Since the approval of the Scheme by the Board, SERB STAR logo and Brochure was prepared; online package was designed and installed with the help of CDAC, Noida and STAR Selection Committee has been constituted. Call for nominations were made through SERB online portal www.serbonline.in.
- vi. SERB-VORTEX: The Board, in recent years, has ventured into several schemes and programmes which have far reaching influence on the S&T landscape of the country. These multifaceted programmes strive to ensure that S&T becomes an integral component of the national developmental processes by interconnecting competencies and research resources and strengthening interconnections with stakeholders.
- vii. To modernize research thoughts and strengthen the review process and making it more contemporary, SERB launched a new initiative called SERB-VORTEX (Vision Oriented Thought EXchange). Main features of SERB-VORTEX are:

- Conclave of investigators in PACs
 - Emergence of new ideas, priority funding
 - Contemporary review process mechanisms
 - Strengthening review process
 - Sharing of review with PIs
 - Sectoral segregation / landscaping of thematic areas
 - Developing R&D Indicators for effective monitoring of sanctioned projects
- viii. National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS): On recommendations of the Mission Governing Board (MGB) of NM-ICPS, the Board has partnered the Mission in identifying a network of Technology Innovation Hubs (TIHs) and Sectoral Application Hubs (SAHs). Write-up, online formats and other necessary documents were prepared by SERB and call for proposals were officially opened on 1 November 2019. Online Portal for NM-ICPS was developed in the meantime and submission of proposals through online portal opened on 1 December 2019.

Several scientists from across academic and research institutions were supported through a wide variety of ongoing schemes/programmes in the reporting period. Some of the notable ones are:

- Ramanujan Fellowship is for brilliant scientists and engineers from all over the world to take up scientific research positions in India. This fellowship is open to scientists and engineers below the age of 45 years. The J.C. Bose National Fellowship is meant to recognize active, performing scientists and engineers for their outstanding performance and contribution. Currently 220 scientists are serving as JC Bose Fellows.
- Visiting Advanced Joint Research (VAJRA) Faculty Scheme: The Scheme offers adjunct / visiting faculty positions to overseas scientist / faculty / R&D professional including NRIs to undertake high quality collaborative research in Public funded academic and research Institutions in India. The Scheme facilitates sustained international collaborative research with co-guiding of Master's, PhD and post-doctoral students as well as expose the best of our young minds to the best of global research practices and enhance our access to the state-of-art facilities in other countries. It is structured to promote cutting edge collaborative research in frontier areas of S&T including the interdisciplinary areas of national priorities such as energy, water, environment, health, security, nutrition, waste processing, advanced materials, high performance computing, cyber-physical systems, smart machines and manufacturing, etc., for accelerated development of scientific and technological progress for the overall economic prosperity of the nation.

Since the Scheme implementation in 2018, 59 accomplished foreign faculties from 16 countries have been selected through a rigorous process, to undertake visits for collaborative research in our Academic and Research Institutions. Out of this 47 had already undertaken multiple research visits in more than 20 Indian Institutions across India. VAJRA Faculty has evolved as a highly competitive scheme. Taking note of the value of ongoing engagement of the VAJRA Faculty with the Indian scientists, SERB has approved 27 renewal applications for second term for a period of one year.

The Scheme paved strengthening of research collaborations with several Indian scientists and in some cases the Indian Scientists could design and setup research instruments with the help of the VAJRA Faculty.

Some of the significant research leads out of the engagements are given below:

- o Under the supervision of the VAJRA Faculty, the group at IIT Bombay had developed the set-up for recording transmission, Raman and PI spectra through individual nanogaps. The group could learn novel fabrication technique and light-matter interactions on nanoscale.
- o The Finite Element biomechanical models of the total hip replacement (THR) developed in the collaboration of the VAJRA Faculty and the group at IISc, Bengaluru have provided key insights for guiding the design of the prosthetic attributes of hip implants. It was found that the acetabular liner exhibited the highest probability for mechanical failure. This study established the biomechanical effects of pre-clinically tested acetabular liners of various compositions and femoral head size/properties and interfacial friction on stress/deformation response at the bearing surfaces in case of cemented THR, for different subject weights.
- o The TIFR Group at Mumbai with the VAJRA Faculty explored the Raman spectra of protein within the evanescent plasmonic field of illuminated metal nanoparticles and observed field-induced enhanced scattering. It was probed whether specific types of neurotransmitters make the cell membrane more vulnerable to amyloid attacks. The observations are very significant in the context of cell-type specific nature of amyloid diseases such as Alzheimer's disease.
- o As a direct result of the VAJRA collaboration undertaken at Indian Institute of Technology Gandhinagar, the VAJRA faculty and Indian lead collaborator together made a potentially profound discovery. Working on the Dual Origins of Gravity the researchers discovered a new equation that was a hybrid of the traditional first law of thermodynamics and the black hole-like first law in that it was locally valid and yet included gravitational entropy.
- o Working on Quantum Metrology, Open Quantum Systems and Quantum Information Systems, the VAJRA group at The Institute of Mathematical Sciences, Chennai has put

forward a novel estimation scheme for the coin parameter and evaluated the ultimate quantum limits to precision for the class of estimation protocols.

- o For water-cooled single-phase flow heat-sink designs, a significant temperature maldistribution cause (not related to inlet plenum) has been identified the group at IIT Indore with the VAJRA Faculty. This one is associated with approximately insulated side-edge thermal boundary conditions (where heat-sink is exposed to convection to air). This identification has led to definition of a mitigation approach that is to be deployed in the proposed new multi-channel heat-sink design approach based on Michigan Tech's new flow-boiling approach.

The first three months of physical presence of the VAJRA Faculty in the Indian Institution had resulted preparation of several manuscripts planned for publication in high impact journals.

- 3.1. IMPacting Research INnovation and Technology (IMPRINT): SERB continued to steer the IMPRINT - II Programme of DST- Ministry of Human Resource Development (MHRD) to address major engineering challenges relevant to India through an inclusive and sustainable mode of translational research steered by the top engineering institutions in the country. The Programme identified 10 technology domains namely: (1) Healthcare, (2) Energy, (3) Sustainable Habitat, (4) Nano Technology hardware, (5) Water resources and river systems, (6) Advanced materials, (7) Information and Communication Technology, (8) Manufacturing, (9) Security and Defence, and (10) Environmental Science and Climate Change that could substantially impact the quality, safety and security of life both in urban and rural areas.

A total no of 2145 preliminary proposals were received in the beginning of the financial year, out of which, Principal Investigators of the 574 selected proposals were requested to submit complete proposals. Further peer review process had resulted, selection of 126 proposals (IMPRINT II A & B) for financial support. While IMPRINT II A/B addresses a wide range of engineering challenges enumerated under 10 domains, it was felt that a fresh initiative is warranted to devote energy toward specific societal mission areas like pollution, waste utilization, potable water, cyber physical systems, alternative energy resources and some more which can make a huge difference to the lives of millions in this country, if successful. This resulted the launch of the next round of IMPRINT II, called IMPRINT IIC (Societal Mission Projects) in Dec 2018 with an aim to seek proposals related to 20 specific technology themes of major societal benefit, suggested by various Ministries. To enhance the involvement of Industry it was also decided that all IMPRINT-IIC proposals must involve an industry partner or potential user group/agency who would offer financial support at least 25% of the project cost out of which at least 10 % should be by cash. Accordingly, the Call for Preliminary Proposal was opened on Dec 15, 2018 and 499 applications were received. A total of 56 detailed proposals were identified for support.

- 3.4 The Board continued to support scientists and technologists belonging to weaker sections of the society the “Empowerment and Equity Opportunities for Excellence in Science” Scheme. The scheme provides research support to scientists belonging to SC/ST categories and it received overwhelming response.
- 3.5 Programme Advisory Committees continue to play a decisive role in providing core research support to scientists. Some of the Core Research Grant (CRG) projects are depicted as an example:

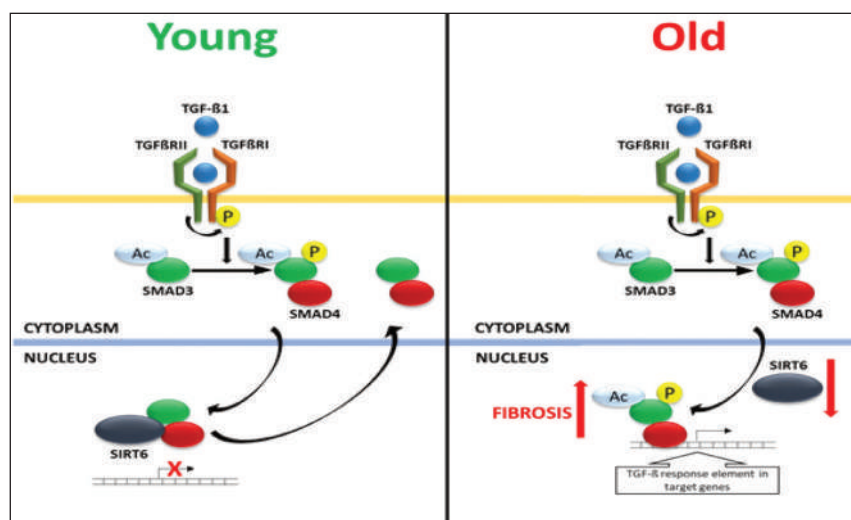
3.5.1. Prevention of eNOS Uncoupling by Enzyme Mimetics: A Novel Therapeutic Approach for the Treatment of Endothelial Dysfunction in Vascular Disease:

Cardiovascular diseases (CVDs) are the major causes of death worldwide. Recently, heart diseases have become a major health issues in India. Recent evidences suggest that endothelial dysfunction (ED) is the hallmark of CVDs. One of the most crucial mechanisms that leads to endothelial dysfunction is the decreased bioavailability of nitric oxide (NO), which acts as a vasodilator, antihypertensive, antithrombotic and anti atherosclerotic molecule. The risk factors for cardiovascular diseases are associated with significant increase of reactive oxygen species (ROS) in the vascular wall, resulting in decreased NO levels leading to endothelial dysfunction. One of the primary reasons for the impaired NO production is associated with oxidative stress-mediated uncoupling of eNOS enzyme, which is responsible for the synthesis of NO. The uncouple of this crucial enzyme leads to the production of superoxide (O_2^-) instead of NO. Under pathophysiological conditions, the antioxidant machinery is compromised due to excess ROS resulting in the degradation of NO and progression of ED.

The current SERB project is focused the development artificial enzymes that can regulate the cellular redox homeostasis and maintain the NO levels. Several novel isoselenazoles and nanomaterials have been successfully synthesized as biological redox modulators (Bhowmick, D. et al. *Angew. Chem. Int. Ed.* 2015, 54, 8449; Ghosh, S. et al. *Angew. Chem. Int. Ed.* 2018, 57, 4510). This project led to the development of manganese-based nanozymes that exhibited excellent efficacy in modulating the cellular redox activity (Singh, N. et al. *Angew. Chem. Int. Ed.* 2017, 56, 14267, Singh, N. et al. *Nanoscale*, 2019, 11, 3855). Further, Mn_3O_4 nanoflowers have been identified as suitable candidate for regulating the NO bioavailability in the vasculature. This nanomaterial increased the bioavailability of NO by controlling the cellular superoxide levels (Singh, N. et al. *Chem. Eur. J.* 2018, 24, 8393). As SOD is the major antioxidant enzyme responsible for the prevention of NO inactivation, novel SOD mimetic cerium vanadate nanozymes were developed (unpublished results). The nanozymes are highly specific to superoxide radicals and complemented the cells with

SOD-like activity after inhibition of Cu-Zn SOD without altering the basal NO levels. The bioavailability of NO and the endothelial cell health were restored in the presence of these materials and in the absence of SOD enzyme. These novel findings demonstrate that the NO levels can be restored in primary endothelial cells by redox modulators. Further in vivo research using animal models is in progress.

- 3.5.2. Under CRG -health science program the projects are supported with a focus on interdisciplinary areas in health and diseases addressing the public health importance. In India the elderly people suffer from either Non-communicable diseases (NCDs) or communicable diseases or both. Further compounded by geriatric disease like arthritis, cystic fibrosis and dementia, etc. During this condition the aged people lose the ability to withstand the minor environmental stresses because of reduced reserves in the physiological function of several organs systems due to accumulation of excess fibrous material that lead to distortion of tissue architecture. In this line a basic research study has been initiated to study how ageing increases the deposition of Fibrosis material in various tissues and organs. Investigator using appropriate model system and through various biochemical assays showed that anti-ageing molecule called SIRT6, stress responsive protein deacetylase plays a major role towards inhibiting the formation of Fibrosis. The representative model has been made how the reduction of SIRT6 during aging condition results in enhanced transformation of fibroblast to myofibroblast and development of multi-organ fibrosis. The significant outcome of the project is published in the quality peer-reviewed journal (*Sirtuin 6 deficiency transcriptionally up-regulates TGF- β signaling and induces fibrosis in mice*, Sangeeta Maity et al, Journal of Biological chemistry, 19th Nov, 2019)



3.5.3. Several CRG proposals were supported under Inorganic & Physical Chemistry and Organic Chemistry PAC having novel thematic area and application values. Some of these areas are as follows.

- Inference of long-time biochemical processes via combination of short-length molecular dynamics simulation with Markov State Model.
- Two-dimensional (2D) layered metal chalcogenides for high performance thermoelectric energy conversion.
- DNA origami based optical nanoantennas for single molecule biosensing and imaging.
- Understanding the role of protein-protein interactions in cellular copper trafficking.
- Hydrogen storage and delivery by using organometallic-based switchable catalysis approach.
- Controlling the efficiency of molecular switches and the dynamics of switchable states on surface.
- Ultrafast charge carrier dynamics of solar energy conversion materials.
- Total syntheses of conjugation-ready oligosaccharides of ESKAPE pathogens for vaccine development
- Total synthesis of polymeric cis-Pyrrolidino[2,3-b] in dolinealkaloids.
- Multi-functional L-amino acid based biodegradable polymerscaffolds for cancer treatment

3.5.4. Observations of multifractal conductance fluctuation spectra in graphene were reported in one of the CRG project being implemented at IISc, Bengaluru. This is the first experimental observation of multifractality in transport coefficients in a quantum-condensed-matter system. The researchers could establish that in the quantum Hall regime, the linear conductivity across the Anderson localization-delocalization transition is characterized by an infinite number of exponents. This is line with the predicted (but never experimentally measured) multifractality of the wave-function near this transition. Observation of universal scaling properties of Quantum Hall States was the first demonstration and experimental verification of a theoretical prediction that the range and strength of interactions can severely affect the universal critical exponents quantifying the Anderson localization-delocalization transition.

2. National Interdisciplinary Center for Cyber Security and Cyber Defense of

Critical Infrastructures at Indian Institute of Technology Kanpur is one of the impact making projects supported under the Intensification of Research in High Priority Areas (IRHPA). The details are given below:

The center has several deliverables namely (i) a national scale SCADA/ICS test-bed for cyber security studies (ii) developing tools and techniques for malware collection, benchmarking of malware detection and classification algorithms; (iii) developing tools and techniques for vulnerability and penetration testing and discovery of yet to be uncovered vulnerabilities in ICS software; (iv) developing tools and techniques for insider-threat proofing; (v) working with power utilities to develop data analytic techniques on PMU data to detect on-going cyber-attacks; (vi) creating at least one start-up on the developed technologies; (vii) developing mobile malware and their analysis techniques.

In the last one year, the test-bed creation in the various critical infrastructure sectors has been accelerated and at this time, except for the power transmission test-bed – all other testbeds have been installed. Power distribution, solar and diesel generation and synchronization, water treatment plant, industrial manufacturing test-beds have all been installed in the lab. The C3I center also moved to a new building constructed by IIT Kanpur where the test beds have been installed. Power Transmission test bed is being commissioned.

The C3I center researchers installed honeypots to collect malware, and also worked with various researchers around the world to collect sizable repositories of windows, Linux, Android malware for applying machine learning based malware detection and classification tools. The students and engineers at the center published 3 papers in International conferences on malware and bot-net detection. 3 more papers are under review. Adversarial training techniques to defeat malware that evade machine learning based detection by adversarial design have been developed.

In the vulnerability and penetration testing, this year has been quite successful. 5 CVE (Common Vulnerabilities and Exposures) numbers have been assigned to vulnerabilities discovered and disclosed by C3I center. Security advisories attributed to C3I center has been made world-wide by the vendors. 2 more CVEs have been assigned but until the vendor sends out security advisories, they will not be put in the NVD database. More than 15 vulnerabilities have been disclosed by C3I center and are being validated by the vendors upon completion of which CVEs will be assigned. Overall, C3I has now made into the league of organizations that contribute to common vulnerabilities and exposures database. Several penetration testing, industrial network traffic capture and analysis tools have been developed which are being further developed.

In the context of insider-threats, a block-chain based solution to detecting any tampering

in a data-base by privileged administrators have been developed, implemented and put to use in a project on block-chain based land-record management. This technique called “Verity” has been demonstrated at various block-chain forums. Further work on insider threat detection are planned.

Several techniques have been developed and implemented to detect false data injection and data tampering in the industrial control networks. On the PLC side, due to resource constraint, an invariant failure based monitoring has been tested and implemented. On the SCADA side, singular spectrum analysis of sensor measurement time series has been implemented. It has been also demonstrated that previous work on singular spectrum analysis has lesser accuracy than our new method.

A start-up development is under discussion at the moment, and we hope by next year, a start-up would be spawned by C3I. We already signed MoU with Tech-Mahindra to develop our Malware-Analysis tool, the Web-application firewall, and HoneyPot technology to the market. We are in the process of signing an MoU with BEL for similar cooperation. Schneider Electric has signed an MoU with us to help develop vulnerability discovery tools.

Mobile malware analysis work has progressed and C3i has developed a tool for android malware detection. An instrumented sandbox for dynamic analysis of Android has also been developed.

A lot of interactions with government agencies such as National Cyber Security Coordinator, Central Electric Authority, National Thermal Power Corporation are on-going. Several industries such as Schneider, Siemens, Tech-Mahindra have been interacting quite often. Disclosures of vulnerabilities have been made to many ICS vendors - Schneider and Rockwell in particular.

C3I center also promotes awareness and education in cyber-security. Yearly cyber-security competition event CSAW in cooperation with New York University has been an on-going activity every year. C3I center organized India’s first ever Capture-the-flag for SCADA (SCADA-CTF) at Nullcon in 2018. C3I also hosted 20+ summer interns during the summer who worked for 2 months on various cyber security projects. C3I also conducted two courses - each of 2 weeks duration, for engineers from various Asian and African countries on the behest of the Ministry of External affairs. A few other training sessions have been organized for various government agencies (not to be named) and students.

3. Early Career Research Award / Start-up Research Grant is one of the flagship programmes of SERB. The scheme aims to provide research support to the researchers who are in their early career for pursuing exciting and innovative research in frontier areas of science and engineering. A large

number of projects were sanctioned to young scientists from across various institutions from the country. A significant number of high impact SCI publications have emanated from several projects.

4. In the reporting period 240 young researchers have been offered National Postdoctoral Fellowship. The NPDF Scheme is aimed to identify motivated young researchers and provide them support for doing research in frontier areas of science and engineering. The fellows are to work under a mentor, and this training is to provide them a platform to develop as an independent researcher.
5. More than 1500 scientists were offered support under the International Travel Support (ITS) scheme which is designed to provide financial assistance for presenting a research paper or chairing a session or delivering a keynote address in an international scientific event (conference/seminar/symposium/workshop etc.) held abroad. Some of the important events supported under the Scheme are: American Society for Microbiology (ASM) 2019, SPIE International Symposium 2019, Gordon Research Conferences & Seminar, 2019MRS Spring Meeting & Exhibit, COSPAR Assembly 2019, 44th International Conference on Coordination Chemistry, Cell Symposium 2019, 44th International Conference on Coordination Chemistry, European Materials Research Society-2019, 2019 MRS Spring Meeting & Exhibit, Asia Oceania Geosciences Society 2019.
6. Assistance to Professional Bodies & Seminar / Symposia Scheme extends partial support on a selective basis, for organizing seminar / symposia/training programmes / workshops / conferences at national as well as international level. More than 300 events were recommended for support in the reporting period.
7. Third party evaluations: SERB undertook following third party evaluations during the reporting period:
 - (i) Third Party Evaluation of MHRD-FAST Scheme: MHRD has an ongoing scheme called Research and Training in Frontier Areas of Science and Technology (FAST) under which 36 Centres of Excellence (CoE) were established for advanced training and Research in identified frontier areas. An Expert Committee was constituted by SERB to carry out the Third Party Evaluation. The Committee evaluated the performance of each CoE and also the scheme as a whole. The Third Party Evaluation Report was submitted to MHRD.
 - (ii) Third Party Evaluation of MHRD NITT-SIIHEI Scheme: Under the

“Startup India Initiative in Higher Educational Institutions (SIIHEI)” of MHRD five new Research Parks, one each at IIT Delhi, IIT Kanpur, IIT Guwahati, IIT Hyderabad and IISc Bangalore at a cost of Rs. 75 cr each over a period of three years were established. SERB constituted an Expert Committee for the Third Party Evaluation and report was prepared.

8. SERB Management Information System (PROBIS): The Board developed a real-time public portal named PROBIS (SERB Program and Outcome based Information System) that could provide information regarding all the projects that had been sanctioned by SERB from 2011-12 onwards. Search facilities were enabled in the system to retrieve information about projects by name of PI, institution, state, etc. as well as search of equipment that had been sanctioned by SERB over the years. The system also provides project output information such as publications and patents that resulted from the projects sanctioned. Dashboards have been created for Secretary and all officers of SERB which can provide information regarding sanctions, budget, process time, delays, pendency, classification of projects under various categories, etc.
9. The online portal www.serbonline.in has been made operational for most of major schemes of SERB.

TECHNOLOGY DEVELOPMENT BOARD

The Government of India constituted the Technology Development Board (TDB) in September 1996 under the provisions of the Technology Development Board Act, 1995. The mandate of TDB is to provide financial assistance to the industrial concerns and other agencies attempting development and commercial applications of indigenous technology or adapting imported technology for wider domestic application. TDB provides financial assistance by way of loan (upto 50% of total project cost @5% simple interest), equity (upto 25% of the total project cost) or grant (in exceptional cases).

TDB's support is sector agnostic and during recent years, projects for Defence, Medical Devices, Healthcare, Engineering, Agriculture, Energy & Waste Utilization, Telecommunication and Information Technology have been supported.

Major highlights of the year 2019-20

During the year 2019-20, TDB has signed following four (4) agreements with total project cost of Rs. 24.17 crore with TDB's financial assistance of Rs. 9.87 crore. The details of agreement signed are as follows: -

- a. An Agreement has been signed with M/s iMinBit TechIndia Pvt. Ltd., Haryana for project titled "Manufacturing and Commercialization of Water Saving RO Based Purification" with financial assistance of Rs.1.48crore out of total project cost of Rs. 3.42crore. The project is a start-up initiative recognised by Start-up India and Stand up India. It aims to build Reverse Osmosis (RO) based water purifiers which will be water, cost and energy efficient. Their innovative technology gives around 70% recovery of purified water.



Water Saving RO Purifiers

- b. An Agreement has been signed with M/s Anarobic Energy Pvt. Ltd., Bijnor for their project titled “Development & Commercialization of bio CNG from Sewage Based Biogas plant, at Sewage Treatment Plant Jagjeetpur, Haridwar” with financial assistance of Rs. 2.15 crore out of total project cost of Rs. 4.32crore. In this project, the company will establish its first biogas plant to produce bio CNG at Haridwar, based on 45 MLD sewage sludge available at sewage treatment plant at Jagjeetpur, Haridwar.



Sewage Based Biogas Plant

- c. An agreement has been signed with M/s Agatsa Software Pvt. Ltd, Noida (UP) for their project titled “Commercialization of Cardiac Care Platform-Sanket Life” with financial assistance of Rs. 3.91 crore out of total project cost of Rs. 11.48crore. This start-up company has indigenously designed and developed an innovative match-box size device called “Sanket Life”, that can perform sequential 12 LEAD ECG test. This device can be connected to a smart phone via Bluetooth and the ECG is displayed on the mobile’s screen through the company’s in-house developed mobile application.



12 Lead ECG Device: SANKET LIFE

- d. An agreement has been signed with M/s Arpan Nutrition Private Limited, New Delhi for their project titled “Commercialization of Zero Erucic Mustard oil for Nutrition and human health” with financial assistance of Rs. 2.33 crore out of total project cost of Rs. 4.95 crore. In this project, the company will develop the identified preserved production system, promote contract farming and establish integrated “seed to oil” supply chain for the production of canola quality mustard oil while retaining its pungency, offering mustard oil better than imported canola oil. The company is also supported by the Division of Genetics and incubated by Zonal Technology Management Business Promotion Development of ICAR-Indian Agricultural Research Institute (IARI), New Delhi along with Ministry of Micro Small & Medium Enterprises (MSME).



Zero Erucic Mustard Oil

Participation in National conference\ Seminar\ Other Events

TDB Attended the “Annual Information Security Summit- 2019” (AISS) held on 3rd - 5th December at Gurgaon. The event is perceived as truly industry led Cyber Security Conference which covers the entire spectrum of Cyber Security ecosystem in the country and beyond. TDB has participated in the event and shared the inputs for Building Secure Automated and AI Enabled Networks. Furthermore, TDB has approved the financial assistance of Rs. 2.80 crore to M/s QuNu Labs Pvt. Ltd., Bangalore who got the award of Most Innovative Company in Innovation Box Event at AISS-2019.



TDB participation in Annual Information Security Summit- 2019

STRENGTHENING SURVEY AND MAPPING ACTIVITY

7.1 SURVY OF INDIA

Survey of India (SoI), the National Survey and Mapping Organisation of the country, under the Department of Science & Technology has the unique responsibility to prepare and provide timely, updated, cost effective and accurate National Topographical Data Base (NTDB) as per National Map Policy, 2005. To fulfill the above responsibility SoI carried out the following activities during 2019-20.

7.1.1 *High Resolution National Topographical Data Base (HRNTDB)*

The following activities are being carried out for generation of HRNTDB:

1. Data Acquisition using professional Survey Grade Drones/procurement of HRSI
2. Ground Control Provision (GCPs)/ High Precision Levelling
3. Geo-referencing of High-Resolution Satellite Imagery (HRSI)/Data Processing
4. Feature Extraction
5. Ground Validation
6. Establishment of Continuously Operating Reference Stations (CORS)
7. Geoid Model Development
8. Preparation & updation of Administrative Boundary Database
9. Toponymy (Place Names)

Achievements:

1. **HRNTDB:**
 - HRSI procured = 278731 Sq.Km
 - Geo-referenced = 122808 Sq.km
 - Feature Extraction = 29642 Sq.Km

2. Defence Series Maps (DSM)

- on 1:50K Scale - Printing Completed.
- on 1:250K Scale - 320 sheets Printed.

DSM sheets/maps being distributed to Army Formations.

3. Administrative Boundary Database: 394 Districts completed and data uploaded on G2G Portal <https://g2g.indiamaps.gov.in>.

4. Toponymy (Place names) - Place/Geographical names in 10 languages - Hindi, English, Bengali, Gujarati, Kannada, Malayalam, Marathi, Punjabi, Tamil & Telugu made available on SoI Public Portal <https://indiamaps.gov.in> for 3760 sheets.

5. Geoid Model Development: Geoid Model Development for entire country under progress 50,000 Linear km High Precision levelling has been completed and Gravity Observation completed on 2500 stations.

6. CORS Network: Establishment of CORS network in the states of Maharashtra & Karnataka Under progress.

7. International Boundary: Demarcation Works undertaken during 2019-20:

- India-Nepal
- India-Bangladesh
- India-Myanmar
- India-Bhutan
- India-Pakistan

India-Nepal 6th Boundary Working Group (BWG) Meeting:

The sixth meeting of India-Nepal Boundary Working Group (BWG) was held in Dehradun, India from 28th to 30th August, 2019. The Indian delegation was led by Lt Gen Girish Kumar, VSM, Surveyor General of India, Survey of India and the Nepali delegation was led by Mr. Prakash Joshi, Director General, Survey Department, Government of Nepal

Both sides have decided to prepare a detailed plan for establishing the common framework; India Nepal Boundary Reference Framework (INBRF) by carrying out GNSS observation on already agreed and constructed monuments.



Joint Boundary Conference (JBC) between India-Bangladesh:

The 3rd JBC between India-Bangladesh was held in Dhaka, Bangladesh from 23-25 Dec, 2019. Discussions were held on GNSS observations of Boundary pillars along India-Bangladesh border for establishing the common framework for maintaining the International Boundary pillars.



8. **Manchitra Portal:** The portal offers free download of SOI maps by Indian Citizens based on aadhar authentication. 365414 SOI Maps have been downloaded from Manchitra portal by Indian citizens till 13 Jan, 2020.
9. **G2G Portal (<https://g2g.indiamaps.gov.in>):** The g2g portal was developed and launched for giving authorised access to all government agencies. Credentials have been generated for 106 government users during 2019.
10. **Spelling of Geographical names:** Survey of India is the nodal agency for correct spelling of geographical/Place names in India. Spelling of 36 geographical/place names have been provided to different State Govt. and Indian Railway.
11. **Publishing License (PL):** PL has been issued to 02 firms during 2019 for publishing an Educational Topo-map in Books/ Atlas.
12. **International Boundary Verification/Certification:** Scrutiny and Certification of the International Boundary for more than 890 publications (both Govt. & Private Agencies) carried out during 2019.
13. **Training:**

Training is an integral part and prime requisite for the personnel in any organization, especially for professional involved in any technical activities. Indian Institute of Surveying & Mapping, the capacity building arm of SoI is conducting various training programmes in the field of Surveying & Mapping. Besides training own staff, the trainees from central govt/state govt, other agencies, industries, private individual and trainees from neighboring countries are being trained throughout the year

No. of trainees passed out during this year:

Departmental	Extra Departmental	Others	Foreigner Trainee	Total
201	153	05	Nil	359

7.2.1 Extra-Departmental Projects:

1. **National Hydrology Project (NHP):** The objective of Rs. 300 Cr. World Bank assisted project is to improve the quality and accessibility of water resources information and to strengthen capacity of targeted water resources management institutions in India.

Achievements:

- Generation of GIS data & 3-5 m Digital Elevation Model (DEM) for approx. 800,000 Sq.Km:

Ground Control Points (GCPs) completed.

Georeferencing of Mono-High Resolution Satellite Imagery = 50% Completed

- Generation of 0.5 m Digital Elevation Model (DEM) for approx. 58000 Sq.km:

Security Clearances completed

Aerial Data Capturing = 1504 Sqkm completed

- Continuously Operating Reference Stations (CORS) establishment in the states of Uttar Pradesh & part of Uttarakhand tender finalised. Contract to be awarded.
- The World Bank in its Third Implementation Support Mission for NHP has ranked Survey of India at **No. 1 position** among all Central Implementing Agencies under NHP.

2. **National Mission for Clean Ganga (NMCG):** The objective of 86.84 Cr project is to generate High Resolution DEM and GIS ready database for the part of River Ganga using LiDAR Technology, one of the the components of the NMCG.

Achievements:

- 0.5 m Digital Elevation Model (DEM) and GIS ready database:
 - o LiDAR Data Acquisition 3094 Sq.km completed till 31st Dec, 2019.
- Geoid Model Development:
 - o High Precision Levelling Completed = 19000 Linear km till 31st Dec, 2019.
 - o Gravity Observation on 652 points completed till 31st Dec, 2019.
 - o Construction of Ground Control Points (GCPs) = 55 Nos. completed till 31st Dec, 2019
- Web Hosting & Application Development
 - o Development of customised application development under progress at GIS&RS Directorate.

3. **Large Scale Mapping for State of Haryana:** The objective of the project is to carry out Large Scale Mapping of 44,000 Sq.km using UAV/Drones, for Revenue, Urban and Rural area including Ground Control Network and preparation of Geo-referenced Cadastral revenue maps for state of Haryana for an estimated cost of 150 Cr.

- Data Acquisition using UAV/Drone = 1242 Sq.Km
- Data Processing = 1000 Sq.Km

4. **Large Scale Mapping for State of Karnataka:** The objective of the project is to carry out resurvey of Land and properties using Drones/UAVs Technology in Karnataka state for 51,000 sq.Km. area an estimated cost of 76 Cr.
 - Data Acquisition using UAV/Drone = 500 Sq.Km
 - Data Processing = 100 Sq.Km
5. **Large Scale Mapping for State of Maharashtra:** The objective of the project is to carry out large scale mapping of Gaothan (Abadi) areas in the Maharashtra State using Drones/UAVs Technology for 40,000 Gaothans/villages an estimated cost of 76 Cr.
 - Data Acquisition using UAV/Drone = 400 Gaothan village.
 - Data Processing = 150 Gaothan village.
6. **Large Scale Mapping for DDA:**

Memorandum of Understanding (MOU) has been signed between Delhi Development Authority (DDA) and Survey of India (SoI) on 23rd of August 2019 for preparation of GIS based Base Map of Delhi and for providing access to all GIS data prepared by Survey of India, required for preparation of GIS based Master Plan for Delhi - 2041. Provisions to the access to various technologies have been included in this document for the benefit of DDA to enable them for preparation of GIS base Master Plan for Delhi-2041.



7.2 NATIONAL ATLAS & THEMATIC MAPPING ORGANISATION

National Atlas and Thematic Mapping Organisation is an attached office under Department of Science and Technology, Ministry of Science & Technology, Government of India. It has a total strength of 470 staffs largely with qualified professionals including geographers, geologists, statistician, mathematician, professionals of geospatial technology are engaged in preparing thematic maps and atlases in this organization.

NATMO's journey started with compilation of National Atlas in Hindi by Prof. S P Chatterjee way back in the year 1956. Today, it is the pioneering organization engaged in Thematic Cartography, Atlas Cartography, Geographical Research and Training. Documentation Centre and Library, including its remote sensing archive give sufficient support and strength in every sphere of its activities. NATMO provide services not only in the field of thematic cartography and geo-spatial technology, but also to extend wide services to a large number of technocrats, professionals, research scholars, planners and students as well. NATMO library is very famous for rare books/CD, journals, topographical sheets, maps etc.

Thematic maps and atlases compiled by NATMO are popular across a large spectrum of stakeholders and also serve as the vital inputs for planning at various levels. The maps and atlases prepared by NATMO serve as visible tools to understand the changes and developments taking place in the domains of geo-environmental, political, socio-economic conditions in the country. NATMO covers almost all the themes pertaining to physical, political, economic, cultural, historical and other related environmental and societal issues that serve as the basic tools for a wide range of users including decision makers and the common public.

NATMO has a proven track record in urban mapping as well. Using high resolution satellite data rectified with GCPs (Ground Control Points) collected through detailed field survey using GPS, are being used as base information for the preparation of large-scale city maps. To promote tourism and related industry, maps on tourist places and routes including adventure tourism maps, maps on national parks and wild life sanctuaries are being prepared and updated.

The organization motivates the planners and decision makers to use maps as complimentary documents for development planning at national level, state/UT level and district and sub-district levels. District planning maps are being prepared to meet the planners' demand.

The mandate of this organization is:

- Compilation of National Atlas in English, Hindi and other regional languages with timely updation.
- Preparation of School Atlases for all boards to provide accurate and standard base information for the educational institutions.

- Preparation of State Atlases and other special atlases.
- Generation of thematic maps and standardization of thematic information.
- Mapping of natural resource assessment towards sustainable socio-economic planning at district level.
- Large-scale mapping and development of digital cartographic base for utility-based services.
- Providing geographical education and training to visually impaired and low vision society through maps and atlases.
- Management of comprehensive Geo-informatics products for the service of the Nation through web portal.
- National and International cooperation on multidisciplinary geosciences through collaborative programmes.
- Providing unrestricted map service to all sections of the society.
- Other activities entrusted through the Administrative Ministry from time to time.

7.2.1 Major Activities and Achievements During the Year 2019-20

International Collaboration:

NATMO is already in collaboration with Geoinformatics and Space Development Agency (GISTDA) of Thailand, as part of the Science & Technology cooperation. Accordingly, after the successful completion of the project 'India-ASEAN Archaeological Atlas from Satellite Data - Connectivity of Regional Culture Finite Routes and Infinite Values', it was decided by both the sides (NATMO and GISTDA) to further continue the cooperation to work on the theme 'SOCIO-ECONOMIC ATLAS OF THAILAND' jointly. To follow up the project, NATMO has already send the Concept Note describing the salient points like scope, objectives, themes, methodology etc. and the response from the partner agency is awaited.

Extra departmental Projects:

Three extra departmental projects have been taken up with as below:

- **Irrigation Atlas of India:**

Irrigation has been a major identified theme in NATMO's National Atlas Volume. Central Water Commission under Ministry of Water Resources Government of India, has approached NATMO to enter into a collaboration for preparing the "Irrigation Atlas of India". The atlas will be prepared in two volumes to be published by middle of the year 2020.

- **Women Empowerment Atlas:**

Science for Equity Empower Development (SEED) Division, Department of Science & Technology, Government of India, awarded the project of preparation of an atlas titled “Women Empowerment Atlas-Science and Technology Perspective” to NATMO for a period of two years. The project aims to highlight the role/participation and contribution of women in the field of Science and Technology and aims at the empowerment of women in the field of science and technology.

In this project, an Atlas will be developed at district level highlighting the women empowered and to visualize the gaps where women are lagging behind along with its demographic, economic and social status. This multi-dimensional project will contain case studies, critical areas as well as hot-spot areas and also the potential areas based on different parameters for understanding on a large scale. Moreover, it would be for the first time that gender disaggregated data would be looked through the scientific lens with a science and technology perspective and geospatially represented using geo-analytics for ready reference by decision makers and grass root planners for women empowerment.

Major emphasis has been given on some thematic areas like education, religious composition, crime against women and government support in different science and technology programs at the beginning. General scenario represents the female students are always lagging behind the males in pursuing education at higher education with high gender parity index in northern, north-eastern and western states except Kerala. Gross Enrolment Ratio (GER) is highest in Tamil Nadu and lowest in Bihar. Dominance of Hindu region followed by Muslim has been observed throughout India except in the north-eastern states where dominance of Christian community has been observed. However, the unfortunate scenario has been observed in the overall crime against women throughout the country along with the increasing trend. Finally, the financial support extended in different science and technology sectors like agriculture, technology, nutrition, sanitation and related outreach program etc showing its predominance in the southern part of India.

- **Village Information System for Integrated Development:**

Large scale mapping under this project has been undertaken in collaboration with Vivekananda Institute of Biotechnology, Ramakrishna Mission, Nimpith, West Bengal. Under this project a pilot study has already been initiated. The village Mahishmari, of South 24 Parganas district of West Bengal has been chosen for developing a model which will be carried out for other areas.

7.2.2 Brief Account of the ongoing Projects:

1. Technology Development Programmes

A) NATMO'S own Geo-portal development

Geospatial data generated in pieces over the years under several projects is now to be made available in the public domain for 24 x 7 access by the users. Keeping this objective in view NATMO has taken up the initiative to set-up its own Geo-Portal. The major achievements include:

1. Data Centre Build (Non-IT Part) completed
2. Passive and Active network completed
3. Necessary hardware software installation done
4. Internet lease line is established,
5. Digitization of maps has been initiated.
6. Creation of different Map Services (for pilot projects) is now ready and it is expected to launch the Geoportal by January 2020.
7. As part of GIS development, important documents like Inception Report, System Requirement Specification (SRS), Design document, Data Models for different services etc. document has been completed.



Shri B. Anand, Financial Advisor, DST at NATMO Data Centre.

Following achievements are made in GIS database development:

1. 10 maps of DPMS processed for Geoportal
2. National School Atlas (1:14M) base maps ingested in staging server
3. Digital Mapping of Purulia DPMS completed
4. Data Model and Data Structure

5. India Administrative Map
6. Administrative Base map of India 1:250,000
7. Digitization of 155 DPMS maps
8. National School Atlas (NSA) 45 maps completed for web upload.
9. 47 map for State atlases completed

B) Golden Map Service (GMS):

On the occasion of Golden Jubilee Celebration of NATMO, this project was taken up with the aim to prepare large-scale map of the cities and towns of the country consisting minute level information relevant to the available utilities, communication, and land use. This map is very useful for planners, architects, tourists and the citizens as well. In the current year two GMS projects, viz. Agartala and Jaisalmer are published. Following four GMS projects are in advanced stage of publication -

1. Puducherry
2. Amritsar
3. Noida
4. Gurugram

C) District Planning Map Series (DPMS)

This project was assigned by DST in the year 1992 and work on the same had been initiated in the year 2002 after formulating the detailed specification. Though this project was shared between NATMO and Survey of India initially, but later on NATMO has been assigned this project solely.

Objective:

To provide a ready-reckoner to the planners, researchers, students in respect of complete geographical, geological, geomorphological, demographic, cultural information and features along with administrative boundary, blocks, specialty, etc. of a particular district both in paper format and in digitized format both in Hindi and English.

The project is almost complete and maps of 275 districts have already been published for the users. Digital version of the maps is also in progress in the final stage and will be published very soon. However, revision and updation work on account of formation of new districts, are in progress. DPMS maps completed during this year are:

1. Tirunelveli
2. Saran
3. Alappuzha
4. Unnao
5. Bhavnagar
6. Visakhapatnam
7. Ujjain
8. Farukhabad
9. Baghpat
10. Bengaluru Urban
11. Bengaluru Rural

Ongoing Projects:

1. Vidisha
2. Betul
3. Upper Siang
4. Mandi
5. Mainpuri

D) National Atlas of India

In the year 1956, the then Prime Minister of India, Pundit Jawaharlal Nehru approved the formation of National Atlas & Thematic Mapping Organisation (then it was National Atlas Organisation) and granted the '**National Atlas Project**' to NATMO. Hence, National Atlas is the flagship publication of NATMO. Accordingly, 'भारत राष्ट्रीय एटलस' first published in the year 1957 and its English Version, 'National Atlas of India' was published in the year 1986. Since then, this publication is being updated and revised keeping pace with the administrative changes in respect of states, districts, etc. along with conversion in digital mode is under process. Following are the objectives:

- i) To have India's National Atlas like the other countries of the world.
- ii) To depict the country in respect of its geology, geography, geomorphology, demography, culture, administration, etc. in thematic map form.

National Atlas of India, both in English and in Hindi version, has been appreciated by the users of every corner. It is for the vertical demand of the users, NATMO is still publishing the editions of the Atlas till today and regular updation and revision of the same is going on. Revision of theme maps is a part of our mandate. India Administrative (Hindi) map was published. Updation of Volume-I, Administrative and Demography is ongoing.

E) Large-Scale Mapping:

In this cyber age, availability and accessibility of accurate and reliable information (both micro and macro level) with geospatial solutions, plays a pivotal role in planning and implementation of national policies in respect of natural resources and management. Effective use of geospatial information and technology has become the platform of solution for different environmental and developmental challenges. But due to absence of high-resolution map data in appropriate forms, many planning and development programme are lagging behind in our country. NATMO has taken initiative for preparation of large-scale maps (1:10,000 scale) on various themes to facilitate micro-level planning like irrigation, agriculture, Village Information System etc. using its own database and methodology. A project on Resource and Livelihood mapping of Mahishmari village at 1:4000 scale is ongoing.

F) Atlas for Visually Impaired (BRAILLE MAP)

As the visually challenged persons cannot use the traditional maps or atlases. A project has been initiated with financial support and approval from DST to prepare Atlas in Braille script. NATMO became the first ever in the country to publish 'Atlas for Visually Impaired' in Braille script, depicting all the continents with special emphasis on India.

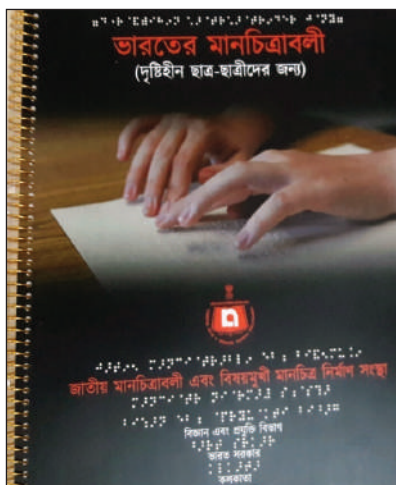


Fig. Bengali Braille Atlas of India



Fig. Bengali Braille Map of West Bengal

'Atlas for Visually Impaired' has been published depicting physical and political features of every continent along with special focus on physical, political features of India have been published in English. Atlas of India in Bengali Braille Script has been published on 11th June 2019 (Fig 1). Atlas for other states of the country in concerned regional Braille Script, has been taken up as well.

This publication has now become an eye opener for the visually impaired students and several requests from other states are being received by NATMO. Accordingly, as per the instruction of the Ministry NATMO has committed to provide at least two copy of the atlas to all the Schools engaged in teaching visually impaired and low vision students. In this respect also NATMO has fulfilled its commitment in time with enough copies of the atlas for distribution among the deserving schools and libraries.

NATMO has conducted one day workshop on "Braille Map Interpretation and Awareness Drive for Braille map Teachers/Trainers" in the month of June. In the same event Braille atlas of India and Braille Map of West Bengal in Bengali Braille script were released in presence of Mr Debabrata Chattaraj, Joint Commissioner for Disabilities, Government of West Bengal, Smt Hena Basu, Secretary, Society for Visually Handicapped and Smt Lisa Banerjee, Principal, Calcutta Blind School. The programme received huge appreciation and wide media coverage as well.



Releasing of Braille Map and Atlas (in Bengali)

Since 2017 NATMO has been actively engaged in outreaching the programme for promoting the map based geographic education for visually impaired and low vision students across the country. During the year, NATMO has conducted national level workshops and Braille Map quiz in almost 22 states. A total number of 62 schools participated in the programme by engaging 870 students..



Prof. Ashutosh Sharma, Secretary, DST & Director, NATMO honouring the winning students of Delhi Braille Quiz

G. Monographs:

Monographs are published by NATMO on specific topics. NATMO's monographs on Geomorphology, Lakshadweep, are popular among the series. Published one monograph titled Delhi: City of Cities which deals with the historical review of Delhi city that elaborates the historical events connected to Delhi through various thematic maps.

- H. Medical Tourism: This is a new theme that has been introduced in the year 2017-18. As a pilot study, NATMO has completed the Medical Tourism map of Kolkata. The map is a ready reference for the people visiting the city from different parts of the country or abroad for treatment purposes. These maps provide information on the various facilities available in the Health Care domain for any medical tourist visiting the city. The project has been extended to other major cities where there is a large flow of Medical Tourists.
- I. 3D Mapping: NATMO has taken up one pilot study to prepare large scale 3D Mapping using advanced technology. The project involves integration of data captured from highly specialized mapping technology tools like GPS, UAV, Photogrammetry Remote sensing and GIS. The advantages of 3D mapping are manifold. Of, late NATMO is venturing its experimental efforts through HRD/capacity building.

7.2.3 Other Services

1. Training and Development for S&T Advancement of the Country

Unlike the previous years, NATMO has been continuing different training programmes in the field of Thematic Cartography, Digital Cartography, Remote Sensing and GIS. The major target groups are officers and staff of various government and non-govt. departments, university and college teachers, scholars and students of the country. Following training courses have been conducted during the year:

1. Three (3) Months Certificate Course in Digital Image Processing
2. Certificate Course in Applied Remote Sensing & GIS
3. **Six (6) Months Certificate Course on Applied Remote Sensing & GIS**
4. Five Days' Workshop-cum Hands-on Training Programme on GEOINFORMATICS
5. 2days Teachers' orientation programme was conducted (26th & 27th August 2019)

2. Library & Documentation Centre:

NATMO has a very rich library and documentation centre, where researchers and scholars can gather a vast ready-made data/information using the database and resources in the library and documentation centre. It has 22,216 books, 65000 maps and topographical sheets at present. About 550 teachers, research scholars and students got benefited from NATMO Library this year.



NATMO Documentation Centre



NATMO Archive

3. Number of people getting benefited from the projects/schemes:

Millions of students all over the country, research scholars, teachers, professors are using NATMO maps and atlases. Recently NCERT has expressed interest towards school

atlases and atlas for visually handicapped. These will soon be recommended by NCERT in school curriculum.

Hundreds of scholars, technocrats, teachers, engineers take training in digital cartography, remote sensing, GIS, GPS technology application from NATMO so far.

4. Exhibitions and Fairs:

As part of publicity and marketing, NATMO has participated in as many as 20 Exhibitions/ Fairs in fifteen states of the country. The response and feedbacks in general are good. Revenue generated out of Exhibitions and fairs is around Rs.1,62,270/-.



Hon'ble Secretary Prof. Asuthosh Sharma opened NATMO pavilion during the occasion of IISF 2019



Technology show by NATMO on the occasion of IISF 2019

5. Important Official Meetings convened during the year

In order to revamp NATMO and its activities a Technical Advisory Committee has been

constituted in NATMO as per the advice of Hon'ble Secretary, Department of Science and Technology. Dr. J R Sharma is nominated as the Chairman of the TAC and two meetings are already conducted to explore the various possibilities to turn NATMO a frontrunner in the area of geospatial data generation and services. The members have given various suggestions to bring NATMO and its products more accessible to the public and utilize the its products for convergence with Government of India's dream projects like Digital India and Smart City initiatives. Three meetings are already held and the last meeting was held on

6. Infrastructure Development

NATMO has completed the construction of **Rashtriya Atlas Bhavan** to get a wholly dedicated place for its research activities which will house a complete Digital Laboratory and Digital Map printing Unit. It is expected that the building will be officially functional form 2020.



Rashtriya Atlas Bhavan

7. Other Programmes include Swachh Bharat Abhiyan: NATMO has observed Swachh Bharat Abhiyan with Programmes conducted inside and outside office.



NATMO officials engaged in cleaning Ganga activities organized as part of Swachh Bharat Abhiyan in collaboration with Rotary Club.

8. Revenue generated during financial year of 2019-2020 (April to January 2020)

NATMO generated revenue of about Rs. three lakhs by selling maps, atlases and monographs from the sales counters of Kolkata Headquarters, Delhi Sales Counter, Exhibition stalls and SOI outlets. NATMO has also earned some revenues as Course fee for providing training on different courses.

Conclusion:

NATMO as a pioneer mapping organisation has been playing a substantial role in contributing to nation development. NATMO's achievements are just the open proof of its integrity and commitment to the societal needs. The successful set-up of data centre in NATMO is going to be a paradigm shift in the activities and deliverables from this organisation in providing more and better map services in the coming years.

ADMINISTRATION

The administration and finance divisions of the Department continued to provide support and necessary administrative decisions for smooth functioning of the Department as well as its subordinate offices.

8.1 New initiatives

i. Swachhata Hi Sewa-2019

SHS-2019 was launched on 11th September, 2019 and culminated on 150th birth anniversary of Mahatma Gandhi i.e. 02nd October, 2019. The theme for SHS-2019 was Plastic Waste Management. During SHS-2019, a series of lectures/ awareness programmes was held in this Department to spread awareness about single use plastics. The detail of lectures/ awareness programmes is as under:

S. No.	Subject	Speaker
1	Plastic Ban: Environment vs Economy	Technology Business Incubator at Sriram Institute of Industrial Research and two of its start-ups Geokriti & BioVir
2	Single use plastic management and effect of single use plastic on vector borne disease	Officials of South Delhi Municipal Corporation (SDMC)
3	Plastic Waste Collection & Disposal	Officials of South Delhi Municipal Corporation (SDMC)
4	Plastics from Waste Electrical & Electronic Equipment (WEE) & its value addition	Dr. Smita Mohanty, Director(Principal Scientist), School of Advanced Research in Polymers (SARP) - LARPM, Central Institute of Plastics Engineering & Technology (CIPET), Bhubaneswar, Orissa
5	Recycling of Polystyrene Waste: A Facile and Green Approach leading to a Technological Innovation	Dr. Chandra Sekhar Sharma, Associate Professor & Member of Core Committee of Indian National Young Academy of Sciences (INYAS), Creative & Advanced Research Based on Nanometrics (CARBON) Laboratory, Department of Chemical Engineering, IIT, Hyderabad

S. No.	Subject	Speaker
6	Thermochemical depolymerisation of mixed plastic waste for fuel production to automotive vehicles	Dr. Venkat Chintala, Associate Professor, Department of Mechanical Engineering & Head, Institute of Alternate Energy Research, R&D, University of Petroleum and Energy Studies (UPES), Dehradun

In addition, two exhibition stalls were also organized by Sri Ram Institute, New Delhi and Kumarappa National Handmade Paper Institute (KVIC-MSME) on 01.10.2019 displaying products regarding plastic waste management.

ii. Digital Gandhi Gyan Vigyan Exhibition:

- 150th birth anniversary of Mahatma Gandhi was commemorated by organizing a Digital Gandhi Exhibition on 02nd October, 2019 followed by workshop on Charkha Generator for around 200 school children on 03rd & 04th October, 2019.
- Under Digital Gandhi Exhibition, Augmented Reality (AR) and Virtual Reality (VR) based exhibits related to life of Mahatma Gandhi were displayed in a virtual walk-through of Sabarmati Ashram shown on screen placed in the kiosk.



- Operation of charkha generator developed by IIT Gandhinagar, which works on the principle of electromagnetic induction, was explained to school children in the workshop and charka generators were gifted to the students as memento.

iii. Energy Saving Measures:

- Roof Top SPV System: The plant of capacity 350 KWp was commissioned on 07th January, 2019.
- Conventional Tube lights (2215 Nos.) replaced with LED lights.
- Outlived ACs (120 Nos.) replaced with 5-Star rating.

These measures has resulted for generation of 3,50,671 KWp units of power from solar and overall saving of Rs. 27.65 Lakhs.

- E-charging station for electric vehicles established in office campus.

8.2 Staff Position

Department has a total number of 207 Group 'A' and Group 'B' (Gazetted) officers as per the table below:

Group	General	SC	ST	OBC	PH	Total
Group A						
Scientific	86	06	02	05	04	103
Non-Scientific	36	13	01	03	0	53
Group B						
Scientific	06	--	01	03*	(1)	10*
Non-Scientific	36	01	01	02	01	41
Total	164	20	05	13	05*	207

*One Employee belongs to both OBC and PH Category.

Department has a total number of 123 non-gazetted staff on its rolls as per the break-up given below:

Group	General	SC	ST	OBC	PH	Total
Group B (non-gazetted)	35	05	04	12	1	58
Group C	52	58	08	26	4	148
Total	87	64	12	38	5	206

8.2.1 *Parliamentary Work*

The Parliament Unit is assigned with the responsibility of handling entire parliamentary work of the Department. It ensures that the parliamentary work pertaining to the Ministry of Science & Technology is accomplished as per the prescribed schedule and procedures. The Unit maintains liaison with the Ministry of Parliamentary Affairs, Secretariats of Lok Sabha/ Rajya Sabha, other Ministries/Departments (including Scientific Departments) with a view to fully discharge the parliamentary obligations of the Ministry of Science & Technology. The Unit also coordinates the visits of the Parliamentary Committees to various scientific institutions which are under the administrative control of this Department.

8.2.2 *Implementation of Official Language Policy*

The Department of Science and Technology continued to make concerted efforts to promote the use of Hindi in official work and to ensure compliance with the provisions of the Official Language Act, 1963 as amended in 1967 and Rules 1976 framed thereunder as also the various orders / instructions issued by the Department of Official Language from time to time with a view to ensure proper implementation of the Official Language Policy of the Government.

DST has a full - fledged Hindi Section consisting of a Joint Director (O.L.) assisted by an Assistant Director (O.L.) and other supporting staff which caters to the need of the Department of Science & Technology and also its Subordinate offices / Autonomous Institutions. Besides monitoring the implementation of the Official Language Policy and the Annual Programme, Hindi Section arranges for in - service training of the staff in Hindi Language, Hindi Typewriting and Hindi Stenography. It also undertakes translation of the material received from various Sections / Desks of the Department from English into Hindi and vice - versa as per need.

For promotion of use of Hindi in this Department and to create conducive environment for the officials to work more in Hindi, various programmes are being undertaken:

- All documents coming under Section 3(3) of the official language Act, 1963 like general orders, notification, cabinet note, annual report and any paper which is to be laid in the parliament, were issued bilingually in both Hindi and English. Letters received in Hindi were invariably replied to in Hindi.
- The officers of Hindi Section conducted 13 inspections of Subordinate offices / Autonomous Institutions and 04 sections of the department regarding progressive use of Hindi.
- During the year, quarterly meetings of Departmental Official Language Implementation Committee were organized regularly. Likewise, Hindi workshops were organized to encourage the officers / staff of the department to conduct their maximum work in Hindi.

- Hindi Advisory Committee is in the process of reconstitution.

Celebration of Hindi Pakhwara: Hindi Pakhwara was organized from 09 to 23 September, 2019 in DST, Ministry of Science and Technology. Various Hindi competitions were organized and the successful participants were given cash awards and certificates.

8.2.3 *Right to Information*

The Right to Information Act, 2005 was enacted by the Government of India to promote transparency and accountability in its functioning. Department of Science and Technology has been implementing the RTI Act in letter and spirit.

To ensure transparency in its functioning, DST has been regularly making suo-moto disclosures on its web-site, as required under Section 4(1)(b) of the RTI Act, 2005.

During the period from 1st April, 2019 to 20th Jan.,2020, a total of 2549 RTI applications and 191 First Appeals were received by the Department and out of which 2500 RTI applications and 182 Appeals have been disposed of as per the provisions of RTI Act, 2005 till date.

8.2.4 *Public Grievances*

An essential pre-requisite to make the public service delivery system more citizen-centric is to have a robust public grievance redress and monitoring mechanism.

Department of Science and Technology has made concerted efforts to redress the grievances received from its stakeholders and the public at large. A total of 1271 public grievances were received by the Department during the period from 1st April, 2019 to 20th Jan.,2020. A total of 1284 grievances has been disposed of by 20th Jan.,2020 including backlog of 115 grievances.

8.2.5 *Vigilance*

The Vigilance Unit in the Department of Science & Technology (DST) is headed by a Chief Vigilance Officer, who is a Scientist 'G' of the rank of a Joint Secretary in the Central Government. He is supported by a Deputy Secretary, Section Officer and other secretarial staff.

2. Apart from handling Vigilance related cases of the Department, its subordinate offices and aided institutions; it also deals with complaints, received from the CVC/CBI and other sources. It plays an active role in ensuring the prompt disposal of these complaints. The vigilance unit also handles vigilance related disciplinary proceedings of appropriate rank. The vigilance side maintains a regular touch both with the CVC and the CBI.

3. During 2019, Vigilance Unit dealt with the following number of complaints:

Source	Opening Balance	Recd. during the year	Total	Disposed	Balance
CVC	12	33	45	20	25
OTHERS	61	135	196	142	54

The balance complaints are at various stages of examination and are under process.

4. The vigilance unit consolidates reports/ returns received from the subordinate offices and aided institutions on vigilance matters and furnishes the reports (monthly, quarterly and annual basis) to various organisations, like Central Vigilance Commission, Central Bureau of Investigation, Department of Personnel & Training. The Department also maintains Agreed List and List of Officers of Doubtful Integrity of Gazetted status, in consultation with CBI.

5. Besides, the Chief Vigilance Officer maintains close liaison with all attached/ subordinate offices to ensure timely completion of various vigilance tasks. The CVO keeps a watch over all cases pending at different stages including the cases of its attached and subordinate offices to ensure a time bound disposal of such cases.

6. In accordance with the directives of the CVC to spread awareness about transparency, accountability and corruption free governance, Vigilance Awareness Week was observed in DST from 28th October to 2nd November, 2019 in association with the Department of Scientific and Industrial Research (DSIR). During this occasion an Integrity Pledge was administered to employees of the DST & DSIR by Secretary, DST. Several events like Essay Writing Competition, Turncoat Debate, Slogan Writing Competition, Poster Making Competition, and Story weaving competition were organized for DST/DSIR employees. A Drawing competition was organized exclusively for the children of employees.



Vigilance awareness week 2019



Selected posters from the competition held for Kids during the Vigilance Week

7. CVO, DST is also currently laying emphasis and focusing on preventive vigilance as a measure to prevent reoccurrence of vigilance cases. An important circular to all aided institutions and others concerned have been issued in this regard.

AUDIT OBSERVATIONS

Annexure-I

Position as on 17.01.2020

Sl. No.	Year	No. of Paras/PA Reports on which ATNs have been submitted to PAC after vetting by Audit	Details of the Paras/PA reports on which ATNs are pending.		
			No. of ATNs not sent by the Ministry even for the first time.	No. of ATNs sent but returned with observations and Audit is awaiting their resubmission by the Ministry	No. of ATNs which have been finally vetted by audit but have not been submitted by the Ministry to PAC
	Nil	Nil	Nil	Nil	Nil

Annexure-II

Position as on 17.01.2020

Department of Science and Technology

Summary of important Audit observations pertaining to the Department of Science and Technology has not been made available by the Department of Expenditure for the year 2019-20.

BUDGET

DEPARTMENT OF SCIENCE AND TECHNOLOGY Summary of Financial Requirements

Sl No.	Head of Development Projects/ Programme/ Scheme	(Rs.in crore)			
		Actual 2018- 2019	BE 2019-2020	RE 2019-2020	BE 2020-2021
1	Secretariat	129.62	158.45	118.45	141.96
2	Survey of India	401.72	416.16	455.56	453.42
3	National Atlas and Thematic Mapping Organisation (NATMO)	19.05	25.75	27.25	42.25
4	Autonomous Institutions and Professional Bodies	1142.50	1182.70	1217.70	1357.00
5	Science and Engineering Research Board (SERB)	1000.00	1000.00	956.57	1000.00
6	Science and Technology Institutional and Human Capacity Building	1004.10	1100.20	1091.30	1169.50
7	Research and Development	471.73	611.00	589.00	718.00
8	Innovation, Technology Development and Deployment	772.60	872.35	811.87	1050.65
9	National Mission on Inter disciplinary Cyber Physical System	0.01	124.00	123.83	270.85
10	Technology Development Board (TDB)	100.00	100.00	100.00	100.00
11	Science Counsellors Abroad	6.52	9.50	9.50	10.00
	Total- DST	5047.84	5600.11	5501.03	6313.63

11. ABBREVIATION

AAS	Agriculture & Allied Sciences
AASSA	Association of Academies, and Societies of Sciences in Asia
ABs	Autonomous Bodies
ACE Meter	Air Conditioner Efficiency Meter
ADFOSC	ARIES Devasthal Faint Object Spectrograph Camera
AI	Artificial Intelligence
AISRF	Australia-India Strategic Research Fund
AISTDF	ASEAN-India Science & Technology Development Fund
AIWGST	ASEAN-India Working Group on Science & Technology
ALICE	A Large Ion Collider Experiment
AM	Additive Manufacturing
AMRIT	Arsenic and Metal Removal by Indian Technology
APPs	Acute phase proteins
ARCI	International Advanced Research Centre for Powder Metallurgy and New Materials
ARI	Agharkar Research Institute
ARIES	Aryabhatta Research Institute of Observational Sciences
AWSAR	Augmenting Writing Skills through Articulating Research
BARC	Bhabha Atomic Research Centre
BIS	Bureau of Indian Standards
BoB	Bay of Bengal
BRICS	Brazil, Russia, India, China and South Africa
BSIP	Birbal Sahni Institute of Palaeosciences
BWG	Boundary Working Group
CAZRI	Central Arid Zone Research Institute
CCMB	Centre for Cellular & Molecular Biology
CCP	Climate Change Programme
CBM	Compressed Baryonic Matter
C-DAC	Centre for Development of Advanced Computing
CENS	Centre for Nano and Soft Matter Sciences
CERI	Clean Energy Research Initiative
CGMS	Corbett Gramin Mahila Sangathan
CHORD	Centre for Human and Organizational Research Development
CHRA	Coastal Hazard and Risk Assessment
CII	Confederation of Indian Industry

CIP	Coseismic ionospheric Perturbations
CMS	Compact Muon Solenoid
CNRS	Centre National de la Recherche Scientifique
CNG	Compressed Natural Gas
CoE	Centre of Excellence
CORS	Continuously Operating Reference Stations
CPR	Centre for Policy Research
CPR	Committee of Plenipotentiary Representatives
CSP	Concentrating Solar Power
CSIR	Council of Scientific & Industrial Research
CSRI	Cognitive Science Research Initiative
CSRI	Cyber Security for physical infrastructure
CURIE	Consolidation of University Research for Innovation & Excellence
DAE	Department of Atomic Energy
DCTC	Dicyanotoluoylcyanide
DDA	Delhi Development Authority
DEM	Digital Elevation Model
DFT	Density Functional Theory
DIIS	Department of Industry, Innovation and Science
DILRMP	Digital India Land Records Modernization Programme
DLEPC	District Level Exhibition and Project Competition
DMD	Duchenne muscular dystrophy
DSRI	Data Science Research Initiative
DST	Department of Science & Technology
EAC	Entrepreneurship Awareness
EADLs	Electron acoustic double layers
EBC	Emission of Black carbon
EDA	Epidemiology Data Analytics
EDARI	Epidemiology Data Analytics Research Initiative
EDP	Entrepreneurship Development Program
EGMASTC	Expert Group Meeting on Academics, Science & Technology Cooperation
EIP	Extrinsic Incubation Period
EIR	Entrepreneurs-in- Residence
EMIC	Electromagnetic Ion Cyclotron
FAIR	Facility for Antiproton and Ion Research
FDP	Faculty Development Program
FIST	Fund for Improvement of S & T Infrastructure in Universities and Higher Educational Institutions

FPI	Fabry Perot Interferometer
FRP	Fibre Reinforced Plastic
GCPs	Ground Control Provision
GEM	Gas Electron Multiplier
Geo-ICT	Geo-Information Communication Technologies
GIST	Global Indian Scientists and Technocrats
GISTDA	Geoinformatics and Space Development Agency
GITA	Global Innovation and Technology Alliance
GLAD	glancing angle deposition
GLP	Good Laboratory Practice
GML	Geography Mark-up Language
GMS	Golden Map Service
GNSS	Global Navigation Satellite System
GRACE	Gravity Recovery and Climate Experiment
HCT	Himalayan Chandra Telescope
HESCO	Himalayan Environmental Studies and Conservation Organization
HICAB	Human and Institutional Capacity Building Programme
HRNTDB	High Resolution National Topographical Data Base
HRSI	High-Resolution Satellite Imagery
HTSTR	High Temperature Spin Test Rig
IACS	Indian Association for the Cultivation of Science
ICAR	Indian Council of Agricultural
ICCM	India Centric Climate Model
ICP	Inductively Coupled Plasma
ICPS	Interdisciplinary Cyber Physical Systems
ICPS	Integrated Cyber Physical Security
ICSTI	International Centre for Scientific and Technical Information
ICTP	International Centre for theoretical Physics
IDPs	Intrinsically disordered proteins
IEITCP	India-Ethiopia Innovation & Technology Commercialization
IGDTUW	Indira Gandhi Delhi Technical University for Women
IGSTC	Indo-German Science & Technology Centre
IHDS	Indian Heritage in Digital Space
IIA	Indian Institute of Astrophysics
IICDC	India Innovation Challenge Design Contest
IIGM	Indian Institute of Geomagnetism
IIGP	India Innovation Growth Program

IISER	Indian Institute of Science Education and Research
IISF	International Science Festival
IMPRINT	Impacting Research Innovation and Technology
IMU	International Mathematical Union
INAE	Indian National Academy of Engineering
INO	India-based Neutrino Observatory
INSA	Indian National Science Academy
INSPIRE	Innovation in Science Pursuit for Inspired Research
INST	Institute of Nano Science and Technology
IORA	Indian Ocean Rim Association
IOTRI	Internet of Things Research Initiative
IPR	Intellectual Property Rights
ISARI	Imaging Spectroscopy & Applications Research Initiative
ISC	International Science Council
ISF	Indo Soviet Friendship
ISCA	Indian Science Congress Association
ISRF	India Science and Research Fellowship
i-STED	Innovation, Science and Technology led Entrepreneurship Development
ITS	International Travel Support
IUSSTF	Indo-U.S. Science & Technology Forum
JBC	Joint Boundary Conference
JCM	Joint Committee Meeting
JDI	Joint Declaration of Intent
JNCASR	Jawaharlal Nehru Centre for Advanced Scientific Research
KIRAN	Knowledge Involvement in Research Advancement through Nurturing
LHM	Landslide Hazard Mitigation
LIGO	Laser Interferometer Gravitational-Wave Observatory
LINKS	Livelihood Incubation Kendras
MACS	Maharashtra Association for the Cultivation of Science
MANAK	Million Minds Augmenting National Aspiration and Knowledge
MGB	Mission Governing Board
MGNU	Molecular Genetics and Neuroimmunology Unit
MHRD	Ministry of Human Resource Development
MSE	Mobile Science Exhibition
MSL	Mobile Science Lab
MSME	Ministry of Micro, Small & Medium Enterprises
MSME	Ministry of Micro Small & Medium Enterprises

NAPCC	National Action Plan on Climate Change
NASI	National Academy of Sciences
NASTEC	Nagaland Science & Technology Council
NATAG	Nano Applications and Technology Advisory Group
NATMO	National Atlas & Thematic Mapping Organisation
NCI	National Critical Infrastructure
NCCRD	National Clean Coal Research & Development Centre
NCSC	National Children's Science Congress
NCSTC	National Council for Science and Technology Communication
NDR	National Data Registry
NDRI	National Dairy Research Institute
NECTAR	North East Centre for Technology Application and Reach
NER	North East Region
NGCMA	National Good Laboratory Practice Compliance Monitoring Authority
NGF	National Geotechnical Facility
NHHID	National Hub for Healthcare Instrumentation Development
NHP	National Hydrology Project
NIAS	National Institute of Advanced Studies
NIDHI	National Initiative for Developing and Harnessing Innovations
NIDHI-SSS	National Initiative for Developing and Harnessing Innovations- Seed Support System
NIF	National Innovation Foundation
NIIST	National Institute for Interdisciplinary Science and Technology
NIPER	National Institute of Pharmaceutical Education and Research
NIS	National Innovation Survey
NIT	National Institute of Technology
NMCG	National Mission for Clean Ganga
NM-ICPS	National Mission on Interdisciplinary Cyber Physical Systems
NMSHE	National Mission for Sustaining the Himalayan Ecosystem
NMSKCC	National Mission on Strategic Knowledge for Climate Change
NNetRA	Nanoelectronics Network for Research and Applications
NPDF	National Postdoctoral Research Fellows
NRDMS	Natural Resources Data Management System
NSA	National School Atlas
NSAG	Nano Science Advisory Group
NSD	National Science Day
NSDI	National Spatial Data Infrastructure
NSRCEL	NS Raghavan Centre for Entrepreneurial Learning

NSTEDB	National Science & Technology Entrepreneurship Development Board
NSTMIS	National Science and Technology Management Information System
NTDB	National Topographical Data Base
OECD	Organization for Economic Co-operation and Development
OGC	Open Geospatial Consortium
OMDC	Overseas S & T Ministers and Diplomats Conclave
PAC	Program Advisory Committee
PASI	Psoriasis Area and Severity Index
PDLC	Polymer Dispersed Liquid Crystal
PEP	Program Execution Partners
PFC	Patent Facilitation Cell
PFP	Patent Facilitation Programme
PGIMER	Post Graduate Institute of Medical Education and Research Chandigarh
PIC	Patent Information Centers
PIP	Program Implementation Partner
PoC	Programme of Cooperation
PSCST	Punjab State Council for Science and Technology
PSD	Pseudo-single-domain
PURSE	Promotion of University Research and Scientific Excellence
QuEST	Quantum Enabled Science and Technology
RCP	Rapid Prototyping Camp
RFID	Radio Frequency Identification
RRCAT	Raja Ramanna Centre for Advanced Technology
RRI	Raman Research Institute
RSC	Regional Science Centre
RST	Remote Sensing Technology
RSF	Russian Science Foundation
RTF-DCS	Research & Training Fellowship for Developing Country Scientists
SAC	Scientific Advisory Committee
SAIF	Sophisticated Analytical Instrument Facilities
SATHI	Sophisticated Analytical & Technical Help Institute
SCO	Shanghai Cooperation Organization
SCSP	Scheduled Caste Sub Plan
SCSTE	State Council of Science Technology and Environment
SCTMST	SreeChitraTirunal Institute for Medical Sciences and Technology
SDC	Swiss Agency for Development and Cooperation
SDGs	Sustainable Development Goals

SEED	Science for Equity for Empowerment and Development
SERB	Science And Engineering Research Board
SHE	Scholarship for Higher Education
SHGs	Self Help Groups
SHRI	Science and Heritage Research Initiative
SIAC	Science and Innovation Activity Centres
SINE	Society for Innovation and Entrepreneurship
SKA	Square Kilometre Array
SMB	Stabilised Mud Block
SRIMAN	Scientific Research Infrastructure Sharing Maintenance and Networks
SSDIs	State Spatial Data Infrastructure
SSR	Scientific Social Responsibility
SSS	Seed Support System
SSTP	State S&T Programme
STEMM	Science, Technology, Engineering, Mathematics and Medicine
STEP	Science & Technology Entrepreneur's Parks
STI	Science, Technology, and Innovation
STIC	Sophisticated Test and Instrumentation Centre
STRC	Science and Technology Resource Centre
SuTRAM	Sustainable Treatment, Reuse and Management
SWH	Significant wave height
SYST	Scheme for Young Scientists and Technologists
TANSPEC	TIFR-ARIES Near Infrared Spectrometer
TARA	Technological Advancement for Rural Areas
TBI	Technology Business Incubator
TCNQ	Tetracyanoquinodimethane
TDB	Technology Development Board
TDP	Technology Development Program
TEC	Total Electron Content
TEC	Technology Enabling Centres
TERI	The Energy and Resource Institute
TFAR	Technology Fusion & Applications Research Programme
TIASN	Technological Interventions for Addressing Societal Needs
TIDE	Technology Intervention for Disabled & Elderly
TIFAC	Technology Information, Forecasting and Assessment Council
TIFR	Tata Institute of Fundamental Research
TIH	Technology Innovation Hubs

TIME-LEARN	Technology Intervention for Mountain Ecosystems-Livelihood enhancement through Action Research & Networking
TMT	Thirty Metre Telescope
TMIR	Technology Mission on Indian Railways
TRACs	Technical Review and Advisory Committees
TRB	Treerich Biobooster
TRC	Tribal Resource Centre
TRC	Technical Research Centres
TRL	Technology Readiness Level
TSP	Tribal Sub Plan
UHV	Ultra-high vacuum
UIS	UNESCO Institutes of Statistics
UNGGIM	United Nations Global Geospatial Information Management
UNIDO	The United Nations Industrial Development Organization,
UPLIFT	Ultracapacitor Powered Lift
UVIT	Ultra Violet Imaging Telescope
UWS	Urban Water Systems
VAJRA	Visiting Advanced Joint Research
VASCSC	Vikram A Sarabhai Community Science Centre
VBDs	Vector-borne diseases
WAH	Water-Agriculture-Healthcare
WEE	Women Entrepreneurship and Empowerment
WEDP	Women Entrepreneurship Development program
WEQ	Women Entrepreneur Quest
WFOS	Wide Field Optical Spectrograph
WISTEMM	Indo-U.S. Fellowship for Women In STEM
WLCG	Worldwide Large Hadron Collider Computing Grid
WoE	Weight of Evidence
WOS-A	Women Scientists Scheme-A
WOS-B	Women Scientists Scheme-B
WOS-C	Women Scientists Scheme-C
WSC	Women Science Congress





सत्यमेव जयते

Department of Science & Technology
Ministry of Science & Technology
Technology Bhawan, New Mehrauli Road
New Delhi - 110016, INDIA