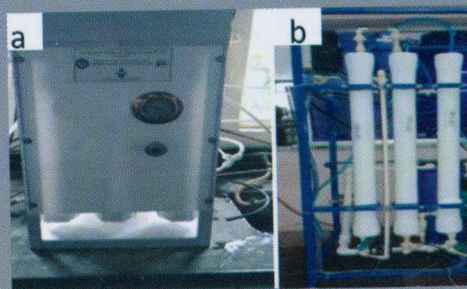
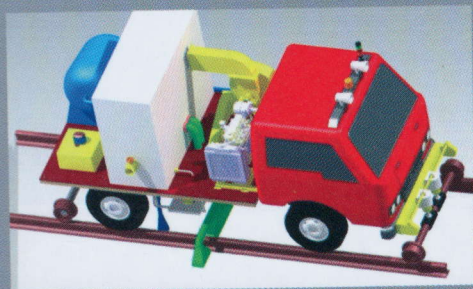


Annual Report 2021-22



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

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CONTENTS

Overview		v
1	S&T Institutional & Human Capacity	1
1.1	R&D Support (FIST, PURSE, SAIF)	1
1.2	State Science & Technology Programme	11
1.3	Policy Research Programme	16
1.4	National Science and Technology Management Information System (NSTMIS)	23
1.5	Training of Scientists and Technologists Working in Government Sector	28
1.6	KIRAN	28
1.7	CSRI & SATYAM	37
1.8	INSPIRE	42
1.9	INSPIRE AWARDS – MANAK	46
1.10	Swarna Jayanti Fellowships Scheme	47
2	Research & Development	50
2.1	International Cooperation Division	50
2.2	National Mission on Nano Science & Nano Technology	70
2.3	Mega Facility for Basic Research	87
2.4	Climate Change Programme (NMSHE & NMSKCC)	95
2.5	National Super Computing Mission	107
2.6	Technology Fusion & Applications Research (TFAR) Programme	115
3	Innovation Technology Development and Deployment	129
3.1	Technology Development Programme	129
3.2	Technology Missions Division (CERI & WTI)	141
3.3	National Geospatial Programme (NGP)	154
3.4	National Science & Technology Entrepreneurship Development Board (NSTEDB)	164
3.5	National Council for Science and Technology Communication (NCSTC)	178
3.6	Science for Equity for Empowerment and Development (SEED) Division	189

3.7	Special Component Plan for Schedule Castes (SCSP) & Tribal Area Plan (TSP)	203
3.8	National Good Laboratory Practice (GLP)	210
3.9	Technical Research Centres	212
3.10	Exhibitions and Fairs	219
3.11	National Spatial Data Infrastructure (NSDI)	221
4	National Mission on Interdisciplinary Cyber Physical Systems (NM-ICPS)	227
5	Autonomous Institutes	239
6	Science and Engineering Research Board	283
7	Technology Development Board	297
8	Strengthening Survey and Mapping Activity	299
9	Administration	321
10	Audit Observation	331
11	Budget	332
12	Abbreviation	333

OVERVIEW

The Department of Science & Technology (DST) is the nodal agency in the country for promoting new areas of Science & Technology. DST also serves in connecting the science and technology sector with different Government horizontals and verticals, academia, R&D and industry. With the objective to strengthen the national S&T capacity and capability, DST provides the largest extramural research and development support in the country to scientists cutting across institutions and disciplines through a competitive mode. This strategically important function significantly contributes towards reinforcing the outcomes of our country's educational, scientific and industrial R&D initiatives and helps transform the overall Science, Technology and Innovation landscape of the country.

The Department continued its efforts towards strengthening the national STI ecosystem to emerge as a forerunner in underscoring the critical role of science and technology in bringing positive transformations for a safe, secure, better society well prepared for future disruptions. Some of the key success stories during the year 2021-22 include:

- India's ranking in global S&T indices continues to rise:** India achieved 46th position featuring within the top 50 innovative economies globally as per Global Innovation Index (GII). The country remains among the top 3 countries in scientific publication in SCI journals as per NSF database and has also reached 3rd Position in terms of no of PhDs, in science and engineering, 3rd position in terms of size of Higher Education System. India also attained 3rd position in terms of number of Startups and number of UNICORNs.
- India surges ahead with Supercomputing Mission:** 4 new Supercomputers have been installed since July 2021 one each at IIT-Hyderabad, NABI- Mohali, CDAC-Bengaluru, and IIT Kanpur under NSM. The mission is aiming to set up a grid of supercomputing facilities to provide access to High-Performance Computing (HPC) facilities to around 75 institutions and more than thousands of active researchers, academicians working through National Knowledge Network (NKN).
- DST's efforts made scientific infrastructure accessible across institutions:** A new program called Synergistic Training Program Utilizing the Scientific and Technological Infrastructure (**STUTI**) was announced recently to envision to boost human resource and its capacity building through open access to S & T Infrastructure across the country.
- DST extends institutional support for women scientists:** The Women Science programme of DST has started a new initiative to support Women PG Colleges under the CURIE (Consolidation of University Research for Innovation and Excellence in Women Universities) Program and invited proposals for the same. Besides, 30 institutions have officially started the GATI (Gender Advancement for Transforming Institutions) Pilot Program this year. The first of its kind program for lateral entry of women researchers in

joint R&D projects between India and Germany was launched.

- **Communities empowered through STI hubs, point of care diagnostic kits, and encouraging entrepreneurial initiatives:** Tech नींव @75 programme, a testimonial of empowerment of communities, was launched on Janjatiya Gaurav Diwas for yearlong celebrating the STI empowerment of the community for creating equitable, inclusive economic growth.
- The Department had initiated the setting up of **Community COVID Resilience Resource Centres (CCRRCs)** for better recovery, building Science Technology and Innovation (STI) capacities and capabilities against various uncertainties at community level. Seven Scheduled Caste (SC)/Scheduled Tribe (ST) Cells and seven Science Technology and Innovation (STI) Hubs have been established for holistic development of SC/ST.
- **Saffron bowl brought to the Northeast:** The saffron bowl of India, so far confined to parts of Kashmir, has now spread its wings to parts of the North East through the focused efforts of the North East Centre for Technology Application & Reach (NECTAR). The successful cultivation of saffron started in Yangang village of South Sikkim and is being expanded to Twang, Arunachal Pradesh and Barapani, Meghalaya.
- **SERB-DST partners with Intel India to launch first-of-its-kind initiative to advance deep tech-based research in India:** The Indian research community will soon be able to pursue industry-relevant research opportunities in the areas of deep technologies that are novel, transformative, and can have a ground-breaking impact on a national scale through 'Fund for Industrial Research Engagement (FIRE)'.
- **INSPIRE Manak reaches out to remote places and involves increasing number of students:** MANAK awards were conferred to the top 60 innovators selected from a total of 3,92,486 students from schools across the country.
- **Marching towards Atmanirbhar Bharat with several indigenous smart, low cost technologies under DST supported make in India:** A new automated technology is developed for collection of toilet waste which is easy to maintain and 7 times cheaper alternative to the bio-toilets, can be used to maintain the toilet system of the Indian Railways. A smart system that can protect power grids from short-circuits has been developed that can be incorporated in any of the large power sector companies who are working with their standard superconducting fault current limiters. Low-cost semiconductor manufacturing process has been developed and used to design integrated circuits (ICs) to handle voltages up to 20 V.
- **Leapfrogging towards sustainability with carbon footprint reducing technologies: EV, alternative & clean energies:** As a part of Mission Innovation 2.0, India is co-leading the Innovation Community on low carbon affordable heating and cooling of buildings along with European Commission and the UK. It has an overwhelming response from Canada, Australia, Finland, Morocco, Netherlands, Sweden, and Saudi Arabia with IEA and RMI participating as stakeholders.

- Innovative and low-cost process developed for the synthesis of in-situ carbon modified LiFePO_4 (LFP), a cathode material for Lithium-ion batteries by ARCI.** Indigenously developed large-scale reactor produces substantial amount of hydrogen using sustainable sources like sunlight and water. Researchers have developed a non-expensive way to coat carbon on lithium metal oxide electrodes for lithium-ion batteries (used in electric vehicles) which will double its life due to protective carbon coating. Technologies have been developed for correcting pressure and flow inconsistencies of industrial processes saving power wasted in the form of steam, as well as convert high ash Indian coal to methanol. Scientists at JNCASR have found a new lead (Pb) free material which can efficiently convert waste heat to power our small home equipment and automobiles.
- DST supported research helps move towards affordable health and wellbeing for all:** Researchers have developed a compound called “6BIO” that can provide a better method to treat Autism Spectrum Disorder (ASD). A molecule that disrupts the mechanism through which neurons become dysfunctional in Alzheimer’s disease (AD) has been developed by JNCASR scientists which could be a potential drug candidate. A new technique to measure DNA modifications can help early diagnosis of multiple diseases. Better drug delivery mechanisms have been developed as well as flexible low cost, wearable sensor that can track sweat for monitoring the health and physiological status of the human body. The first National Heart Failure Biobank (NHFB) in the country that would collect blood, biopsies, and clinical data as a guide to future therapies was inaugurated at the Sree Chitra Tirunal Institute for Medical Sciences and Technology (SCTIMST).
- Grassroot Innovations (Vocal for Local):** DST along with National Innovation Foundation (NIF) has supported several grassroot innovations like traditional method of making Etikoppaka toys, Laxmi Asu Making Machine which has revolutionized the weaving of the Pochampally silk and reduced the drudgery of thousands of weavers involved in the occupation as well as polyherbal and cost-effective medicine to treat Mastitis, an infectious disease of dairy cattle.
- DST supported research assesses state level vulnerability, health & other effects of climate change:** The National climate vulnerability assessment report supported by DST has identified 6 eastern states--Jharkhand, Mizoram, Odisha, Chhattisgarh, Assam, Bihar, Arunachal Pradesh, and West Bengal as states highly vulnerable to climate change. Researchers have found that climate parameters accounted for 9-18% of the total infectious disease cases in children. The Mineral dust, biomass burning, secondary sulfate, secondary nitrate from northwest India and Pakistan, polluted cities like Delhi, the Thar Desert, and the Arabian Sea area, and long-range transported marine mixed aerosols are the main sources of aerosols in the central Himalayan region. North-Western, Central, and further to south-central region of India were found to be the new hotspot of intense heatwave events over the past half-century highlighting need for developing effective heat action plans in the three heatwave hotspot regions with a focus

on different vulnerabilities among the inhabitants. Researchers have also calculated the economic impact of aerosols, dust, and clouds reducing solar energy generation from photovoltaic and rooftop solar installations, found severe cyclonic storms in the North Indian Ocean region increasing in the past four decades.

- **DST support looks towards better disaster management:** WIGH researchers have found the first geological evidence of an earthquake at Himebasti Village on the border of Assam and Arunachal Pradesh, documented by historians as Sadiya earthquake in history, which is recorded to have caused massive destruction in the region and almost destroyed the town in 1697 CE. This finding could contribute to a seismic hazard map of the eastern Himalaya, which can facilitate construction and planning in the region. On the other hand Mishmi ranges (MR) in the North-Eastern tip of India, which has witnessed the imprints of the largest earthquake ever recorded in the Himalaya in the Kamlang Nagar town of Arunachal Pradesh, India has a widely distributed earthquake pattern, unlike the western and central Himalaya where the pattern is concentrated south of the Indus Suture Zone (ISZ), in the margin between the Eurasian and Indian Plates) over a nearly 30-km-wide at 10 - 20 Km depth.
- **DST support helps access to clean and potable water for all:** An improved wastewater treatment solution developed that can completely reuse industrial dye wastewater from textile industry, eliminating its toxicity and making it suitable for domestic and industrial usage. A much-improved Advanced Oxidation Process (AOP) technology targeting zero discharge water management system is being utilized for the complete reuse of industrial dye wastewater for domestic and industrial usage at a rate of 10 Kilo litres /day. A new technology using UV-Photocatalysis can treat municipal sewage and highly polluting industrial wastewater streams.
- **DST supports agricultural technologies ranging from grassroot to lab based for doubling farmer's income:** Grassroot technologies like a variety of mango called *Sadabahar*, which is resistant to most major diseases and common mango disorders, practice to develop support roots in cashew trees to protect from borer attacks and cyclonic storms, self-pollinating apple variety that does not require long chilling hours were supported. A composite paper made of carbon (graphene oxide) loaded with preservatives has been developed by scientists which can be used as wrappers to help extend shelf life of fruits.
- **Waste Management technologies with DST's support helps the march towards waste to wealth:** A novel high-performance bioreactor system integrated with sustainable pre-treatment process enables anaerobic digestion of complex fat-rich sludge from dairy industry. Researchers have developed a technology to produce energy-efficient walling materials using construction and demolition (C&D) waste and alkali-activated binders. A new high rate biomethanation technology for the integrated treatment of sewage and organic solid waste and concomitant generation of biogas and bio manure can treat groundwater and wastewater and convert it to potable water. A low-cost, integrated

composting technology, which includes microbe-aided vermistabilisation can convert toxic sludge from the textile industry into plant probiotics in a short time.

- DST support has helped develop a slew of new age technologies: A highly stable and non-toxic security ink from nano-materials that spontaneously emits light (luminescent) due to its unique chemical properties can combat the counterfeiting of branded goods, bank-notes, medicine, certificates, currency. Scientists at INST have produced electron gas with ultra-high mobility, which can speed up transfer of quantum information and signal from one part of a device to another and increase data storage and memory. A classification method based on Deep Learning (DL) network can evaluate hormone status for prognosis of breast cancer. Researchers at RRI have discovered a new exotic, strange state of materials in contact with an environment that alters its physical properties in the presence of an electromagnetic field, leading to better quantum technologies, which are tunable and controllable as per the user requirements.

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 2021-22 are briefly presented in the following sections:

- **Fund for Improvement of S & T Infrastructure (FIST)** in Universities and Higher Educational Institutions is supported in competitive mode Department has restructured the FIST programme to orient it towards the goal of Atmanirbhar Bharat by creating R&D infrastructure not only for R&D activities in academic organizations but also for use by the start-ups/ manufacturing industries/ MSMEs. All FIST supported facilities now need to connect with the I-STEM (Indian - Science Technology and Engineering Facilities Map) portal to display the utility and availability of slots of different facilities in their premises, for sample analysis by researchers outside the host organization. Activities pertaining to Scientific Social Responsibility (SSR) have also been introduced under the restructured FIST to make the program connect with more inclusive approach towards the different sections of the society. During the year, more than 500 fresh proposals have been received in seven subject areas which are in the process of evaluation.
- **"Promotion of University Research and Scientific Excellence (PURSE)"**: The main objective of the scheme is to pro-actively support for strengthening the R&D base of the performing Universities. The programme is now restructured and re-oriented including a combination of I_{10} index of faculty members in the University, H index of the University along with NIRF Ranking to formulate the new criteria for selection of Universities under PURSE. Universities have been encouraged to carry out Mission mode research activities to focus on thrust areas which align with National priorities of Excellence in Manufacturing, Waste processing, Clean Energy, Water and Start up India. The research should also align well with goals of Self-Reliant India (Atmanirbhar Bharat) and Start-up India etc. In the current year, three more Universities (University of Kashmir, Srinagar; Institute of Chemical Technology (ICT), Mumbai; and Vellore Institute of Technology, Vellore) were supported against PURSE 2020 call.

- **Sophisticated Analytical Instrument Facilities (SAIF)** have been established in different parts of the country to provide the facilities of sophisticated analytical instruments to the research workers in general and specially from the institutions which do not have access to such instruments to enable them to pursue R&D activities. There are at present 15 Nos. SAIF Centres in the country. Approximately 2000 research papers were published with the support provided by the SAIFs during the year and about 30,000 users from Pan India, belonging to all sectors have utilized and benefitted from the facilities at SAIF. Approximately 70% of the users utilizing the SAIF facility were from outside the host institute. An average of 90,000 samples were analyzed by all the SAIF centres. Around 9 Cr. has been earned out of the user charges.
- **Sophisticated Analytical & Technical Help Institutes (SATHI)** is setting up a shared, professionally managed services and strong S&T infrastructure facilities for intensifying the base of S&T infrastructure and manpower, S&T led innovation and start-ups, technology development and futuristic areas of S&T. Three SATHI facilities have been hosted in first phase at (i) IIT Delhi, (ii) IIT-Kharagpur and (iii) BHU- Varanasi. In the current year total twelve (12) no's of "SATHI Ki Baat" conducted to get the updates about progressive steps followed. The procurement & Installation of first set of equipment are undergoing at SATHI facility of (a) IIT Delhi (b) BHU Varanasi & (c) IIT Kharagpur. A call for proposal of Sophisticated Analytical and Technical Help Institutes (SATHI) program – 2021, was made by the department and against which 135 proposals has been received, which are under consideration.
- **Synergistic Training program Utilizing the Scientific and Technological Infrastructure (STUTI):** STUTI is a new initiative intended to build human resource and its knowledge capacity; envisions hands-on training program and sensitization of the state-of-the-art equipments as well as towards sharing while ensuring transparent access of S&T facilities.
- **State S&T Programme** facilitates states to achieve the specific S&T objectives at their level. Currently, a total 31 S&T Councils (28 states + 3 UTs) are being supported. The programme also supports studies and surveys on local S&T related issues etc. A year-long program "Vigyan Utsav" with twelve identified themes has been launched to showcase the emerging Science, Technology and Innovation (STI) ecosystem at States/ UTs and its contribution towards *Atmanirbhar Bharat*. Since September to December 2021 the programme has been able to reach out to 2.5 lakh stakeholders through various modes of communication. 24 Patent Information Centers have been established at various State Councils. Different organisations had filed 10 new patent applications, one copyright and one trademark application after due assessment of patentability of about 34 new requests.
- **Policy Research Programme (PRP)** under Policy, Coordination and Programme Management (PCPM) division in Department of Science and Technology (DST) is mainly focused to promote STI policy research in the country and gather evidence-

based input for future policy making in STI related areas. Three **Centres for Policy Research (CPRs)** have been supported under the programme to institutions across the country to understand STI processes for making effective policies, strengthen them and link these evidences to policy making. During the year, fellowships were supported to the third and fourth cohorts of the fellows. Fifth cohort of DST-STI policy 12 fellows have been recruited under the DST STI Fellowship programme.

- **Formulation of the 5th National STI Policy** to achieve “Atmanirbhar Bharat” and holistic developments, demands the new/modified national STI policy to meet the future aspirations at global platform. Formulation of a new, 5th national STI policy was initiated during the early of 2020. Formulation of the new STI policy draft involved several modes of outreach programmes, several rounds of consultations at various levels to invite suggestions/inputs on the first draft of the document. All the suggestions/feedbacks have been incorporated into the draft policy. As part of the policy formulation, more than 400 consultation meetings with participation of more than 40,000 individuals. More than one lakh ideas/suggestions have been received from different age groups.
- **National Science & Technology Management Information System (NSTMIS)** conducts national surveys to generate and make available information on manpower as well as financial resources devoted to S&T activities. A spin-off publication of the National S&T Survey entitled ‘Directory of R&D Institutions 2021’ was brought out. The S&T Survey 2021-22 on resources devoted to research and development activities launched (both in print and e-mode) and data collection is in progress. A survey titled ‘India Innovation and Systems Survey 2019’ in collaboration with UNIDO, Austria is in progress which attempts to understand the innovation in the country from the systems perspective.
- **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. The financial grant was extended to 600 ongoing projects and 47 new projects recommended by the Subject Expert Committees under WOS-A. WOS-B support was extended to 99 projects with location specific interventions addressing issues in rural/urban areas. Total of 120 women completed the 12th batch of training under WOS-C. Out of the total women trained in 12th batch, about 60% are placed in different organizations related to IP management. The Vigyan Jyoti support is extended to 100 districts (including 13 aspirational districts) of 33 states/UTs of the country. Vigyan Jyoti is providing various interventions to ~10000 meritorious girls of Class IX-XII from JNVs, KVs, Army and other Government Schools in Phase-II. An **Online portal** has been developed for the Vigyan Jyoti Programme. Curriculum-based STEM workshops (C-STEM) is also a new inclusion of academic activity for Class IX-X students with an aim to empower girl students. Support to ‘Women PG Colleges’ was initiated in 2021 with the aim to enhance its outreach to the masses and nurture more women organizations for the benefit of a large number of girls in STEM.

- Under CSRI-PDF, 14 Post-Doctoral Fellows have been selected this year. Further, release has been made under 10 ongoing CSRI-PDF. Financial support was extended to 12 new projects and 60 ongoing projects. Total 58 research publications have come out through CSRI projects during the year. Under the Science and Technology of Yoga and Meditation (SATYAM) program, fund release was made in 37 new projects and 19 ongoing projects. Projects under SATYAM contributed 12 research publications this year.
- **Innovation in Science Pursuit for Inspired Research (INSPIRE)** is a flagship scheme of DST 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. 9868 INSPIRE scholarships were offered during the year. A total of 7020 and 1310 ongoing scholars received their Scholarship under the Direct and Institutional mode respectively for continuing their undergraduate/post graduate degree courses at various IIT's, IISER's, NISER etc. Besides this **581** KVPY scholars were offered fellowship to pursue B.Sc. and M.Sc. in basic and natural sciences and **1024** KVPY scholars received their ongoing fellowship to pursue B.Sc. and M.Sc. in sciences. 303 INSPIRE Fellowships were offered during the year. 281 INSPIRE Faculty Fellows received their Fellowship including. A mobile application for INSPIRE Scheme to track the status of INSPIRE application(s) instantly through Unified Mobile App was developed and is available through the Umang platform for access by all the INSPIRE aspirants/beneficiaries.
- The “**Million Minds Augmenting National Aspirations and Knowledge (MANAK)**” programme brought 7.05 lakh ideas from middle and high schools across the country, out of which 52,720 brilliant ones have been shortlisted for showcasing at district, state and then at the National Level Exhibition & Project Competition.
- **International Cooperation** established active bilateral S&T programs of cooperation with more than 45 countries including dedicated program for Africa, ASEAN, BRICS, EU and neighboring countries. About 300 Bilateral, multilateral and regional R&D joint projects including multi-institutional networked projects and about 20 Industrial and applied R&D projects involving industry participation with Canada, France, Germany, Israel, Italy, Russia, Spain, South Korea, Sweden and USA were supported. Carried out dissemination of information and networking through about 100 bilateral workshops; symposiums and exhibitions;
- **National Mission on Nano Science & Nano Technology** promotes basic research and focuses on Nano Technology adaptation and transfer to industry for use by masses. 21 new projects were supported under the basic research areas. 11 new proposals were funded in technology development areas. The R&D and Technology-oriented projects supported through the special calls to solve challenges due to COVID 19 have successfully developed the products and transferred the technology to their industry partners.

- 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. This includes participation of India in collaboration with the Department of Atomic Energy to have access to some of the above state-of-the-art global facilities for the Indian scientific community, especially from the academic sector.
- 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. A first ever report of all-India state-level and district level vulnerability maps titled '**Climate Vulnerability Assessment for Adaptation Planning in India Using a Common Framework**' was brought out. The findings identify the most vulnerable states and districts in India with respect to current climate risk. The R7D projects supported have brought out more than 600 publications during the year.
- **National Supercomputing Mission (NSM)** jointly implemented with MeitY targets to set up high performance systems ranging from a few 100 Tera FLOPS to Ten's of Peta FLOPS in the country. Installation of 10 supercomputers under Phase II was carried out during the year. Under Phase-III, design and development of indigenous server node, interconnect switch, storage, and system software stack for the next generation of HPC systems has been taken up.
- **Technology Fusion & Applications Research (TFAR)** Programme is meant to boost research in emerging technologies under single platform with the focus research for fusion, convergence and application of emerging technologies like Quantum Enabled Science & Technology, Network Project on Imaging Spectroscopy and Applications (NISA), Epidemiology Data Analytics and Indian Heritage in Digital Space. More than 100 projects were supported both as individual and also network-modes under the above different programmes.
- **Technology Development Programme** supports R&D for development of innovative technologies in identified areas. Total No. of 08 sub Schemes under TDP are aligned to National priorities and ongoing National programmes. 9 TECs and 2 satellite centers are actively pursuing various activities as per mandate. In order to provide the Solutions for COVID'19 NHHID developed the prototypes for Smart Thermometer, Au Sanitizer, Au Mask, Standalone Respiratory Support Devices and Ventilator, Usiru - Cpap and Bipap Non-Invasive Ventilator.
- **Clean Energy Research Initiative (CERI)** covers the research spectrum of entire gamut of clean energy. Several new dimensions were added to the programme to accelerate the pace of clean innovations to meet national needs. The initiatives include

System Mission Innovation Challenge: Smart Grids and Affordable heating and cooling of buildings, Clean Coal technologies, Methanol & Methyl Ether, Solar Energy, etc.

- **Water Technology Initiative** aims 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. DST in collaboration with the NWO has launched a bilateral programme on Cleaning Ganga and Agri Water with the objective of developing solutions and studying the impact of Agri interventions on the quality and quantity of water in Ganga river basin Hindon basin. In this programme, 3 bilateral programmes have been approved for further support.
- **National Geospatial Programme (NGP)** aims at promoting R&D in emerging areas of Geospatial technologies and applications. First and only National Center for Geodesy (NCG) has been established by DST at IIT Kanpur. Anew Diploma of **Indian Institute of Technology** (DIIT) program has been initiated from the current year. The program is offered for specialization in three different domains, i.e., **Geodesy, Navigation & Mapping, and Remote Sensing & GIS**. Six new projects have been supported during 2021-22 focusing on IOT Enabled Smart Cities, Pollution; Health; City GML based 3D models using LiDAR point cloud; Indoor Location Based Services; Spatial Data Infrastructure for Indoor Navigation in Multi-storey Edifices; and City Governance etc. A Center of Excellence (CoE) has been established as a virtual laboratory in order to act as a knowledge partner to provide remote support to all the members of the Network Programme. For the first time, a set of three 21- days Summer/ Winter School (level-2) on “Geospatial Science and Technology” have been conducted in online/ hybrid mode including hands-on practice. A portal has been launched (on NSDI-SOI Geospatial Cloud) to demonstrate the efficacy of the **COVID-19 Data Analytics and Visualization Framework**.
- **NSTEDB** through its strong network of incubators is leveraging the technological strength of the higher learning institutes to the benefit of the start-ups. NSTEDB has adopted a multipronged approach in its mission to foster innovation & technology-based entrepreneurs. In 2021-22, two new Center of Excellences to support startups with incubation and funding supported at FITT, IIT Delhi. During 2021-22, 388 programmes were organized & 10425 beneficiaries were sensitized/trained under the Innovation and entrepreneurship Training programme. During the year, NSTEDB has rolled out a specially devised initiative, **NIDHI4COVID 2.0** to support startup led covid solutions relevant in the second wave of COVID. India's first CDSCO approved indigenous RT-PCR & antigen tests for COVID-19 has been developed by MyLab Discovery Solutions Pvt. Ltd,incubated at NIDHI CoE at NCL Venture Centre, Pune. It has also developed India's first self-test diagnostic kit CoviSelf. Under NIDHI SEED support system a total of about 65 startups have been supported so far and a total of 43 Technology Business incubators have been equipped so far..
- **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. The National Science Day was celebrated on 28 February . Similarly, the National Mathematics Day programme Celebrated on 22 December to commemorate the birthday of Srinivasa Ramanujan, the great mathematician with a focus on popularizing Mathematics. **National Programme on Risk & Health Science Communication-** A full-fledged programme was evolved with emphasis on content creation, content reinforcement and its zonal utilization, along with assessments of outcomes and recycling the lessons learned. Over 100 projects are being implemented across the country in 20 States/UTs. The messages are going far and wide in preparing the nation in the fight against COVID 19. Content reinforcement has been provided with COVID Katha, VaigyanikDrishtikon (150+ stories), and India Science Channel (Doctor's Interviews, 424 Documentaries).

- **Science for Equity for Empowerment and Development (SEED)** scheme supports several field based programs with the application of S&T linked to directly benefiting the society has been implemented under. Long term Core Support is extended under Technological Advancement for Rural Areas (TARA). The schemes and programs of the division are also being converged with line function ministries/departments for the last-mile delivery and national development programs to achieve Sustainable Development Goals (SDGs). Under the Scheme for Young Scientists and Technologists (SYST) Point-of-care, cost effective, easy-to-perform diagnostic toolkits developed to detect *Salmonella*, *Staphylococcus aureus*, *Clostridium perfringens*, *Campylobacter jejuni* and *Campylobacter coli* contamination of food. A pen drive size android app enabled user friendly DNA sensor was developed for onsite detection of scrub typhus. A bouquet of coloured artificial diets for rearing silkworm was developed to produce naturally coloured cocoon.
- Interventions through the **Tribal Sub-Plan** had directly benefited peoples, in addition to improved socio-economic status there had been a significant improvement in skills, building on local innovation & local knowledge.
- The projects implemented (completed) through the **Scheduled Caste Sub Plan** during the year directly benefited people and there has been a significant improvement in the socio-economic conditions of people.
- **Good Laboratory Practice (GLP)** as on date, there are 49 GLP certified test facilities in the country. 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 38 member-countries of the OECD and other countries, thus removing the technical barriers to trade.
- 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. These TRCs 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.

- **NSDI** has been on demonstrating the National Data Registry (NDR) Geo-portal and the individual organisational Data Nodes; provisioning a proof-of-concept Geospatial Cloud based Infrastructure (NSDI Geo-platform) services for hosting geospatial data/applications; maintaining the NSDI Clearinghouse Node.
- **National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS):** The Mission initiated during the year 2018-19 has already set up 25 Technology Innovation Hubs in the top-ranking institutions almost in all States covering the entire country. Industry partnerships are developed with all TIHs to focus on developing solutions on people centric problems. Other academic institutes are connected as SPOKES. Thus, NM-ICPS is a Pan India Mission and covers all Central Ministries, State Governments, Industry and Academia. For easy analysis of COVID infections, a technology platform was developed wherein people can upload their X-Rays and the platform will analyse through AI technologies and provide exhaustive analysis in minutes for free of cost. This was developed in a record time of 4 months. Similarly, proximity estimation, medical data analytics etc. was also developed and is in testing phase.
- 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. **DST's autonomous institutions contribute to multifarious research ranging from Health, Medical devices, Energy to unraveling the mysteries of the Universe.** Following is a glimpse of the some of the key achievements:
 - Sree Chitra Tirunal Institute for Medical Sciences and Technology, Trivandrum (SC-TIMST) has developed two biomedical implant devices called Atrial Septal Defect Occluder and Intracranial Flow Diverter Stents in collaboration with National Aerospace Laboratories, Bangalore (CSIR-NAL) using superelastic NiTiNOL alloys. SC-TIMST also entered into Technology Transfer Agreements with BioradMedisys for these two Biomedical Implant Devices.
 - Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR) developed material to tap waste heat generated by appliances and reuse it. A new material, Silver Antimony Telluride, can facilitate energy conversion. In another development, a team scientists have tuned the nature of the chiral activity of millimetre-sized rice-shaped grains with the help of 3D printing. By exploiting 3D printing to design chiral active matter, scientists can systematically encode different extents of chiral activity and explore its consequences on the emergent dynamical behavior which can be useful in medicinal drug designing, and separation where self-recognition, sorting, and discrimination of molecules are required. Fabricated a device that can mimic human brain cognitive actions and is more efficient than conventional techniques in emulating artificial intelligence, thus enhancing the computational speed and power

consumption efficiency. A team of researchers have designed a robust, mobile group oxygen concentrator named *OxyJani* that can be used in rural settings and be rapidly deployed in emergencies in any location.

- o Agharkar Research Institute (ARI), Pune, Birbal Sahni Institute of Palaeosciences (BSIP), Lucknow, Institute of Advanced Study in Science & Technology (IASST), Guwahati and Sree Chitra Tirunal Institute for Medical Sciences and Technology (SC-TIMST), Thiruvananthapuram were approved for testing COVID-19 samples and testing sample to detect SARS-CoV-2.
- o International Advanced Research Centre for Powder Metallurgy and New Materials (ARCI) developed Super-hydrophobic functionalized carbon textiles as multifunctional advanced materials for effective and economic separation/removal of contaminated oil/toxic chemicals in the water.
- o ARCI developed (at lab-scale) wear and corrosion resistant Nickel alloy coatings by pulsed electrodeposition (PED) for application on die components used in plasticware industry. These coatings can also withstand temperatures up to 500°C.
- o Institute of Advanced Study in Science and Technology (IASST), Guwahati has used “Tea & banana waste to develop non-toxic activated carbon” which is useful for several purposes like industrial pollution control, water purification, food and beverage processing and odour removal.
- o Indian Association for the Cultivation of Science (IACS), Kolkata has made seminal contributions in the area of DNA repair mechanisms and genome stability, which advances understanding of genomic alterations underpinning carcinogenesis and signaling of cancer progression.
- o The IIA's Indian Astronomical Observatory (IAO) located at Hanle near Leh in Ladakh is becoming one of the promising observatory sites globally. A faster method of predicting space weather has been identified in a type of Solar Radio Bursts (SRBs) observed using the global network of solar radio telescopes called CALLISTO a clue to the mystery behind the high abundance of Lithium— a trace element on Earth has been traced while an active galaxy found in a very bright state with 10 times more X-ray emission than normal, equivalent to more than 10 trillion Sun, and located 5 billion light-years away could help probe how particles behave under intense gravity and acceleration to the speed of light. An algorithm that can increase the accuracy of data from exoplanets by reducing the contamination by the Earth's atmosphere and the disturbances due to instrumental effects and other factors has been developed while a new method to understand the atmosphere of extrasolar planets has been found. Besides, we now have clues to mystery of solar flares & CMEs in regions on Sun with disturbed magnetic field can help improving solar weather predictions
- 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. Some of the flagship programmes include 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, SERB-TETRA, SERB-SUPRA, SERB-VORTEX, SERB-STAR, etc. Some of the new initiatives during the year include SERB-POWER, SERB on Covid-19, etc. SERB has approved setting up of, up-to 3 Centres of Excellence (CoEs) in the area of Earth and Atmospheric Sciences, for developing Artificial Intelligence & Machine Learning (AI & ML) approaches to geohazard, weather & climate prediction. These CoEs will be developed as network centres in linkages with Ministry of Earth Sciences.

- **TDB** provides 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 accepts applications for financial assistance throughout the year from all sectors of economy such as Health & Medical, Engineering, IT, Chemical, Agriculture, Telecommunications, Road Transport, Energy & Waste Utilization, Electronics, Defence, Civil Aviation, Textile, etc. TDB has signed a Loan agreement with M/s Botlab Dynamics Private Limited, New Delhi, a startup incubated at IIT Delhi for the project titled “Design and Development of a Reconfigurable Swarming System Consisting of 500-1000 Drones for 3D Choreographed Drone Light Shows” and with M/s Manjeera Digital Systems Private Limited, Hyderabad for the project titled “Development and Production of Receiver Modules for NavIC and GPS” to commercialize NavIC and GPS receiver modules”.
- Under the Strengthening survey and mapping activity through Survey of India and NATMO, has made some significant contributions with some geospatial solutions catering to various domains including the COVID 19. Survey of India has undertaken preparation of HRNTDB for entire country by using High Resolution Satellite Imageries (HRSI) to cater for accurate high-resolution data requirements/demands from various users and organisations. Establishment of CORS network in the states of Uttarakhand, Uttar Pradesh, Haryana, Karnataka, Rajasthan, Maharashtra, Madhya Pradesh is completed (Nearly 40% country covered for CORS). NATMO is contributing

The Department has made sincere efforts to utilize the allocated budget fruitfully to implement its planned activities and programmes during the year. DST and its autonomous institutions geared themselves up to help India deal with the challenges including that of COVID pandemic. The department also implemented the lessons learnt last year to reach out to the world with STI solutions that brought positive transformations in every sphere, be it healthcare, sustainability, energy efficiency, food production or even the way we work

CHAPTER 1

S&T INSTITUTIONAL & HUMAN CAPACITY BUILDING

The umbrella scheme S&T Institutional & Human Capacity Building includes various human and institutional capacity building programmes along with STI Data & Policy research are part of this Umbrella Scheme.

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

Department of Science & Technology implements four major scientific infrastructure related programs.

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

FIST was launched in the year 2000 at the end-part of 9th plan period and is continuing with renewed energy and commitments towards strengthening the infrastructure of post-graduate education & research in various areas at the departments of universities/ colleges including Medical, Agriculture, Animal Husbandry and Engineering sectors. Over the years, the FIST Program has played a significant role in the strengthening of both the teaching and research infrastructure in different academic and research institutions. However, with the shift in priorities and the S&T needs of the country, restructuring of the program was necessary in the context of the current National interests, National Missions, Sustainable Development Goals, and its scope to strengthen the vibrant economy towards building a self-reliant India.

The Program is being implemented at four levels of supports i.e. Level 0, Level 1, Level 2 and Level 3. While Level 0 is for 'College as a whole', the Level 1, Level 2 and Level 3 are for six broad subject areas i.e. Life Sciences, Physical Sciences, Chemical Sciences, Engineering Sciences, Earth & Atmospheric Sciences and Mathematical Sciences for Department in Universities and academic Institutions. The supports under the Program are basically for improving quality of research through modernization of laboratories by acquiring basic/ state-of-the-art major research equipment, associated infrastructure facilities including modernization of labs, set up of specialized research facilities for conducting internationally competitive and contemporary research as per global standards.

Since 2000 in last twenty rounds of operation, 2998 projects (496 projects in Level 0, 2231 projects in Level 1, 269 projects in Level 2 & 02 projects in Level 3) were identified in more than 700 universities & academic institutions for support at a total budget of about Rs 3043

crores during this period and were extended support mainly for Equipment, Networking & Computational Facilities, Infrastructure and Maintenance of the facilities.



Figure. High Resolution X-Ray Diffractometer Facility at Department of Physics, BITS Pilani, Pilani Campus, Rajasthan

The announcement for submission of fresh proposals under the program was made during August, 2021. More than 500 fresh proposals have been received in seven subject areas from various departments of universities & academic institutions across the country. The screening meetings in seven subject areas were organized in the current year. The presentation meetings are being organized presently to select around 80 departments for FIST Support in the current cycle.

Technical review and monitoring is an important part of the FIST Program. In the current year, the technical and financial progress of ongoing one hundred and seventy-five (175 no) FIST projects in different subject areas were evaluated and few projects were suggested to move with mid-course corrections in the implementation aspects.

In the current year, nine FIST interaction meetings have been organized by involving stakeholders from various academic institutions, associated with ongoing FIST projects sanctioned in different subject areas. The stakeholders were apprised of the recent changes incorporated in the FIST Program.

Department has restructured the FIST programme to orient it towards the goal of Atmanirbhar Bharat by creating R&D infrastructure not only for R&D activities in academic organizations but also for use by the start-ups/ manufacturing industries/ MSMEs. Appropriate mechanisms including use of the FIST facilities through multiple shifts have been communicated to the beneficiaries through a public notice to promote optimal utilization of these resources. The beneficiary organizations need to display a public notice exhibiting the FIST Logo to represent the face of the restructured FIST Program. They also need to connect with the I-STEM (Indian - Science Technology and Engineering Facilities Map) portal to display the utility and availability of slots of different facilities in their premises, for sample analysis by researchers

outside the host organization. Activities pertaining to Scientific Social Responsibility (SSR) have also been introduced under the restructured FIST to make the program connect with more inclusive approach towards the different sections of the society.



Figure: LOGO OF FIST Program

1.1.2 Promotion of University Research and Scientific Excellence (PURSE)

Department of Science & Technology has restructured and re-oriented PURSE program. A combination of I_{10} index of faculty members in the University, H index of the University along with NIRF Ranking is used to formulate the new criteria for selection of Universities under PURSE. Universities have been encouraged to carry out Mission mode research activities to focus on thrust areas which align with National priorities of Excellence in Manufacturing, Waste processing, Clean Energy, Water and Start up India. Universities are encouraged to harness their areas of excellence into thematic effort of an accomplished team, with clearly articulated objectives. The broad objective is to support potentially high impact, interdisciplinary research (both basic and applied) aligned to national priorities and missions. The research should also align well with goals of Self-Reliant India (Atmanirbhar Bharat) and Start-up India etc.

Under PURSE, the support is provided to acquire research facilities, research man-power cost, acquiring research consumables, funds for travel, organizing workshops and conferences, contingencies and maintenance of the facilities. Universities are encouraged to harness

their areas of excellence into an inter-disciplinary thematic effort of an accomplished team, with clearly articulated objectives. Proposals towards individual R&D support would not be accepted under this Scheme. The synergy and focus of research may preferably be aligned to National Missions/ priorities. The Department of Science & Technology has announced the call for inviting the proposals for consideration of support under PURSE. A total of Sixty-Nine applications have been received which are being processed.

In the current year, three more Universities identified for support against PURSE 2020 Advertisement were supported. University of Kashmir, Jammu and Kashmir was sanctioned with PURSE Grant of Rs 9.44 Crores for four years duration to carry out the research in the area of “Gastrointestinal Cancers in Kashmir Valley, Climate Change Studies and Design of Novel Materials and approaches for the abatement of Water Pollution”. DST has sanctioned a major sum of Rs 15.80 Crores for acquiring the research facilities to Institute of Chemical Technology (ICT), Mumbai towards the thematic research on “Self-Reliance in Working around sustainable, helpful, reliable and high yielding processes and technologies (“Swashray”)”. The aim of SWASHRAY is to develop and demonstrate sustainable, high yielding processes and technologies for manufacturing of priority drugs, intermediates and specialty chemicals. Vellore Institute of Technology, Vellore was sanctioned an amount of Rs 19.15 Crores was Additive Manufacturing for Fostering Transdisciplinary Research

DST also organized Well Wisher Committee meetings at Jamia Hamdard, Hari Singh Gaur Viswa Vidyalaya, Sagar and Punjab Agricultural University, Ludhiana involving eminent experts from Programme Management Board of PURSE to discuss the technical and financial progress in the implementation of PURSE.

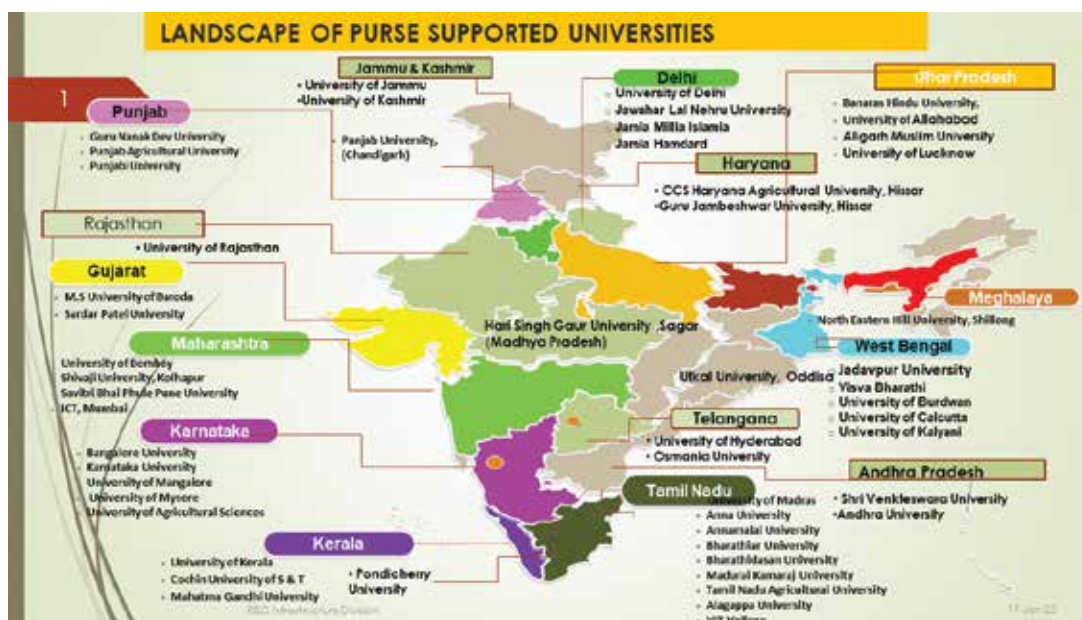


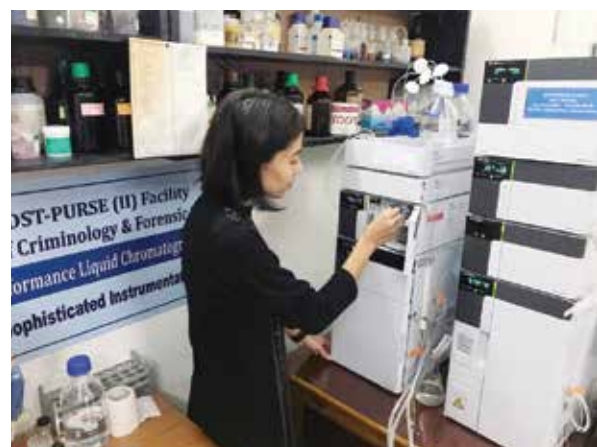
Figure. Land scape of DST PURSE Supported Universities



X-Ray Photoelectron spectrometer (XPS) at Pondicherry University, Pudducherry.



Fast Protein Liquid Chromatography established out of DST PURSE at Hari Singh Gour Vishwavidyalaya, Sagar, Madhya Pradesh



UPLC Facility established out of DST PURSE at Hari Singh Gour Vishwavidyalaya, Sagar, Madhya Pradesh

1.1.3 Sophisticated Analytical Instrument Facilities (SAIF)

Sophisticated analytical instruments are vital for pursuing research in many areas of modern science and technology. Although, research infrastructures in different Universities/institutes have been augmented and modernized in the last two decades, many institutions in the country still lack the existence of specialized facilities to carryout both basic and advanced research in contemporary areas of Science and Technology. These sophisticated instruments are expensive and are seldom provided through individual project mechanism. Moreover, these instruments are of inter/multidisciplinary utility and thus it is desirable to use them on sharing basis for their optimum utilization. Considering these aspects, the Department of Science & Technology has set up Sophisticated Analytical Instrument Facilities (SAIFs) in different parts of the country under its Sophisticated Analytical Instrument Facilities Programme to provide the facilities of sophisticated analytical instruments to the research workers in general and specially from the institutions which do not have access to such instruments to enable them to pursue R&D activities requiring such facilities and keep pace with developments taking place globally.

At present 15 SAIFs are being supported by DST at IIT, Chennai; IIT, Mumbai; CDRI, Lucknow; Punjab University, Chandigarh; NEHU, Shillong; IISc., Bangalore; AIIMS, New Delhi; Gauhati University, Guwahati; C.V.M., Vallabh Vidyanagar; STIC, Kochi; Shivaji University Kolhapur; IIT Patna; IEST Shibpur; M.G. University, Kottayam and Karnataka University Dharwad.

SAIFs are equipped with instruments such as X-ray Diffractometers, Thermal Analysis Systems, Transmission Electron Microscopes, Mass Spectrometers, Nuclear Magnetic Resonance (NMR), ICP etc. to meet the need of research workers. SAIF facility is accessible to all the users from various academic institutes, R&D laboratories industries and start-ups, irrespective of whether they belong to the host institute or not.

Major Highlights of year 2021-22

Facility Management Committee Meetings & SAIF centre visits

FMC meeting were organized for centres located at IISc Bangalore, IIT Bombay, Panjab University Chandigarh, CSIR-CDRI Lucknow, AIIMS New Delhi & Karnataka University Dharwad. FMC meetings for rest of the centres are underway. SAIFs portray their requirements, achievements, performance etc in these meetings. These centres are also visited physically by the expert committee to oversee the functioning.

Analysis Provided/Usage of facility

The facilities at SAIF are meeting analytical needs of researchers, scientist and industries for material characterization including qualitative/quantitative analysis, structure determination, surface topographic studies etc. to name a few

- Approximately 1800 research papers were published with the support provided by the SAIFs during the year
- About 25,000 users from pan India, belonging to all sectors have utilized and benefitted from the facilities at SAIF
- Approximately 70% of the users utilizing the SAIF facility were from outside the host institute
- An average of 75,000 samples were analyzed by 15 SAIF centres

Workshops & training Programs

Centres conduct trainings and workshops on regular basis to make researchers and users aware of the facilities these centres have to offer. However, the pandemic and the situation emerging out of it has put a halt on such trainings. To overcome this a series of webinars are organized by SAIF centres on topics related to NMR, ICP-AES, TEM, SEM, Spectroscopy, virtual tour of the sophisticated instruments etc. In total, approximately 50 webinars and workshops were hosted by SAIFs during the year.

Contribution of SAIF centres during COVID Pandemic

DST sponsored SAIF at Panjab University, Chandigarh has collaborated with an USA based air purifying manufacturer to assemble and distribute air purifiers to various hospitals in India, to help aid in the battle against the virus and provide patients, doctors, and staff with much needed clean air. In this effort total 42 hospitals have been covered in 11 states of India. Few of these units were also delivered to Covid testing and Covid vaccination centres.



Assembling of Air purifies at SAIF centre



Distribution of Air purifies



Air purifies in use at ICU facility



Air purifiers in use at Covid vaccination centre

1.1.3 *Sophisticated Analytical & Technical Help Institute (SATHI)*

SATHI program is meant for setting up shared, professionally managed services and strong science and technology infrastructure facilities at national level. SATHI is envisaged to be functional with efficiency, accessibility and transparency of highest order under one roof to cater services to the demands of researchers, scientists, students, start-ups, manufacturing units, industries and R&D Labs. In terms of “help” it will deal with knowledge generation and its dissemination by adopting best practices of such facility, i.e., expansion of different knowledge chain that starts from R&D to applied science, then to translational research side and how to take forward to next stage to gain better societal outreach through such facility.

The usage of these facilities will be guided by the basic principle of maximum and effective utilization and accessibility to all; viz: 80% to external users by booking the slots on web-based platform. Largely SATHI scheme aims for : (a) procurement and maintenance of high-end equipment and infrastructure facility necessary for research/ testing/ manufacturing/ fabrication, (b) to cater service by understanding the demands of researchers, scientists, students, start-ups, manufacturing units, industries and R&D Labs, (c) to provide access and sharing of scientific equipment and infrastructure, (d) For capacity building of engineers and

technocrats for efficient operations and interpretations of results/ outcome, (e) Monitoring of usage pattern of expensive scientific research infrastructure for its maximum utilization by applying infrastructure management with efficient operations and to be a part of 'Atmanirbhar Bharat Abhiyan' (Self Reliant India Campaign).

Three SATHI facilities are hosted in first phase at (i) IIT Delhi, (ii) IIT Kharagpur and (iii) BHU- Varanasi. Each SATHI facilities is supported with Rs. 125 crores spread over 3 years duration, starting from current FY 2019-20. In the current year total twelve (12) no's of "SATHI Ki Baat" conducted by involving ongoing SATHI centres to get the updates about progressive steps followed at recently supported SATHI centres and for sharing the common thoughts of host institutes as well as different stakeholders of SATHI.

Dedicated building with suitable infrastructure, such as uninterrupted supply of utility like electricity, water, sanitation, internet connection etc at the available space of (more than 20000 Sq. ft., within single building location) are operational at all three SATHI facilities. The respective Governing Body (GB) meeting of each SATHI facilities were organized periodically and the incorporation of dedicated Section-8 company has happened at host institutes for smooth operation of SATHI facilities. The procurement & Installation of first set of equipment are undergoing at SATHI facility of (a) IIT Delhi (b) BHU Varanasi & (c) IIT Kharagpur and following are some selective state-of-art facilities depicted below.



State-of-the art Steady-state photoluminescence (PL) spectroscopy facility of SATHI at Sonipat Campus of Indian Institute of Technology Delhi

The call for proposal of Sophisticated Analytical and Technical Help Institutes (SATHI) program – 2021, is announced recently by the department. The department has received a total of One hundred thirty-five (135) proposals under the SATHI call of 2021, which are under consideration.

1.1.4 Synergistic Training program Utilizing the Scientific and Technological Infrastructure (STUTI)

STUTI is a new initiative of the Department which would cater to optimum utilization of the equipment granted by the DST. The program STUTI is intended to build human resource and its knowledge capacity through open access S&T Infrastructure across the country. As a complement to the various schemes of DST funding (FIST, PURSE, SAIF, CURIE and SATHI) for expansion of R&D Infrastructure at academic institutions, STUTI scheme envisions a hands-on training program and sensitization of the state-of-the-art equipment as well as towards sharing while ensuring transparent access of S&T facilities.

There are two major objectives of the program:

- Organization of training program on DST supported R&D equipment targeting Scientists/ Professors/ PhDs and PDFs actively involved in research across various institutions in the country.
- Organization of awareness program on R&D equipment/ facility for school students (Science stream) in catchment areas by means of short training and popular science events.

The advertisement for call for proposal for the STUTI 2021 program was released and Forty-five applications have been received which are being processed.

1.2 State Science & Technology Programme

Under State Science and Technology Programme (SSTP), a year-long program “*Vigyan Utsav*” with twelve identified themes was inaugurated by the Hon’ble Minister of State (Independence Charge) of the Ministry of Science & Technology, Dr. Jitendra Singh to showcase the emerging Science, Technology and Innovation (STI) ecosystem at States/UTs and its contribution towards *Atmanirbhar Bharat*. Since September to December 2021 the programme has been able to reachout to 2.5 lakh stakeholders through various modes of media.

Through SSTP, DST provides budgetary support to State S&T Councils for their S&T human resources and minor infrastructure. The support facilitates the State S&T Councils to strengthen the Science Technology and Innovation (STI) ecosystem in the States.

Significant achievements of some of the State S&T Councils under the State S&T Programme during 2021-22:

- **Gujarat Council on Science and Technology (GUJCOST)**

GUJCOST has established Five Regional Science Museums (RSMs) at Rajkot, Bhuj,

Bhavnagar, Patan and Vadodara and four RSMs during current financial year would be open for public. The Council has also facilitated establishment of 10 new supercomputing facilities and 18 “Design Labs” in engineering and research institutions to catalyze research using modelling, simulation, data analysis and nurture creative ideas of young engineers to deliverable projects through support from Government of Gujarat.



Supercomputing facility established by GUJCOST at University



Design lab established by GUJCOST in Engineering College

- **Haryana State Council for Science & Technology (HSCST)**

In order to enhance the R&D activities at the State level, 12 innovative research ideas having socio-economic relevance for the State, were recommended for the grant of Rs.20.00 lakhs.

Ministry of Culture, Govt. of India had sanctioned establishment of Science Centre namely *Aryabhatta Vigyan Kendra* at Ambala that will act as a Centre for Science Education through scientific exhibits and facilities for informal learning of various scientific principles in a playful manner.

- **Himachal Pradesh Council for Science, Technology & Environment (HIMCOSTE)**

HIMCOSTE framed and notified the Science Technology & Innovation (STI) Policy for the State of Himachal Pradesh and is now the third State in the country to have STI Policy. The Policy emphasizes upon creating a vibrant innovation ecosystem by offering environment and opportunity to the innovators and stakeholders for overall sustainable development of the mountain region. It also insists upon delivery of technology from lab-to-land in an eco-friendly manner, with a decentralized and bottom-up approach for the upliftment and betterment of the society.

In order to upgrade the skills of Masons and Engineers in the State, several trainings on **Construction of Earthquake Resistant Buildings** were conducted with participation of 300 Masons and 58 Engineers across the State.



Earthquake resistant demonstration building constructed for training purpose at Dehar, Sundernagar Mandi

- **Kerala State Council for Science, Technology & Environment (KSCSTE)**

KSCSTE initiated establishment of SC Cell, selected 500 innovative projects for support under Student Project Programme (SPP) and developed the Digital Project Proposal Submission System (DPPSS KSCSTE) to accelerate seamless Research Project Proposal Submission. The Council has developed probiotic consortium for bio floc and fish farming and facilitated entrepreneurial ventures by women in *Wayanad* in mask making, bamboo straw & paper plate and biofertilizer production units.

- **Punjab State Council for Science & Technology (PSCST)**

PSCST demonstrated first-of-its-kind paddy straw based briquetting unit of capacity 24 TPD at Village Jalalabad East, District Moga in collaboration with Private Partner M/s Gill Brother. After successful demonstration of its first plant, within one year PSCST established second briquetting unit of capacity 100 TPD at Village Kulburchan, District Patiala in collaboration with Private Partner M/s Punjab Renewable Energy Systems Private Limited. These briquettes are being used as replacement of fossil fuel in Industry.

It also created a R&D platform in collaboration with The Energy and Resources Institute (TERI) and International Advanced Research Centre for Powder Metallurgy & New Materials (ARCI) for improving the performance of the paddy straw briquetting machinery through advanced coatings on machine components. This platform would be available to all organizations for carrying out applied research on ex-situ paddy straw management.

PSCST initiated setting up of 4 STI led SC Clusters at Ludhiana, Moga, Jalandhar and Bathinda involving 8 knowledge institutions, 10 SC dominated villages have been

adopted to identify specific needs of SC community pertaining to livelihoods, health and nutrition.

PSCST has initiated developing framework for mapping and augmenting STI ecosystem in Punjab in collaboration with Centre for Technology, Innovation and Economic Research and C-DAC. A State STI Observatory (a digital platform) is also being developed to provide holistic data on key STI indicators.

Patent Facilitation Programme (PFP)

Patent Facilitation Programme of DST is being implemented through Patent Facilitation Centre (PFC) established at TIFAC and Patent Information Centers (PICs) established at State S&T Councils. The objectives of the program is to create IPR awareness and technical understanding of patents in the country, facilitating patent filing, obtaining and maintaining patents, providing patent information as an input to R&D and handling IPR policy matters.

PFC filed 10 new patent applications, one copyright and one trademark applications after due assessment of patentability of about 34 new requests. Twelve Indian patents and one European Patent were granted as given in Table-I.

Table-I: List of Patents Facilitated by PFC and Granted in 2021-22

S. No	Patent No.	Date of Grant	Applicant	Title
1.	365565	28-04-2021	Tezpur University, Tezpur, Assam	Nanocatalyst for bio oil production
2.	366731	15/05/2021	Tezpur University, Tezpur, Assam	A process for manufacture of turmeric powder from raw turmeric rhizomes
3.	370356	25-06-2021	Indian Institute of Technology Bhubaneswar	A processing condition monitoring system and/or method for motor operated utility products such as food processors and the like.
4.	370710	30-06-2021	Indian Association for the Cultivation of Science, Kolkata	Peptidomimetic ligands regulate BCL-2 expression by stabilizing DNA secondary structures
5.	370787	30-06-2021	Tezpur University, Assam	Mesoporous secondary nanostructures as multifunctional heavy metal scavenger

S. No	Patent No.	Date of Grant	Applicant	Title
6.	371059	02-07-2021	Panjab University, Chandigarh	Sophorolipid based nanostructured lipid carriers targeted for drug delivery purposes
7.	371088	05-07-2021	College of Engineering, Perumon	RFID based smart library system
8.	372999	28-07-2021	Indian Institute of Technology, Kharagpur	A system for non-contact measurement and analysis of surface profile of a sample/3-D object
9.	377984	27-09-2021	Panjab University	Cocrystals of Naringenin
10.	378489	01-10-2021	Malaviya National Institute of Technology, Jaipur	A mobile equipment for a user
11	381620	11/11/2021	Management of fungal deterioration of stored medicinal plant products	Forest research institute
12.	382675	25/11/2021	Novel 5-[4-(2-Biphenyl-4-Yl-2-Oxoethoxy)-Benzylidene]-Thiazolidine-2,4-Diones, Their Synthesis And Uses Thereof	1.Guru Ghasidas Vishwavidyalaya (A Central University) 2.Indian Council of Medical Research (ICM
European Patent Granted				
1.	3294125	12-08-2021	Indian Institute of Science, Bangalore	Device and method for detecting creatinine and albumin to creatinine ratio

PFC organized one-week Advanced Training for Patent Search through online mode from September 20 to September 24, 2021. Thirty participants from across the country attended the Workshop.

Geographical Indicators (GI) tag for *Chamba Chappal* and Lahaul's knitted socks and gloves were granted from Himachal Pradesh.

PIC at Goa State Council for Science & Technology (GSCST) filed GI tag for Goan Bebinca and AgasacheVaiygenm in 2021.

Two patents were granted, 01 industrial design, 5 trade mark and 1 copy right got registered through the technical support of PIC at HSCST.

PIC at KSCSTE facilitated filing of 6 Patents, 2 Copyrights, 2 Trademarks, 2 Industrial Designs and 3 Patents were granted during this period.

PIC at PSCST was awarded with IP recognition Award for proving impeccable IP services to innovators during COVID. A special 'IP literacy Drive' for Punjab was launched for building capacities of different innovation partners. A team from USPTO including Intellectual Property Counsellor for South Asia was facilitated to Phulkari Artisans Cluster adopted by PSCST and a Special Open Knowledge Session on IPR was organized at IISER, Mohali for researchers and startups at Institute.



GI registered by HIMCOSTE
for *Chamba Chappal*



GI registered by HIMCOSTE for *Lahaul's knitted socks and gloves*



1.3 Policy Research Programme

Policy Research Programme (PRP) under Policy, Coordination and Programme Management (PCPM) division in Department of Science and Technology (DST) is mainly focused to promote STI policy research in the country and gather evidence-based input for future policy making in STI related areas. Under the programme, Centres for Policy Research (CPRs) in national academic institutes have been established across the country with the objective of strengthening the Policy Research Mechanism for generating evidence-base for policy planning. Similarly, a policy fellowship programme (PFP) is being supported with the aim to generate a pool of critical mass of the policy researchers in the country.

During the current year, three CPRs have been supported under the programme: 1) Indian Institute of Technology Delhi, 2) Punjab University and 3) Indian Institute of Science, Bangalore. Additionally, the fifth cohort of DST-STI policy fellows have been recruited under the DST STI Fellowship programme.

1.3.1 Centres for Policy Research (CPR)

DST-CPR at IIT Delhi:

It was established in the FY 2013-2014 and has been contributing on policy research in different S&T sectors. In the FY 2020-21, the CPR is engaged in assessing the current landscape and status of the Indian innovation system (IIS) and devising policies and approaches to improve its performance. The centre has been contributing to devise the policies to leverage innovation to meet sustainability and inclusivity challenges, especially by enhancing access

to basic needs and services and promoting environmental integrity and safety. The centre has also tried to exploit opportunities for leveraging science, technology and innovation to promote economic and human development in the country. The centre has also contributed to devise the Policy Fellowship programme of DST. The centre has completed a study on incubators that could be useful in developing policies to enhance incubator effectiveness. Similarly, other studies have also been carried out that also may add value to policy-makers in different domains. It may further help in national/state level policy formulations in respective domains.

Additionally, the centre has been engaged in training the number of scholars at three levels; project scientists, DST-STI postdoctoral fellow and DST-STI senior postdoctoral fellow and it has published several articles and reports as well. The centre has developed some national and international collaboration with the Office of the Principal Scientific Advisor, NITI Aayog, the World Bank, the Science Technology and Public Policy Program at Harvard University.

DST-CPR at Punjab University, Chandigarh:

It was established in the FY 2013-2014 and has been contributing in the policy research in different S&T sectors. In the FY 2020-21, the CPR has contributed towards three main objectives including development of a new country specific model for promotion of Public Private Partnership (PPP) for R&D; identifying the areas of policy gaps for stimulation of private sector investment in R&D and suggest changes in policy environment; and adopting evidence-based approaches for identifying and promoting areas for generation of intellectual properties.

Development of a new country specific model for promotion of Public Private Partnership (PPP) for R&D: Industry-Academia (I-A) collaborations and public-private partnerships (PPPs) have become a subject of great interest as for innovations to be practical and applied in nature, strong research collaboration between industry and academia is imperative. The CPR conducted a study to collate information on Industry-Academia and Public Private Partnership Programmes undertaken by the Public sector including Ministries and their associated departments and the private sector. The Centre has initiated the development of a dedicated portal to encompass all the information regarding PPP for STI of various ministries under one roof.

Studies on higher education institutes (HEIs) demonstrated that out of nearly 900 institutions in the country, only a handful of academic institutes e.g. IITs, ICT-Mumbai and IISc-Bangalore are known for generation of patents and technologies. These institutes are also in the forefront of engaging the industrial sector in its R&D programmes and possess almost all determinants of good I-A interface. Detailed case study on 'BIRAC, Govt as a Successful Model of PPP for R&D in India' has also been undertaken. The BIRAC model can be an exemplary model for laying PPP for STI.

The CPR has brought out a Suggestive Roadmap for Strengthening R&D Ecosystem through PPP, especially for developing countries based on the best practices followed world over was developed.

Identify are as of policy gaps for stimulation of private sector investment in R&D and suggest changes in policy environment: India's aspiration to enhance its Gross Expenditure on R&D from current 0.7% to atleast 2% requires morethan 50% of private sector contribution to the national R&D ecosystem from current nearly 36% levels (NSTMIS, 2019). To address the above-mentionedissues, a study was under taken to analyse the R&D incentivization mechanism followed globally. It is widely acknowledged that the government mediated R&D stimulation of the private sector play sakey role instimulating the private sector to contribute to the national R&D ecosystem. A comparative analysis of R&D incentivization revealed that innovation backed countries like US, China, S. Korea and Japan have developed systematic R&Dtax incentives schemes for the private sector as per the size and scale of the industry. In addition, the direct financial support to industry from the government is widely explored in innovation-based countries whereas in India only a limited amount of direct financial support is given to industry. Hence, the direct financial support schemes on lines of financial assistance schemes as implemented in US, UK, China, S. Korea and Japan should be widely explored to develop a co-funding mechanism for S&T projects.

Another study was carried out to study the incentivization pattern of pharmaceutical industries in India. It was observed that DSIR recognition is mandatory for industry in India to avail the R&D fiscal benefits. However, there are only a limited number of industries which are recognized by DSIR, hence widespread awareness of government recognition of industrial R&D has to be carried out. In addition to that,regulatory norms associated with provision related to R&D tax incentivization and patent box regime should be streamlined for attracting the private sector to the national R&D ecosystem.

Adopt evidence-based approaches for identifying and promoting areas for generation of intellectual properties:

To have a deeper insight, research publications and patents granted profile of 904 institutions of India comprising top HEIs and national R&D labs were analysed. A questionnaire-based survey on top excelling institutions and universities was also carried out to study IP ecosystem in those institutions excelling in research publication but lacking in IP generation and to study the reasons hampering it. Based on the survey it is found that, maximum institutions, despite doing good research,are hesitant to file patents due to lack of knowledge, resources and guiding support from the respective institutes. Considering this, the centre has drafted a book covering every aspect related to IPs fromfiling to its grant, fee payable, concerned organizations, rights, exceptions, jurisdictions,Acts & Rules, and processes to register IP, infringements, etc. The main mandate of the book is to educate researchers/students about IP to enhance the translational research ecosystem in the academic sector. The book is in press and will be released shortly.

In continuation, the centre further conducted a study on commercialization of patents granted to them by scrutinizing 'Form-27' submitted by the patentees at Indian patent office. As per the evidence-based studies conducted by the centre, there is a lack of awareness on IP issues and because the process of seeking the protection of IPs is time consuming and costly affair, the inventors opt for publishing their research in public domain instead of securing legal rights over it.

Significant Research Achievements: DST-CPR at PU, Chandigarh, played a crucial role in providing evidence-based recommendations that were implemented on a national level and some of the recommendations are also addressed in the Science, Technology and Innovation Policy Draft. These evidence-based recommendations along with explicit data on evidence was submitted to DST and published in form *3 books, 6 publications and 15 reports*. The major evidences provided for following recommendations were taken forward at national level;

- Since 2014, the Centre has been reiterating the need to broaden the scope of CSR funds for R&D activities. MOCI has recently declared R&D investments by the private sector as an activity under CSR funds.
- Based on the studies on American and European PPP Models, the Centre had suggested positioning of 'Moderators' between Industry and Academia, which has now taken form as Technology Enabling Centers, a DST initiative to act as a facilitator for commercialization of technologies arising from universities.
- In order to strengthen the region-specific development in S&T in the country, the Centre had advocated the formation of Knowledge Clusters on the lines of Chandigarh Region Innovation and Knowledge Cluster (CRIKC). The Office of PSA (O/PSA) has recently initiated the creation of 'City Clusters'. Prior to this the PSA, GoI and Scientific Secretary in the Office of the PS visited CRIKC Headquarter to understand the CRIKC model.
- Reviving the weighted Tax deduction scheme for DSIR recognized industries performing R&D; addressed in STIP Draft. A detailed report on 'Stimulation of Private Sector R&D in India...a Global Comparison', was submitted.

The recommendations on streamlining the patent filing process, promoting patents commercialization and sensitizing young minds about IP issues has been included in the STIP draft.

Additionally, the centre has published the articles/reports, conducted several virtual webinars, developed few collaborations and trained the personals towards the capacity building. The centre has developed the comprehensive 'Public Private Partnership in Research & Development' Web Portal, which can be accessed via <https://ppprnd.puchd.ac.in>.

DST-CPR at Indian Institute of Science, Bangalore:

It was established in the FY 2014-2015 and has been contributing in the policy research in different S&T sectors. In the FY 2020-21, the CPR was pursuing the research on the four different themes as given below;

Research, Innovation and Entrepreneurship:

Entrepreneurship: Innovation and entrepreneurship are widely recognized as the engines of economic growth and development. It is important to analyze the major drivers, barriers, opportunities, and challenges to entrepreneurship in the country. Thus, under the mandate, the Centre is focused on analyzing policies and programs for promoting science and technology driven entrepreneurship, institutional practices conducive to the process of exploitation of entrepreneurial opportunities, knowledges pillovers, and R&D funding. **Biofuel policy:** Bioenergy plays a crucial role in the renewable energy transition in India. The Centre's research on biofuel policy has studied (a) the vulner ability and politics behind the transition, and (b) different efforts by the government to move the country towards a bioeconomy, more specifically the efforts to develop lignocellulose-based bioethanol and biogas, commonly known as second generation (2G) biofuels. **Rare Diseases Research Ecosystem:** Science policy interventions play a central role in the advancement of research in rare diseases. The Centre's work on rare disease research ecosystem is focused on (a) studying the impact of public policy and public health interventions on the quality-of-life outcomes of persons with rare diseases, (b) stakeholder-mapping and analysis of public policies for promoting rare disease research in India, and (c) implications of open data practices for rare disease research and treatment.

Open Science

Open science is an umbrella term referring to verticals like open access, open research data, open research protocols, sharing of research infrastructure, and citizen science. In continuation of the Centre's research on studying the knowledge dissemination component, especially the ongoing transition in scholarly communication practices, this work focuses on critically examining strategies and policy choices for open access publishing and open science practices in India.

STID Diplomacy

Science, Technology, and Innovation (STI) Diplomacy is being increasingly used by countries a round the world as an important instrument in foreign policy and diplomacy activities. The Centre's research on STI diplomacy is focused on (a) studying the role of STI, particularly in emerging technologies, in India's foreign policy agenda, and (b) examining relationships between India's STI capabilities and foreign policy goals, and (c) developing policy options for India's efforts in STI diplomacy.

Higher Education

Higher education institutions play a central role in developing the human, social, and knowledge capital of the STI ecosystems. The Centre's work on higher education is focused on: (a) Scientometric studies of publications from Indian institutions with a view to elucidate their research productivity and strengths in different fields of science and technology, and (b) a study on doctoral education in India whose aim is to assess the level and quality of training received by doctoral students to prepare them for both academic and non-academic careers.

Significant achievements of the centre can be summarized as follows;

- A key achievement is the compilation of the open access, open science/ open research data policies of various countries (global north and global south), and organizations and analysis of those policies with an objective to understand the possible strategy and policy choices for India.
- Analysis of innovation diplomacy strategies was performed and various recommendations to strengthen Indian STI diplomacy strategy have been proposed in a paper published in the journal *Science Diplomacy Review*.
- A framework to promote citizen science in India was proposed with various recommendations to engage with different stakeholders including researchers, science academies, science administrators, higher education institutes and general public. It also highlighted various challenges and opportunities of doing citizen science in the country.
- Analysis of various facets of data sharing and concept of open data for rare diseases from Indian perspective. Some of the key challenges and suggestions to mitigate these have been identified. Further, a survey that would inform background, interest, and awareness level of some of the actors in RD ecosystem have been carried out which will help to design a preliminary sketch of RD stakeholder groups in the country.
- Developing a methodology for assessing entrepreneurship ecosystems and to devising new metrics of entrepreneurship in developing countries in collaboration with the World Bank. The methodology provides a general framework for an entrepreneurship ecosystem assessment combining indicators of performance and inputs, conducts analysis of policy instruments, and the functionality of the ecosystem.

Additionally, the centre has published the articles/reports, conducted week seminars, symposium series & workshop, participated in the discussion on the draft of 5th national STI policy, developed few collaborations and trained the personals towards the capacity building. The centre has the WebPortal, which can be accessed via www.dstcpriisc.org.

1.3.2 STI Policy Fellowship Programme

Apart from the CPR activities, a DST-STI policy fellowship programme has been supported since 2016. The fellowship is supported in three categories: Senior Policy Fellows, Post-doctoral fellows and young policy professionals. These policy fellows are being assigned with a defined research topic in the area of STI policy domain. During the year, fellowships were supported to the third and fourth cohorts of the fellows. Application were invited during the year for the fifth cohort of the Policy fellowship and through due process of evaluations 12 fellows have joined the fellowship.

1.3.3 Formulation of the 5th National STI Policy

For India to achieve “Atmanirbhar Bharat” and holistic developments, several challenges and gaps need to address in different S & T sectors. It demands the new/modified national STI policy to meet the future aspirations at global platform. In this regard, formulation of a new, 5th national STI policy was initiated during the early of 2020. The draft of the policy was kept for public consultations inviting comments/suggestions/feedbacks from the general public. Several modes of outreach programmes were conducted to have the participation of citizens across all strata of the society and all corners of the country. Several high-level consultations have been conducting at various levels to invite suggestions/inputs on the first draft of the document and all the suggestions/feedbacks have been incorporated into the draft policy. The draft policy document was processed through several iterations of revision to finalize the draft policy document. As part of the policy formulation, more than 400 consultation meetings with participation of more than 40,000 individuals. More than one lakh ideas/suggestions have been received from different age groups. All these ideas/suggestions have been thoroughly analysed and were suitably incorporated into the final draft of the policy.

1.3.4 Centre-State Coordination on STI areas

One of the goals in the new draft policy is to strengthen Centre-State coordination and collaboration mechanism in building a strong STI ecosystem and promoting innovation and entrepreneurship. As a first step in this direction, DST through its team of Policy Research Fellows has undertaken an exercise of preparing a detailed STI mapping to capture the STI ecosystem of each State and Union Territory in terms of research, higher education, innovation, incubators, start-ups, community-based organizations, industry, business opportunities, socio-economic parameters, policy initiatives, etc. Also, an attempt has been made to identify some major problems, challenges, gaps areas, faced by the States including key weaknesses in the ecosystem. This is being carried out through collecting and collating publicly available information and more so through one on one interaction with nodal officers of several States and UTs. This exercise is currently ongoing and is expected to provide a glimpse of broad landscape of the STI ecosystem prevailing across the Indian state & UTs.

1.4 National Science and Technology Management Information System (NSTMIS)

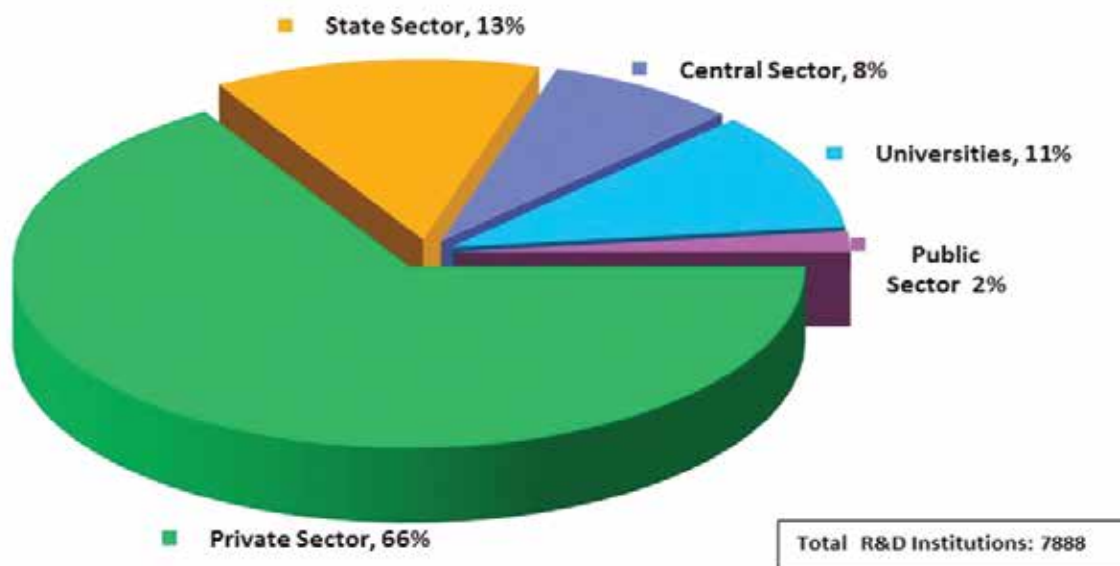
National Science & Technology Management Information System (NSTMIS) has been entrusted with the task of building the information base on resources devoted to scientific and technological activities for policy planning in the country. The programme continued its efforts of generating and making available information on human as well as financial resources devoted to scientific and technological (S&T) activities by conducting national surveys conducted both through in-house as well as sponsored studies. As a result, a large number of structured information resources are being published by the Division in the form of reports, directories, statistical data, and other forms of documents. These publications are acclaimed both nationally and internationally and are widely referred to by scientists, funding agencies, planners, policy makers, scholars and academicians.

1.4.1 S&T Resource Studies

The S&T Survey 2021-22 on resources devoted to research and development activities launched (both in print and e-mode) and data collection is in progress. A response rate of more than 30% 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 as received and e-reminders to enhance the response rate is in progress. Based on the outcome of the survey, the next issue of national publication “**Research and Development Statistics**” is likely to be published next year which would serve as an evidence base for the policy formulation in the S&T sector.

The division brought out a spin-off publication of the National S&T Survey entitled ‘**Directory of R&D Institutions 2021**’. The present directory is twelfth in the series containing list of around 7888 R&D institutions with complete addresses arranged alphabetically by S&T sectors. Details on various communication modes such as phone, email, web site addresses have also been provided, wherever possible. The Directory is widely used by professional engaged in policy making, planning science, administration, industry, teaching and research apart from other stakeholders in the S&T sector.

DISTRIBUTION OF R&D INSTITUTIONS IN INDIA - 2021

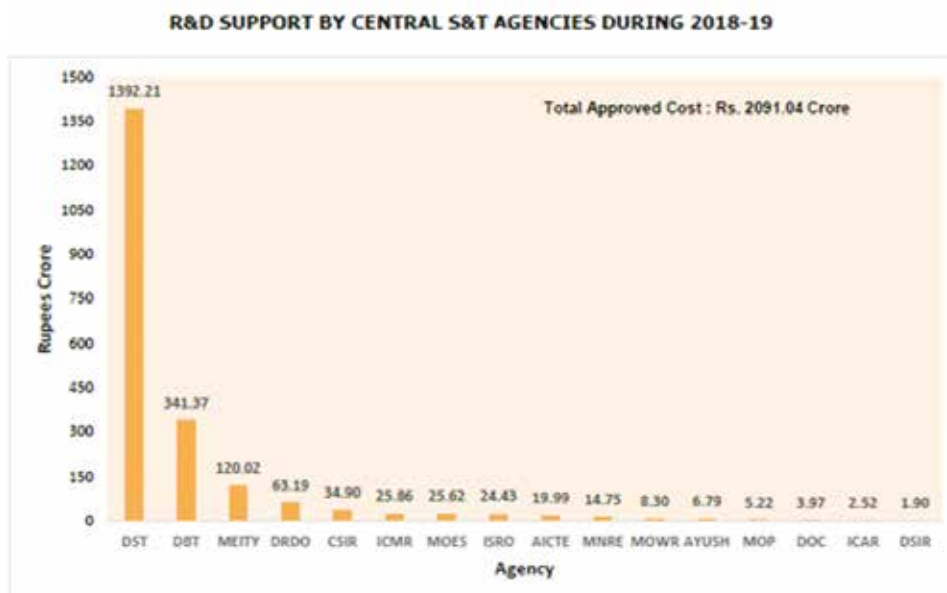


Source: NSTMIS, Department of Science & Technology, Government of India.

A survey entitled ‘**India Innovation and Systems Survey 2019**’ in collaboration with **UNIDO, Austria is in progress**. The survey attempts to understand the 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. Six meetings of the Technical Advisory Committee (TAC) were held pertaining to selection of sectors/ industries for the system of innovation surveys and the dimensions of the firm level innovation survey, finalization of questionnaires, population of the survey, sampling frame and size, data collection approach and flash survey approaches to validate the survey questionnaire.

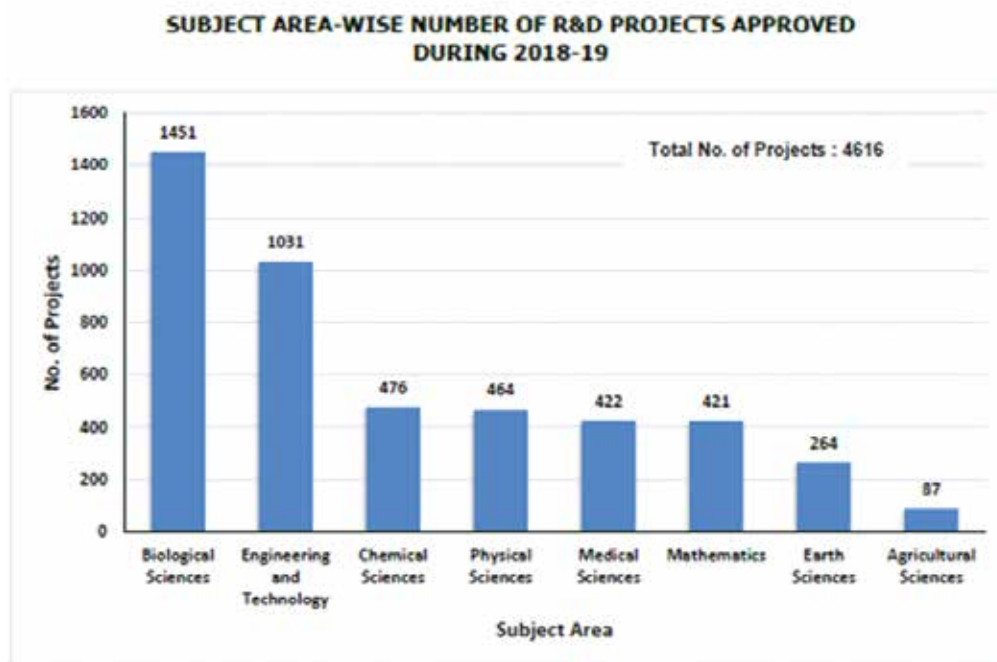
1.4.2 Information System/Database Activities

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** were published together. In addition, the report entitled “**Analysis of Outcome of Extramural R&D (EMR) Projects 2010-15**”, fourth in the series is being published. A snapshot of the Extramural R&D Projects Directory, 2018-19 is depicted below:



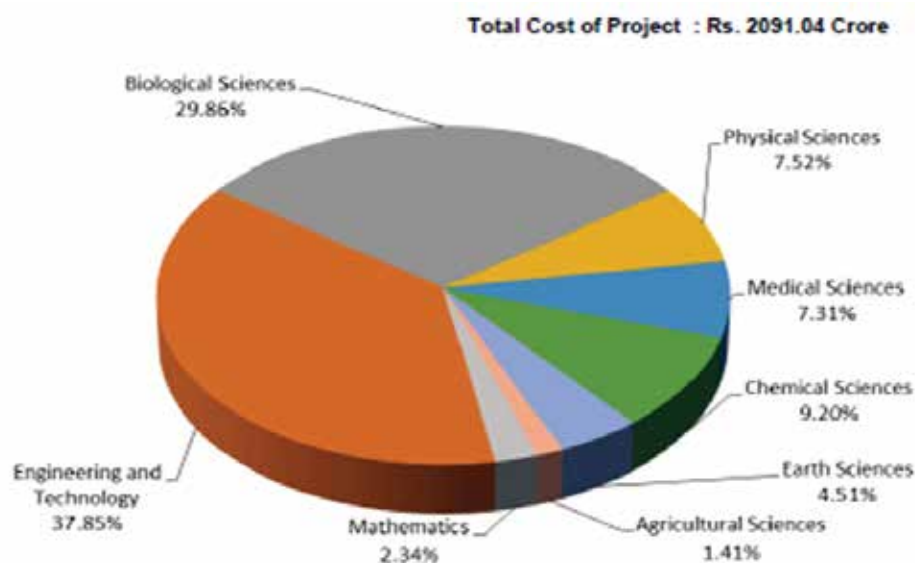
Source: NSTMIS, Department of Science & Technology, Government of India.

DST accounted for the maximum Extramural Research (EMR) support of Rs. 1392.21 Crore (67%) followed by the Department of Biotechnology (DBT) with Rs. 341.37 Crore (16%). The two Departments together contributed to 83% of the total extramural R&D funding in India.

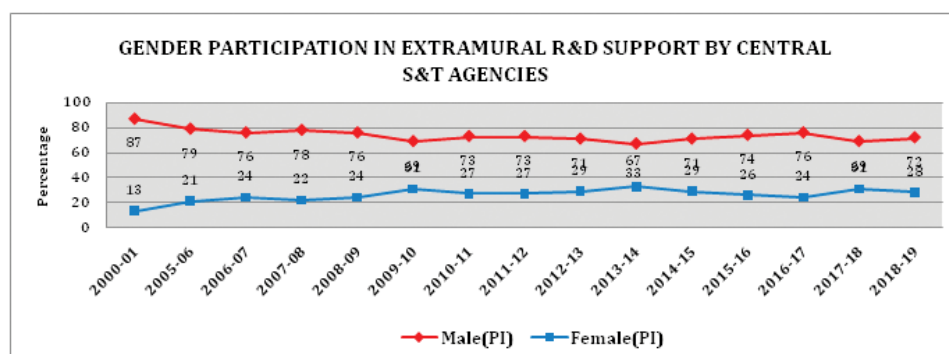


Source: NSTMIS, Department of Science & Technology, Government of India.

SUBJECT AREA-WISE R&D SUPPORT DURING 2018-19:



Source: NSTMIS, Department of Science & Technology, Government of India.



1.4.3 Index Monitoring Cell (IMC)

Division has been assigned the responsibility of IMC, DST to provide inputs on latest S&T Indicators - for the global indices such as “Monitoring of Network Readiness Index” and “Global Competitiveness Index” being coordinated by Cabinet Secretariat, NITI Aayog, Department of Telecommunication, etc.

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 during the year to review the outcome/progress of 18 projects. Further, meeting of Expert Committee on Bibliometrics (ECB) was held to review the outcome of 13 completed projects and progress of 4 ongoing projects in the area of bibliometrics. At present, there are more than 75 on-going projects in the scheme. List of select projects completed during the year were:

- Data mining and analysis of Indian origin academicians in foreign universities for exploring opportunities of academic interaction - Updation/maintenance and extension exercise for BRICS countries
- Publication of Directory of Scientific Instruments & Components
- Role of tax incentives in promoting R&D in the country
- Agricultural research and development infrastructure in select Indian states
- Assessment of Govt. of India's Gender Mainstreaming Programs for Women in Science
- Inventorization of Agriculturally important microorganisms for catalyzing agri-preneurship
- Impact Analysis and benefits by researchers and innovators in engineering studies: India
- Analysis of costs and strategies for using academic research to develop a commercially viable product- A case study in privately owned dental college
- Higher education financial to tribal students: Impact assessment
- Impact of industrial collaborations in inducing the culture of scientific research among engineering students
- Impact of industry collaboration on innovation, Entrepreneurship and higher learning outcomes: A study with reference to technical Institute in Karnataka

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 of Scientists and Technologists Working in Government Sector

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, 2020-21 & 2021-22 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 organizations 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.” Till 2019-20 the training programs were run in physical/residential mode. Owing to the COVID-19 pandemic, online training programmes were approved under this scheme during 2020-21. About 1390 scientists are likely to benefit from these training programmes in 2021-2022.

Twelve online training programmes were approved exclusively for women scientists during 2021-22 under Women component of the Programme, in which approximately 300 women scientists are likely to be benefitted in 2021-22.

A portal for online registration of applicants under the programme and further processing of their nominations has been devised and implemented during 2021-2022.

1.6 Women in Science and Engineering-KIRAN (WISE-KIRAN)

The Department of Science and Technology has renamed KIRAN (Knowledge Involvement in Research Advancement through Nurturing) Scheme as Women in Science and Engineering-KIRAN (WISE-KIRAN) Scheme this year in order to acknowledge the efforts of Government for empowerment of Women Scientists. With inclusion of new programmes, WISE-KIRAN Scheme has come up in more strong way to bring gender parity in Science & Technology domain through various mechanisms. Various programmes of WISE-KIRAN scheme address various challenges faced by women scientists in STEM education, research and career. The

achievements of various programs under KIRAN during the year 2021-22 are as follows:

HUMAN RESOURCE DEVELOPMENT

Women Scientists Scheme: Women Scientists Scheme is providing different kinds of opportunities in S&T fields through its three components viz. WOS-A, WOS-B & WOS-C.

Women Scientists Scheme-A (WOS-A): WOS-A provides opportunity to women scientists who had break in their career for research in 5 subject areas (Physical & Mathematical Sciences [PM], Chemical Sciences [CS], Life Sciences [LS], Earth & Atmospheric Sciences [EA] and Engineering & Technology [ET]) of basic and applied sciences. This year around 1551 proposals (179 in PM, 255 in CS, 833 in LS, 106 in EA, 178 in ET) have been received under WOS-A programme. Around 47 projects have been recommended by the Subject Expert Committees in Life Sciences (28 projects) and Engineering & Technology (19 projects). The Expert Committee Meetings of other subject areas are being conducted. The grant has been released in around 440+160 ongoing projects. The process for sanctioning of new projects has also been started. Women Scientists have published more than 550 Research Papers in SCI Journals through their WOS-A projects.

Women Scientists Scheme-B (WOS-B): WOS-B programme encourages women scientists to analyse the challenges in the society and provide S&T solutions to overcome these issues. They are also expected to train marginalized section of society for better livelihood generation. This year the division has extended the financial support to 99 projects with location specific interventions addressing issues in rural/urban areas in four thematic areas: Agriculture, Food and Environmental Challenges (AFEC), Health Care and Nutrition (HCN), Energy and Water & Waste Management (ER&WWM) and Engineering & IT Solutions and Artificial Intelligence (EIT&AI). These projects are focussing on challenges related to climate change, Forest ecosystem, Air Pollution, Crop improvement, Soil conservation, Livelihood generation/enhancement of Farmers, Women agripreneurship creation, waste to wealth, livelihood enhancement for tribal farmers of lower belt of UT Ladakh, Biofuel production technology, Disposal of Biomedical waste, retinal vascular calibre and associated changes in cardiovascular diseases, Autism, AI on Weed eradication, ML-Agricultural productivity, and Renewable Energy etc. Further, release has been made in 46 ongoing projects under WOS-B.

Outcome of WOS-B Projects:

A project supported under WOS-B is focusing to enhance the climate change adaptive capacity and agriculture productivity in ParambikulamAliyar (PAP) basin area which is drought prone area through ICTs and other technological interventions to monitor crop production during khariff and rabi seasons. PI has developed website (<http://weatheroutlookanamalai.com/about>) to provide daily weather information and agromet advisory for the registered groundnut and maize farmers.

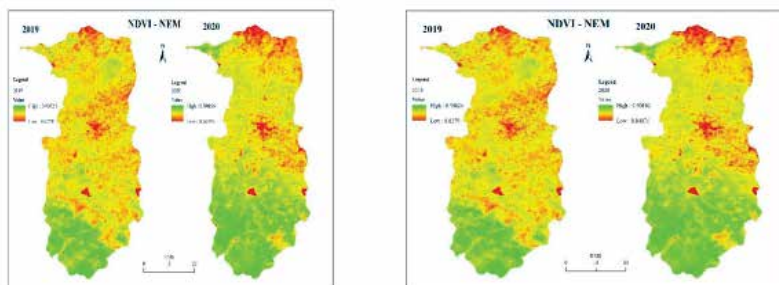


Fig 1: MODIS composite NDVI images during kharif season

Another project is aimed to develop a modified flat silk sheet through natural spinning technique on plane wooden and Formica sheets with different shapes without killing the silkworm. Innovative products by using this technology can be used for various other high value textile and nontextile application. The waste materials like silkworm pupa and feces are additional sources of revenue generation. The PI has conducted training programmes for dissemination of new technology among 300 sericulture farmers in Kolar, Chikkaballapur area Bangarapet. It is estimated that this technology would be able to increase revenue by 30 ~ 40 times of sericulture farmers.



Fig 2: Training workshop on new technology for sericulture farmers

One of the woman scientist is working on a project of converting trash into treasure by transformation of waste into high performance electrodes for charge storage devices towards zero-emission transportation. She has developed electrode material from waste material and also done hybrid capacitor fabrication.

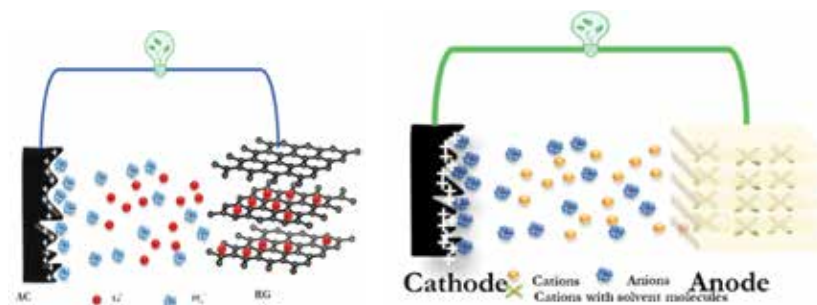


Fig 3: Schematic representation: AC//pre-lithiated RG LIC and AC//pre-sodiated RG NIC

Diarrhoea is one of the leading causes of death in children of Rajasthan state. WOS B supported a study to gather knowledge, attitudes and practices with regard to current/existing water handling, sanitation and defecation practices in rural schools of Rajasthan. Women Scientist through this project attempted to analyse WaSH (Water, Sanitation and Hygiene) indices at school level as a proxy for village level monitoring and goes on to create a GIS assisted planning tool for regional planning efforts.



Fig 4: Visits to 33 vulnerable school of Phagi tehsil for assessment of current of WaSH indicators

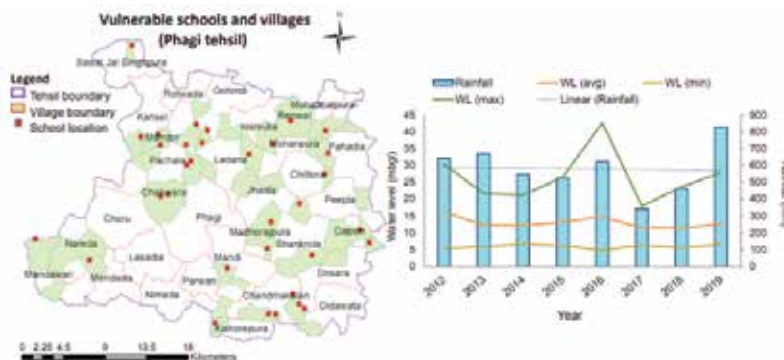


Fig 5: Location map by PI on vulnerable schools and temporal variations (2012-2019) in rainfall and groundwater level of Phagi tehsil

A Project intends to develop a non-invasive electrochemical glucose biosensor device based on Reverse Iontophoresis (RI) technology that enables extraction of glucose directly from the transdermal interstitial fluid to the skin surface. The needle free diabetes monitoring device based on this electrode would be widely useful for diabetic patients, In-home caregivers, in primary health care centres in rural areas etc.

Women Scientists Scheme-C (WOS-C): The program provides opportunity to women with mid-career break and having qualifications in S&T to pursue their career in Intellectual Property Rights (IPR). It prepares them towards self-employment by providing on-the-job training in the area of IPR. An All-India advertisement for inviting online applications for 12th Batch was brought out in July 2021. 3831 applications were received in response to this advertisement and 3773 applicants were shortlisted to appear for the exam held at 55 centres in 45 cities on September 18, 2021.

Finally, 120 women have been selected after interviews and induction programme of 12th batch. Hon'ble Minister of Science & Technology has inaugurated the one-month orientation programme for 12th batch on 21st December, 2021 and distributed certificates to women scientists successfully pass out from 11th batch. 60% women scientists are placed in different organizations related with IP management.



Fig. 6. Inauguration of Orientation Programme and Certificate Distribution by Hon'ble Minister of S&T under WOS-C.

Indo-US Fellowship for Women in STEMM (WISTEMM):

The WISTEMM program has been extremely successful in providing opportunities to outstanding Indian women researchers, scientists and engineers in their early or mid-career stages for international collaborative research opportunities in premier institutions of USA to enhance their research capacities and capabilities.

The research collaborations seeded through the WISTEMM program have resulted in 16 publications in top scientific journals, presentations at national and international conference, and post-doctoral opportunities. Some of these collaborations have led to institutional partnerships and development of 18 joint research proposals. Further, 6 WISTEMM interns got opportunity for PDF in US. These opportunities have been life-changing, empowering

young women to pursue research careers in STEM and giving them the confidence to take on leadership positions in their institutions.

Vigyan Jyoti:

The Department of Science & Technology introduced Vigyan Jyoti Programme with a view to address under representation of women in Science Technology Engineering and Mathematics (STEM) fields. During 2021, the programme is extended to 100 districts (including 13 aspirational districts) of 33 states/UTs of the country. Out of 100 districts 11 districts have predominantly tribal population. 100 Jawahar Navodaya Vidyalayas are acting as Vigyan Jyoti Knowledge Centres. Vigyan Jyoti is providing various interventions to 10000 meritorious girls of Class IX-XII from JNVs, KVs, Army and other Government Schools in Phase-II. All the JNVs are associated with relevant Knowledge Partners such as IIT, NITs, IISERs, National R&D labs, Central/State Universities, etc. to get required scientific resources and assistance. Year-round activities such as Student Parent Counselling, Interaction with role models, ATL workshops, Science Camps, Lectures/Special Classes, Visit to Knowledge Partner (KP)/ Labs/Industries etc. are part and parcel of the programme.



Fig. 7. Visit to various Knowledge Partners organized during 2021

Achievements: Despite pandemic and lockdown situation, during the year 2021, around 492 online special classes/lectures were conducted covering basic and complex concepts of Physics, Chemistry, Mathematics and Biology which are important to qualify entrance examinations. More than 114 lectures, from eminent scientists/role models were also organized. Further, one science camp, 10 visits to KPs/Industry/Lab, two ATL workshops and 100 student parent counselling sessions were organized. To give further aid to the selected students, resource material relevant for competitive examinations, C-STEM kits, Science project e-booklet have been distributed to the students.



Fig. 8. Distribution of Resource Material to students under Vigyan Jyoti

Special Interventions during 2021:

- **MoU with IBM India:** IBM India has extended its MoU with NVS to continue various activities under Vigyan Jyoti in 2021.
- **Online Portal:** A dedicated portal (vigyanjyoti.dst.gov.in) has been developed for Vigyan Jyoti Programme by IBM India. This portal not only showcasing various activities under Vigyan Jyoti but also has provision of Learning Management System (LMS) for students.
- **Science Utsav for Class IX-X girls:** This year around 5000 girls of Class IX-X have been associated with Vigyan Jyoti Programme. A virtual Science Camp 'Science Utsav' was organized in July 2021 for dedicated syllabus based virtual activities for Class X students.
- **Curriculum based STEM Workshops:** Curriculum-based STEM workshops (C-STEM) is also a new inclusion of academic activity for Class IX-X students with an aim to empower girl students to become design thinkers & problem solvers. 20 Sessions of C-STEM have been conducted during 2021.



Fig. 9. Curriculum-based STEM (C-STEM) Workshops

- **Career Counselling Sessions:** Career counselling sessions have been organized for class XII girls to help them in exploring career choice in different streams through recognized agencies.
- **Vigyan Jyoti at Social Media:** Twitter handle of Vigyan Jyoti programme @JyotiVigyan has been created to showcase day to day activities conducted for the girl students.

S & T INFRASTRUCTURE DEVELOPMENT

CURIE (Consolidation of University Research for Innovation & Excellence in Women Universities)

Nine (9) Women Universities in the country have been supported Under “CURIE” (Consolidation of University Research for Innovation and Excellence in Women Universities) for improving R&D infrastructure and establishing State-of-the art laboratories in order to create excellence in S&T domain. In view of limited number of women universities and large number women PG Colleges, Division has decided to expand the scope of CURIE programme to PG Colleges.

New Component under CURIE: WISE-KIRAN Division started a new component under CURIE to support 'Women PG Colleges' in 2021 with aim to enhance its outreach to the masses and nurture more women organizations for benefit of large number of girls in STEM. A call for proposal has been announced which is active till 10 January 2022. It is expected that this expansion of CURIE programme will be beneficial for girls and organizations of small cities as well.

POLICY INTERVENTION FOR GENDER EQUITY

Gender Advancement for Transforming Institutions (GATI):

DST has started a new initiative "Gender Advancement for Transforming Institutions" (GATI) in 2020 to develop a mechanism to assess and accredit institutions on the basis of gender sensitive approach. DST has realized that intervention is required at policy level to promote women in STEMM to improve gender equality. This year 30 premier institutions have been selected as GATI pilot institutions. Out of 30 institutions, 12 are Research Institutes, 7 Academic institutes and 11 Institutes are of national importance. Further, six (6) institutions of UK have also been identified to partner with Indian GATI Pilot institutions and share their experience of Athena SWAN award journey with them. DST facilitated the partnership between Indian Institutions and UK Athena SWAN institutions and accordingly 5 groups were formed.

Division has prepared ten key points-based principles of GATI which has been endorsed by all pilot institutions. The Division has also developed Draft Framework Version 1.0 of GATI pilot. A dedicated web portal (<https://gati.dst.gov.in>) has also been developed for GATI Programme to share the information with all the stakeholders.

Meetings and Workshops organized under GATI pilot: Division has organized 10 meetings cum workshops with Indian Institutions and UK Institutions for orientation, learning, experience sharing, mentoring, etc Apart from peer group meetings, Advance HE, UK has conducted Mutual Learning Workshop with team India, Australia, Ireland and UK to discuss best practices and way forward. DST has also organized two workshops; first on "The GATI Self-Assessment and Accreditation Framework: An Overview" and second on "The GATI Self-Assessment and Accreditation Framework: The First Steps" for pilot institutions. More than 70 scientists have participated in the event.



Fig. 10. Interactive sessions and workshops under GATI.

Ease of Doing Research in COVID-19 Pandemic:

The WISE-KIRAN Division extended its special measures this year as well which have been taken during 2020 in view of COVID-19 pandemic. This year also, Division has prioritized fellowship release as most urgent and relaxed few formal procedures for release of grant in ongoing projects with permission of finance. Division has also renewed Office Memorandum for extension of project duration by one year without any additional cost.

1.7 CSRI & SATYAM

1.7.1 Cognitive Science Research Initiative (CSRI)

Cognitive Science Research Initiative (CSRI) started in 2008-09 is aimed to encourage research in highly interdisciplinary area of cognitive science that trying to address various questions through combining ideas, principles and methods of psychology, computer science, linguistics, philosophy, neuroscience etc. In CSRI, support is available for multi-centric mega projects, individual projects, Post-Doctoral Fellowship (PDF) and to conduct workshops, schools, conferences and seminars, etc.

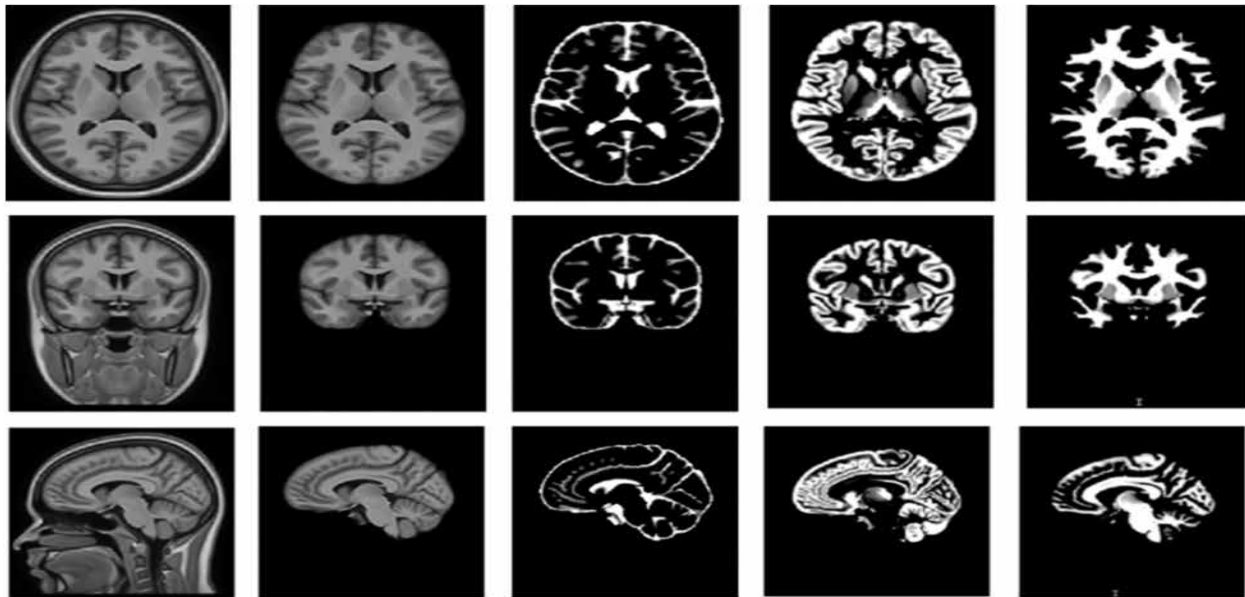
Programme Division has announced a call under CSRI in 2021 to promote individual research, Post-Doctoral Fellowships and to conduct multi centric studies on focussed research areas. Division received 756 individual proposals and 115 PDF Applications. For the first time call for multi-centric proposals has been announced in CSRI in three thematic areas: 1. Educational neuroscience including language literacy and mathematical skills in children and devices and tools for better learning; neurodevelopmental underpinnings of educational neuroscience; 2. Cognitive aging including multimodal assessment of brain function and behaviour, and 3. Objective and hypothesis driven studies on behaviour and social cognition. 125 proposals have been received in Multi-centric research proposal category.

Under CSRI-PDF, 14 Post-Doctoral Fellows have been selected this year. Further, release has been made under 10 ongoing CSRI-PDF projects to conduct research in Cognitive Science. Release has also been made towards 12 new projects and 60 ongoing projects. A Task Force meeting was conducted to review the progress made under ongoing projects. 23 investigators have presented their work in which 5 projects were graded as Very Good, 11 as Good and 7 as Satisfactory. Another Task Force Meeting was conducted to review overall progress of 'National Neuroimaging Facility' which is established by DST under CSRI at Centre for Behavioural and Cognitive Science, University of Allahabad, Prayagraj. This facility is fully functional and open to all the researchers who want to use this setup for research purpose. Total 58 research publications have been contributed through CSRI in this year.

Highlights of CSRI projects:

Development of an Electronic Atlas of the Indian Human Brain

This project is aimed to generate normative information about the human brain and also address the question: whether the brain structure for the Indian population different at a global and local levels, from other populations? A pilot study was conducted at IIIT, Hyderabad with 50 young adults. Findings of the study suggest that the global sizes of the Indian and Caucasian brains are different. This difference was noteworthy for all three global measures, i.e. length, width and height. The Indian brain is comparable in terms of length to that of the Asian population (Chinese and Korean), while it is significantly smaller in terms of height and width. The size difference persists at a structural level (hippocampus and putamen) also between the Indian, Caucasian and Chinese populations.



Indian brain template (IBA50) and the tissue probability maps. Only a sample slice is shown.
Top to bottom: Axial, Coronal and Sagittal slices. Left to right: MRI slice, skull stripped brain, Cerebrospinal Fluid (CSF) probability map, Grey Matter (GM) probability map and White Matter (WM) probability map.

Cultural differences and neural correlates of cognitive insight in schizophrenia

Cognitive insight refers to a person's ability to examine their psychotic experiences and the inferences they draw from these experiences. The present study examined factor structure of Beck's cognitive insight scale (BCIS) in a large sample of patients with schizophrenia (SCZ) and healthy volunteers (HV) from India and assessed the relationship between cortical thickness and cognitive insight in order to establish relationship between cultural factors and cognitive insight and cortical thickness in the Indian population. This study was conducted at NIMHANS, Bangalore wherein total 240 participants recruited (SCZ-140; HV-100) in the study and of these, 58 participants (SCZ-33; HV-25) underwent magnetic resonance imaging. The study found a three-factor structure for BCIS which is different from the original two factor structure; self-reflection (SR) of original two-factor structure was sub-divided into– SR1, introspection and SR2, openness to feedback. There was a significant difference between HV and SCZ in the new factors, SR1 and SR2 but not in the original SR factor. Difference was also seen on MRI analysis; while there was a significant positive correlation between original SR factor and thickness of right posterior cingulate cortex, SR2 was positively correlated with thickness of left ventrolateral prefrontal cortex. The difference in factor structure in Indian participants and their distinct neural correlates point out the cultural differences in cognitive insight.

1.7.2 Science and Technology of Yoga and Meditation (SATYAM)

Science and Technology of Yoga and Meditation (SATYAM) program aims to foster scientific research on the effects of yoga and meditation on physical & mental health besides on cognitive functioning in not only in patients with disorders but also in healthy people.

This year, Task Force recommended 32 new projects for financial support under SATYAM. In addition to this, 11 projects were also recommended for minor revision. Further, sanctions have been issued for implementation of 37 new projects and 19 ongoing projects under SATYAM. Projects under SATYAM contributed 12 research publications this year.

Special Call under SATYAM to Combat with COVID-19:

Programme Division organized an Expert Committee Meeting to review the progress under COVID-19 related special call under SATYAM. 20 investigators presented the progress before Committee. Out of 20, the Committee graded 4 projects as excellent, 5 Very Good and 8 as Good. The Committee appreciated that this special call remains able to fulfil the purpose as the projects have come out with innovative results.

Tele Yoga has become established process and now is in use for research purpose. Few IoT/mobile based applications have also been developed. Some of the clinical studies have shown yoga has good impact in reducing stress level and improving immunity which can be used as add on therapy in future.

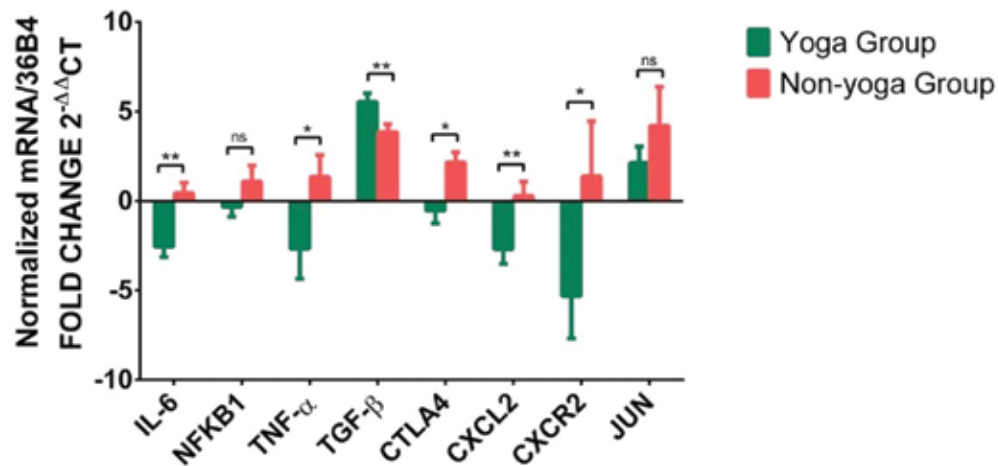
Highlights of SATYAM projects:

Effect of yoga on Rheumatoid Arthritis

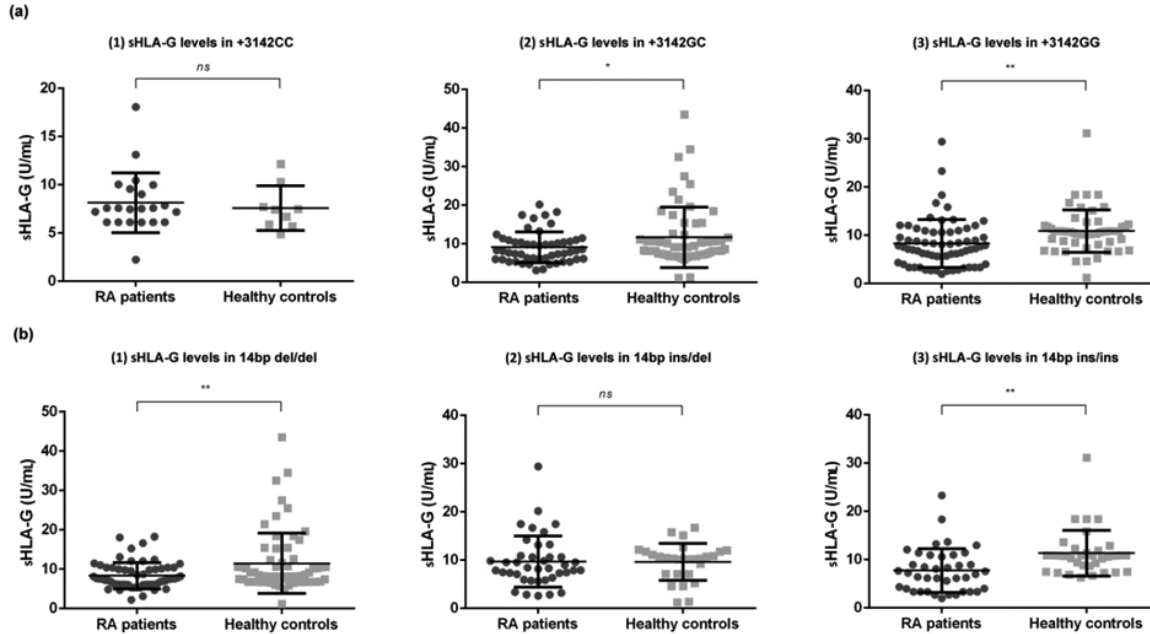
This study helps to understand the complexities and severity of rheumatoid arthritis in Indian population. Rheumatoid arthritis patients of total knee joint replacement surgery have been included in the study from AIIMS, New Delhi. This study aimed to see genes involved in pathogenesis, epigenetic modifications and mutation analysis, and study the effects of lifestyle-based yoga intervention. Both synovial tissue and blood samples were collected from patients. The blood samples of age and gender-matched Healthy Controls were also obtained from Blood Bank, Department of Transfusion Medicine, AIIMS, New Delhi. For a gene-specific methylation study, four genes were selected from the common DEGs of microarray analysis. Out of these four genes, two were found significantly upregulated, i.e., *CXCL2* and *FOS*, whereas two were found significantly downregulated, i.e., *BAD* and *TNFRSF25*. The sHLA-G levels were significantly lower in RA patients as compared to healthy controls in 14bp del/del and 14bp ins/ins. This holistic approach of yoga to RA is not only improving the quality of life for people with rheumatoid arthritis and associated depression and reduce caregivers' burden. The results of this study showed that yoga reduces the severity of RA as evident by reduced DAS-28ESR scores, levels of oxidative stress and inflammation markers

and causes downregulation of pro-inflammatory genes, hence it may be possible to use it as an adjunct therapy.

Change in expression levels of selected genes at 8 weeks timepoint



Pre and Post yoga intervention analysis of various selected transcripts.



Correlation of HLA-G levels with (a) +3142G>C and (b) 14bp ins/del HLA-G polymorphism in RA patients (n=140) and healthy controls (n=125).

Other Activities:

Conference Support: DST has supported “**National Conference on Yoga and Ayurveda for COVID and Post COVID Health Management**” which was held during February 20-25, 2021 at Yoga Bhawan, Kerala. The said Conference is aimed to explored the impact of Yoga practice in prevention, management and post-pandemic health complications and ensure holistic health, longevity, happiness and peace.

Another International Conference on Yoga (International YOGACON 2021) wherein several sessions have been conducted during June 2021. The Conference was organized by AIIMS, Rishikesh in association with American Academy of Yoga and Meditation.

Webinar on International Yoga Day: The Department of Science & Technology has organized a webinar on 21st June 2020 to celebrate 7th International Yoga Day on the theme “*Yoga for Improving Heart Health*”. Prof. K.K. Deepak, Department of Physiology, AIIMS, New Delhi was the speaker and Secretary, DST presided over this webinar. More than 100 Scientists have participated in this webinar.

1.8 INSPIRE

“**Innovation in Science Pursuit for Inspired Research (INSPIRE)**” is a flagship scheme of Department of Science and Technology (DST) which aims to attract meritorious youth 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 Scheme” in general demonstrates the ‘Minimum Government, Maximum Governance Model’ due to the use of technology in its operations right from submission of the application to the delivery of grants including its operations. Scheme is implemented through the on-line dynamic INSPIRE web-portal and scholarship(s)/fellowship(s) are released to the INSPIRE beneficiaries within 60 days of the receipt of requisite documents online.

Despite challenges faced due to Covid-19 in year 2021-22 also, work related to providing timely financial support to the large beneficiary pool of students at college and university level continued. A number of steps were taken to provide relief during this period. These include:

- Timelines for uploading the requisite documents under INSPIRE- Scholarship for Higher Education (SHE) and INSPIRE Fellowship components for award/release of scholarships/fellowships were extended.
- Online Assessment Meetings for up-gradation of JRF to SRF were permitted without compromising on the up-gradation norms.
- Call center activities were strengthened further for addressing the issues of beneficiaries of INSPIRE schemes effectively.

- To facilitate the research activities smoothly, special permission was granted to carry forward the unspent Research grant (up to 7.0 lakh) to next year for all INSPIRE Faculty Fellows whose 1-4 years of Fellowship were completing during 01.01.2021 to 31.12 2021.

Scholarship for Higher Education (SHE) component under INSPIRE scheme aims to attract top 1% rank holder students to pursue their career in basic and natural science areas in higher academic qualifications by providing scholarships and mentorship grants. The scheme offers 12,000 (10,000 Direct Mode + 2000 Institutional Mode) Scholarships every year @ Rs 0.80 lakh per year (including Mentorship grant) for undertaking Bachelor and Master level qualification in natural and basic sciences for the talented youth in the age group of 17-22 years. Main feature of this component is to develop scientific and research temperament among UG and PG level science students through research projects during their vacation period. SHE component call for 2020 was completed and in response to call inviting applications under SHE- Direct mode, 24,014 applications were received and 9868 INSPIRE scholarships have been offered to the selected candidates (Figure 1). Selection of students was based on their performance in class 12th examination conducted by State/ Central School Education Examination Boards and competitive examinations such as JEE (Main & Advance), NEET etc. All the selected students pursue the undergraduate / post graduate levels courses in basic and natural sciences. Out of the total students who were offered INSPIRE SHE scholarships, 47% are Female.

A total of 7020 and 1310 ongoing scholars received their Scholarship under the Direct and Institutional mode respectively for continuing their undergraduate/ post graduate degree courses at various IIT's, IISER's, NISER etc. Besides this **581** KVPY scholars were offered fellowship to pursue B.Sc. and M.Sc. in basic and natural sciences and **1024** KVPY scholars received their ongoing fellowship to pursue B.Sc. and M.Sc. in sciences.

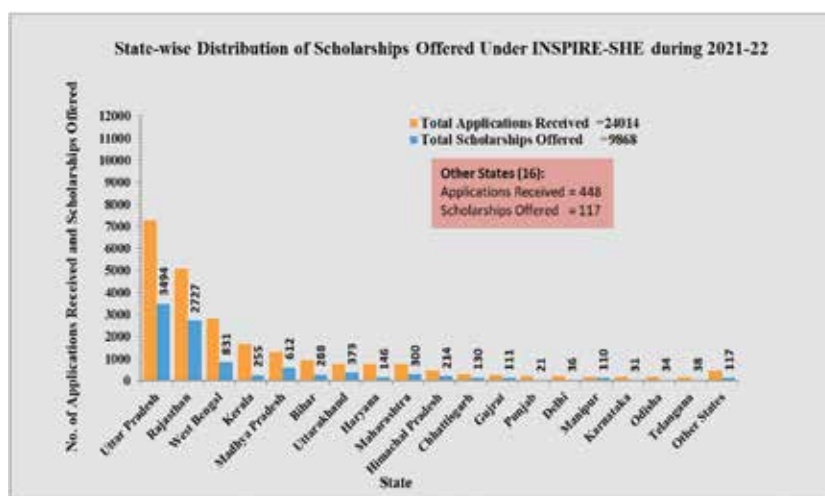


Fig 1: Applications Received and Scholarships Offered under SHE Component

INSPIRE Fellowship component offers 1000 Fellowships every year for carrying out doctoral degree in both basic and applied sciences including engineering and medicine in the age group of 22-27 years. INSPIRE fellowship is offered to students having secured 1st Rank in Basic & Applied Sciences including engineering, medicine, agriculture, veterinary at the University/ academic institute of national importance i.e. IITs, NITs, IISERs level examination. Students who have obtained scholarship at UG and PG level under INSPIRE-SHE are eligible for INSPIRE Fellowship if they have secured 70% marks in aggregate at the M.Sc. level and taken admission to the Ph.D. Program in any recognized university/ academic institutions in the country. The Fellowships are tenable for a maximum of five years (2 years as JRF and 3 years as SRF) period or completion of PhD, whichever is earlier to pursue full-time PhD program. The Fellowship amount including the contingencies is equivalent to CSIR-UGC NET Fellowship and is governed by GoI norms & regulations.

The Level-1 scrutiny of applications of INSPIRE Fellowship Call 2020 was completed. Out of 2088 received applications, 1742 applications were cleared for level-2 evaluation for award of INSPIRE fellowships. Level-2 evaluation of applications is under progress. Out of the awarded/offered INSPIRE Fellows 63% are female and 37% are male (Figure 2). Of the total INSPIRE Fellowship beneficiaries, about 31% are SHE Scholars who have joined doctoral degree program in science and technology after availing 5 years INSPIRE Scholarship. Three hundred and twenty-two INSPIRE fellows were promoted from Junior Research Fellowship (JRF) to Senior Research Fellowship (SRF) after evaluation of the research work carried out by them. Besides this, 10 INSPIRE Senior Research Fellows and 3 UK Fellows have been selected for short-term Research Internship Program at the various Laboratories/ Universities of UK and India respectively under Newton Bhabha Ph. D. Placement Programme-2020-21. Nine students selected for participation in 12th JSPS -HOPE meeting last year but could not participate due to cancellation of the event owing to COVID-19 pandemic participated in 13th HOPE Meeting via online mode this year.

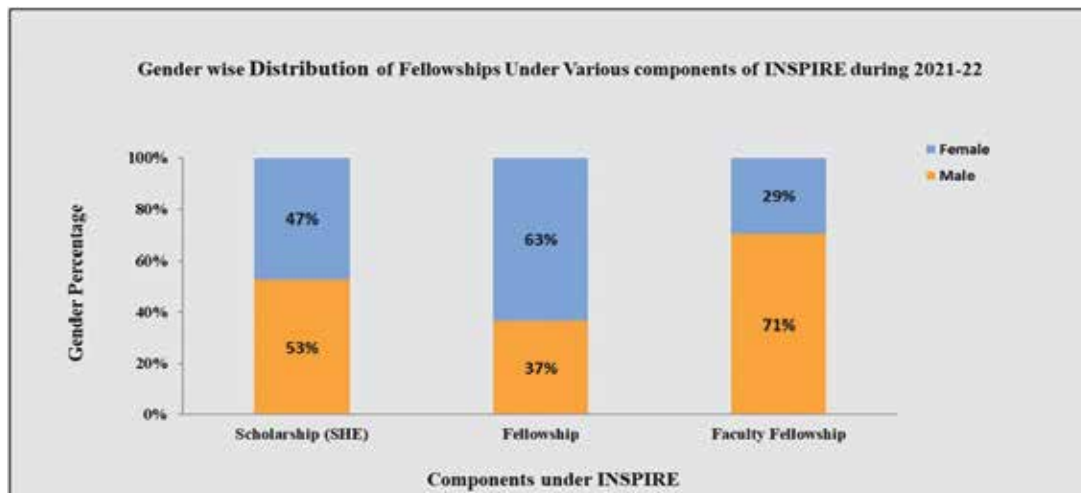


Fig 2: Gender-wise Distribution of Fellowships under INSPIRE Components

INSPIRE Faculty Fellowship component offers 100 post-doctoral research fellowships for five years period in both basic and applied sciences including engineering and medicine in the age group of 27-32 years. Its salient features are:

- To provide attractive opportunities to young achievers for developing independent scientific profiles and launch them in fulfilling long term careers.
- Expected to augment high quality scientific manpower for scientific and educational institutions, specially the Central and State universities.
- This component provides an independent research opportunity and not a guarantee for position beyond 5 years.
- While the vertical migration among students in different INSPIRE components is encouraged, the scheme also provides an opportunity to students for lateral entry into this component.

During the year 2021, 281 INSPIRE Faculty Fellows received their fellowship and are pursuing the post- doctoral research through contractual and tenure track position for 5 years in both basic and applied science areas including engineering, agriculture, veterinary and medicine. During the year, 95 INSPIRE Faculty Fellowships were offered the fellowship. Out of the awarded/offered INSPIRE Faculty Fellows 29% are female and 71% are male. More than 2900 applications have been received against the 18th advertisement call brought out during the year 2021 for selection of INSPIRE Faculty Fellowship. Scrutiny of these applications is under progress.

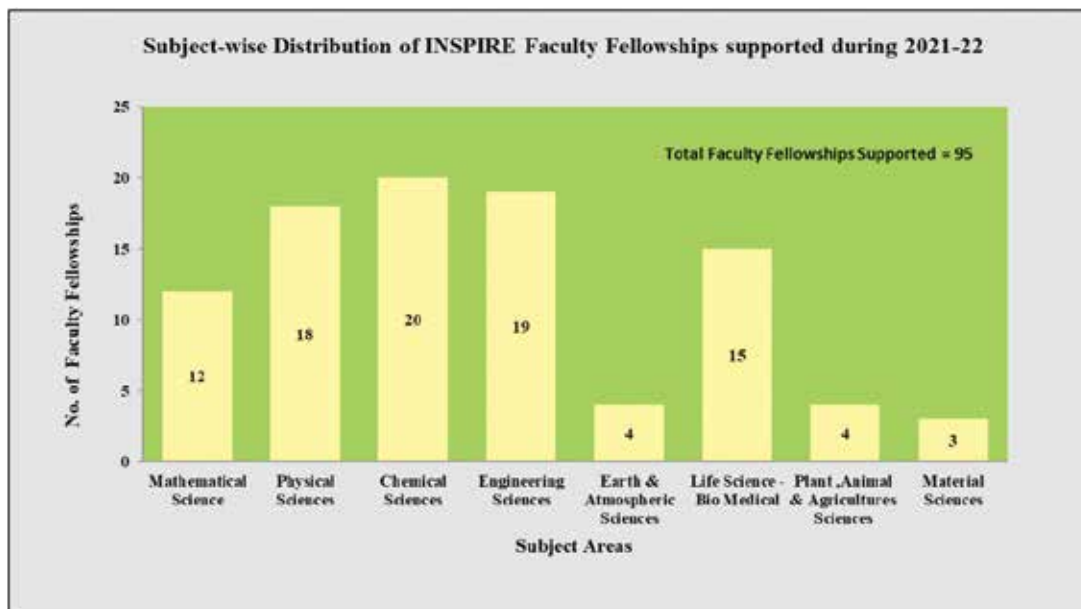


Fig 3: Subject Area-wise Distribution of INSPIRE Faculty Fellowships

Mobile application for INSPIRE Scheme to track the status of INSPIRE application(s) instantly through Unified Mobile App was developed and is available to the INSPIRE aspirants/beneficiaries. During the year (1st April 2021-13th December, 2021), out of 2,05,19,866 hits, 1,03,22,105 hits were through UMANG and rest were through Web Browser. Out of 1,03,22,105 hits through UMANG, 74,467 hits from Mobile Devices were unique.

1.9 INSPIRE AWARDS – MANAK

Department of Science & Technology (DST) is implementing **INSPIRE Award MANAK (Million Minds Augmenting National Aspiration and Knowledge)** scheme with objectives to attract young students to study science and pursue research career and promote creative thinking and foster a culture of innovation among them. Under the Scheme, 10 lakh ideas are targeted from 5 lakh schools across the country every Year.

A massive awareness campaign in a virtual mode wherein more than 60,000 teachers and school representatives in addition to Block, District and State Nodal Officers participated. In addition, wherever possible, in-person meetings with various stakeholders were conducted so that nominations from every corner of the country could be mobilized. During the year, nominations were opened on 15th July, 2021 and continued till 24th October, 2021. A total of 7.05 lakh ideas and innovations were received from all States and UT's across the country and also from Kendriya Vidyalaya, Jawahar Navodaya Vidyalaya and Sainik Schools. On taking a closer look at the final statistics, it was ascertained that 715 districts of the country were represented. While 53% of nominations were received from girls and 47% of nominations were from boys. From the schools which had participated, nearly 83% of them were situated in rural parts of the country. A comprehensive review exercise has been undertaken with the involvement of around 400 experts from different parts of the country with deployment of Information Technology for shortlisting the MANAK awardees. Out of 7.05 lakh nominations received, 52,720 students have been shortlisted to participate in the District Level Exhibition and Project Competition (DLEPC) and subsequently the S/N LEPC (State and National).

Owing to the prevailing COVID-19 challenges, the DLEPC, SLEPC and NLEPC were conducted in an online mode and a *MANAK competition app* was developed and widely disseminated with all participating students of previous years so that the exhibitions and project competitions which were temporarily on-hold due to challenges associated with physical exhibitions could move forward. The app was listed on Google Play store and iOS App store to enable students to download it conveniently and participate further. For the 53,021 nominations which were shortlisted from the 6.53 lakh ideas and innovations received during FY 2020-21, the online D/SLEPC was conducted through *MANAK competition app*. After this, the adjudication process involving District and State Authorities was conducted through online mode.

The 8th NLEPC (National Level Exhibition and Project Competition) of the INSPIRE Awards – MANAK was successfully organized during 4-8 September, 2021 in a virtual mode. Awards

were conferred to sixty creative students by Dr. Jitendra Singh, Minister of State (Independent Charge) Science & Technology and Earth Sciences. In the exhibition 581 students from different parts of the country shortlisted after a series of State and District Level Exhibition and Project Competitions were showcased. Navshri Thakur, a student from Hoshangabad, Madhya Pradesh, bagged the first prize for her innovation titled “multi-useful kitchen machine”, Owais Ahmed from Bidar, Karnataka, bagged the second prize for his innovation “safety horizontal stretcher” and Dasari Ashok from Vikarabad, Telangana, bagged the third prize for the innovation titled “ceiling fan lifting tool”. For all the MANAK award winners, the incubation cycle is ongoing and important steps like protection of their Intellectual Property Rights (IPR) is taken care of.



To facilitate all the stake holders of MANAK. A massive upgradation exercise of E-MIAS (E Management of INSPIRE Awards Scheme) portal was undertaken which has led to easy and fast access to information on portal.

1.10 Swarna Jayanti Fellowships Scheme

Government of India initiated **Swarna Jayanti Fellowships Scheme** to commemorate 50th year of India’s independence 24 years back, in 1997-1998. Swarna Jayanti Fellowship Scheme was instituted to provide special assistance and support to selected number of young scientists with excellent track-record aged between 30 to 40 years. The vision for the Scheme is to enable outstanding Young Scientists to pursue research in frontier areas of science and technology. The fellowship is scientist specific and not institution specific, very selective and has close academic monitoring. The selection process is competitive and the

candidates are selected through a three-tier rigorous screening process involving 6 Subject Area Committees, National Core Committee and Empowered Committee.

The support from DST includes a fellowship of Rs. 25,000/- per month in addition to the salary drawn from their parent Institution and certain amount as research grant for five years, while the project submitted by the selected Fellows is being considered for funding by the Science & Engineering Research Board (SERB) as per SERB norms, for recurring and non-recurring heads. Projects with innovative research idea and potential of making impact on R&D in the discipline are selected for funding. Scientist (s) selected for the award are allowed to pursue unfettered research with a freedom and flexibility in terms of expenditure as approved in the research plan.

The exposure through Swarna Jayanti Fellowship Scheme has enabled the Fellows in achieving higher scientific recognition. In the initial decade of the implementation of the scheme it has been observed that around 60% of the Swarna Jayanti Fellows were nominated and awarded the Shanti Swarup Bhatnagar award. In the year 2021 itself out of 11 Shanti Swarup Bhatnagar awardees, 6 are Swarna Jayanti fellows (**Dr. Arun Kumar Shukla - Biological Sciences, Dr. Kanishka Biswas - Chemical Sciences, Dr. T Govindaraju - Chemical Sciences, Dr. Debdeep Mukhopadhyay- Engineering Sciences, Dr. Anish Ghosh - Mathematical Sciences and Dr. Saket Saurabh- Mathematical Sciences**).

The research conducted by SJF fellows solve decades-old scientific problems and even gives rise to new interdisciplinary areas. The output of each Swarna Jayanti Fellow can be seen in terms of their publications (on an average 12 papers per project in reputed journals) and the number of research personnel awarded PhD with their guidance. The research papers arising out of Swarna Jayanti Fellowship Scheme, are often published in various International and National journals of high repute. Some of the awarded fellows have been successful in filing patent for the technical process that they have developed through their project awarded under Swarna Jayanti Fellowship, a few of which were commercialized as well.

Since the implementation of the scheme **220** fellows have been awarded the Swarna Jayanti Fellowship with the following breakup:

Sr No	Broad Area	Fellows Selected
1.	Chemical Sciences	43
2.	Earth & Atmospheric Sciences	13
3.	Engineering Sciences	44
4.	Life Sciences	46
5.	Mathematical Sciences	27
6.	Physical Sciences	47
7.	Total	220

The following table summarizes the process of selection in each discipline in current year:

Broad Area	Applications received	Screened-in for Presentations	Selected for presentation National Core Committee (NCC)	Nominated by NCC
Chemical	27	11	6	3
Earth & Atmospheric	20	5	3	1
Engineering	84	10	4	3
Life	100	11	6	4
Mathematical	16	6	4	3
Physical	55	13	5	3
TOTAL	302	56	28	17

The list of fellows selected for Swarna Jayanti Fellowship for the year 2020-21 is as follows:

Sl.	Fellows Name & Institute	Discipline
1.	Dr. Siddhesh S. Kamat (IISER-Pune)	Life Science
2.	Dr. Sridharan Devarajan (IISc-Bengaluru)	Life Science
3.	Dr. Niti Kumar (CSIR-CDRI, Lucknow)	Life Science
4.	Dr. Nitin Gupta (IIT- Kanpur)	Life Science
5.	Dr. Modhu Sudan Maji (IIT- Kharagpur)	Chemical Science
6.	Dr. Sakya Singha Sen (CSIR - NCL, Pune)	Chemical Science
7.	Dr. Chandramouli Subramaniam (IIT- Bombay)	Chemical Science
8.	Dr. Atul Abhay Dixit (IIT- Gandhinagar)	Mathematical Science
9.	Dr. Mousomi Bhakta (IISER-Pune)	Mathematical Science
10.	Dr. Ujjwal Koley (TIFR- CAM, Bengaluru)	Mathematical Science
11.	Dr. Arvind Singh (PRL, Ahmedabad)	Earth & Atmospheric Science
12.	Dr. Subhro Bhattacharjee (TIFR-ICTS, Bengaluru)	Physical Science
13.	Dr. Pabitra Kumar Nayak (TIFR- Hyderabad)	Physical Science
14.	Dr. Shamik Banerjee (IOP-Bhubaneswar)	Physical Science
15.	Dr. Rishi Raj (IIT- Patna)	Engineering Science
16.	Dr. Mayank Shrivastava (IISc-Bengaluru)	Engineering Science
17.	Dr. Amartya Mukhopadhyay (IIT- Bombay)	Engineering Science

RESEARCH AND DEVELOPMENT

2.1 International Cooperation Division (ICD)

SALIENT ACTIVITIES DURING THE YEAR: Indicative trends in fostering international bilateral cooperation and partnerships during 2021-22 have been as follows:

- Active bilateral S&T programs of cooperation with more than 45 countries including dedicated program for Africa, ASEAN, BRICS, EU and neighboring countries;
- Dissemination of information and networking through about 100 bilateral workshops; symposiums and exhibitions;
- Facilitation of bilateral advanced schools and training programs including participation of young student researchers in international meets;
- About 300 Bilateral, multilateral and regional R&D joint projects including multi-institutional networked projects;
- About 20 Industrial and applied R&D projects involving industry participation with Canada, France, Germany, Israel, Italy, Russia, Spain, South Korea, Sweden and USA;
- Co-investment of resources including funds for symmetric joint research projects and strategic joint initiatives with Australia, Israel, Japan, Portugal, Russia and United Kingdom.
- Execution of Africa-India S&T Initiative Program through strengthening of African Centers of Excellence in select scientific areas by twinning with Indian institutes.
- Support to bi-national S&T Centres under institutional framework- Indo-French Centre for Promotion of Advanced Research, Indo-German S&T Centre, and Indo-U.S. S&T Forum;
- On-line meetings of Indian and foreign young scientists and researchers.
- Implementation of India Science & Research Fellowship (ISRF) for scientists from Afghanistan, Bangladesh, Bhutan, Maldives, Myanmar, Nepal, Sri Lanka, Thailand researchers to undertake R&D work in India;
- Proactive engagement and participation in international advanced research facilities like FAIR and DESY in Germany, Indian beam-line facility at KEK Japan, CERN in Geneva,

Elettra in Italy, and Rutherford Appleton Lab in UK.

- International partnerships for joint research and technology development in areas of national priority through engagement with Industry Associations, like Technology Summit with CII and Global R&D Summit with FICCI.

2.1.1 Special COVID-19 Initiatives

As a follow-ups to the Indo-Italian COVID Webinar, various Indian and Italian research labs were connected to work together on long term perspectives and future challenges to mitigate this pandemic in (i) Infectious diseases: COVID-19-Therapeutics, diagnostics, vaccines for viral respiratory diseases (ii) Post COVID-19: Impact on health and immunity (iii) Artificial Intelligence: Tools in COVID-19 disaster management (iv) Focused Algorithms for Infectious Disease Modeling (v) Mathematical Modeling of COVID-19 Spread.

2.1.2 INTERNATIONAL S&T COOPERATION 2021-22

International Cooperation Division of the Department has the mandated responsibility of (i) negotiating, concluding and implementing Science & Technology Agreements between India and partnering countries; (ii) providing interventions on S&T aspects in international forums. This responsibility is carried out by the Division in close consultation with the Ministry of External Affairs; Indian Missions abroad; S&T Counsellors in Germany, Japan, Russia and USA; stakeholders in scientific, technological and academic institutions; sister scientific government departments; and with various industry associations in India.

Guiding Principles for International S&T Cooperation

DST is able to strategically leverage 'international collaborative advantage' by building chosen international alliances and partnerships with selected countries that can have perceptible yields, such as:

- Leverage international alliances which can value-add to national programs and missions;
- Gaining global competitiveness through bilateral collaboration;
- Accelerate institutional and human capacity building through international exposure and linkages;
- Connect Indian research with global efforts in frontier areas of S&T and in addressing global challenges;
- Participation and access to mega-science projects and international advanced research facilities;
- Promote eco-system of innovation and techno-entrepreneurship through collaboration

with countries high on innovative index to provide value addition to various national initiatives;

- (vii) Adoption of new paradigms of innovative practices by developed and emerging economies in the Indian ecosystem;
- (viii) Enable applied and industrial R&D through industry-academia connect program aimed at creating new IP, process, proto-types or products;
- (ix) Connect Indian innovation model to gain access to markets in developing countries;
- (x) Use soft prowess of S&T to build and develop bilateral relationship and people-to- people contact through capacity building and fellowship programs.

2.1.3 Spectrum of Cooperative Activities undertaken

During the year, DST undertook a spectrum of international cooperative activities such as: (i) bilateral S&T Joint Committee Meetings and ministerial missions; (ii) bilateral and international workshops, webinars and symposiums; (iii) joint research projects; (iv) multi-institutional networked R&D projects; (v) establishing virtual joint laboratories; (vi) training programs; (vii) access to advanced research facilities abroad & participation in international mega-science projects; (viii) continue support to bi-national S&T bodies; (ix) fellowships and visitation programs for both Indian and foreign researchers; (x) participation of young student researchers in international meets; (xi) promoting academia-industry partnerships for industrial R&D on bilateral level; and (xii) Technology and R&D summits, technology fairs, S&T exhibitions.

2.1.4 New Programme of Cooperation

Programs of Cooperation in Science, Technology and Innovation were concluded with Italy, and Russia. These documents provided an opportunity to develop cooperation in identified themes in a given period.

Joint S&T Committee/ Council Meetings were held with Denmark, Egypt, Netherlands and Philippines during Year 2021-2022 to review ongoing cooperation as well as to explore new cooperation in the emerging areas of Science & Technology (S&T) like Green Hydrogen, Artificial Intelligence, 5G, quantum computing, Key Enabling Technologies, Space Technology, Cyber Security, Green Hydrogen and fostering the cooperation by involving, academia, industries and start-ups besides review of the ongoing cooperation.

New Indo German programme on IRTG

IRTGs (International Research Training Groups) are structured research and training programmes that strive to strengthen bilateral partnerships through joint research, a joint

qualification programme, cross-border supervision of doctoral students from partnering countries, and long-term coordinated and reciprocal exchange visits by doctoral students at respective partnering institutions. Their emphasis is to provide early career researchers with an opportunity to obtain doctoral degrees within the framework of a focused research programme and a structured training programme. Two or more institutions from India and Germany will choose the themes of mutual interest and formulate the research projects to DST and DFG wherein about 25-30 Doctoral students will work for their doctoral Degrees from both countries. The Doctoral students have opportunity to visit the laboratories in India and Germany to work on their chosen topic for research.

Bilateral Research Projects and Programs

Africa DST is collaborating with World Bank to strengthen select African Center of Excellence (ACEs) established by the World Bank in various parts of Africa (Ethiopia, Ghana, Kenya, Nigeria, Rwanda, Senegal, Tanzania, Uganda) through a consortium of 10 Indian institutions including 8 premiere IITs and 2 DST R & D institutions. Indian Institute of Technology, Roorkee is the lead institute on the Indian side. This collaboration includes student and faculty exchange, visitation programme, joint research, curricula development etc. in 4 focused research areas i.e. Material Science and Renewable Energy; Water infrastructure and management, environment; Informatics and ICT & Railway. Currently, these institutes are engaged through joint workshops and about 6 virtual workshops are held.

Australia Under AISRF - Round 14, DST has received 44 proposals in the priority areas quantum technologies, earth observation remote sensing, groundwater resources management, downstream processing, recycling and tailings reclamation of critical minerals. These proposals are under further consideration for support.

Belgium The 5th Meeting of the India-Belgium Joint Committee on Science and Technology was held on 18th January through an online platform. Both sides discussed S&T policy development relevant for the bilateral cooperation, reviewed the status of the ongoing joint project and Astronomy cooperation. Both sides discussed on possible cooperation of various topics such as microbiological Bio-Banks, Geology, Cyber Security and Remote Sensing.

The 4th call for proposals for networking activities by the Belgian Federal Science Policy Office (BELSPO), DST and DBT aims at supporting exchanges that leverage long term research cooperation between multiple Belgian and Indian Research institutions, based on existing infrastructure, with significant impact on a priority research area. Focus areas with DST are Space, including astronomy, solar physics and remote sensing; Marine sciences (Except Bio concept); Geology; and Cybersecurity. Focus areas with DBT are Marine biotechnology and Life sciences with focus on micro-organisms. Both sides have received 26 proposals and completed the evaluations of these projects.

Canada Two virtual meetings were held with Canadian officials for drafting the Memorandum of Understanding (MoU) between the Department of Science and Technology (DST) and National Research Council (NRC) Canada and between DST, DBT, and Natural Sciences and Engineering Research Council of Canada (NSERC) on 7th Sep 2021 and September 15, 2021, simultaneously.

Colombia Meeting of DST and DBT with Colombian delegation was held on 1st Oct 2021 at premises of the Department of Science and Technology regarding the future collaboration in various scientific areas.

Czech Under the India-Czech bilateral Agreement on Scientific, Technical and Industrial Cooperation, a total of 20 high ranking joint proposals were supported during the year 2021-22.

Denmark Implemented 5 Joint Research projects on (i) Cyber Physical System addressing issues on Sustainable Irrigation (ii) Monitoring Groundwater Quality (iii) data-driven control and optimization for a highly Efficient Distribution Grid (iv) design and operation of large grid-connected hybrid power plant and (v) off grid renewable energy driven cold storage jointly selected against the last two joint calls in the area of Energy and Cyber Physical System. 3rd Joint Committee meeting was held virtually on 14th January 2022 which agreed to launch a fresh call for proposals in the area of Green Fuels including Green Hydrogen.

Egypt The fifth Joint Committee Meeting on Science and Technology between India and Egypt was held on October 05, 2021 virtually. Both sides agreed to strengthen cooperation in the area of Agriculture waste processing, nanotechnology for environmental applications, Renewable energy and Medical Biotechnology through focussed R & D joint projects, workshops and exchange of researchers. Support was extended to approved 25 projects towards initiation.

Germany During year of the report a total number of 11 projects have been sanctioned on various themes for exchange visits by Indian and German scientific and academic groups and research students. Under the ongoing DST DAAD Germany cooperation, a new call with Germany under DST-DAAD call 2021 was launched on 1 October 2021 with closing date of 19 November 2021. All received 96 projects are under the evaluation process.

70th Nobel Laureates meetings in Lindau, Germany Due to the pandemic in 2021, the 70th Nobel Laureates meetings were held from 27th June to 2nd July 2021 through online mode. The students selected for the year 2021 have been given the opportunity to join the meetings on a virtual platform. 30 students from Physics, Chemistry, and Medicine have participated from India.

Hungary Under Indo-Hungarian Inter Governmental S&T Cooperation Programme, joint call for proposals was issued by the Department of Science and Technology (DST) and National Innovation Office, Budapest (Hungary) for inviting joint research projects carried

out by Indian and Hungarian researchers on the mutually agreed areas of i) Biotechnology, including agriculture and food industry ii) Information and communication technologies iii) Renewable energy and iv) Water management and water cleaning. Based on scientific strength, technical aspects, project objectives and national priorities of both the countries, eleven projects are ongoing.

Israel Under the Indian Israeli Joint Research Cooperation Programme (IIJRC), a joint call for proposals was issued by the Department of Science and Technology (DST) and Ministry of Science and Technology, Israel for inviting joint research projects carried out by Indian and Israeli researchers on the mutually agreed areas of (i) Advanced materials for next gen solar energy utilization and storage (ii) Quantum devices for sensing imaging and communication. Eight projects are being supported and they are ongoing.

India-Israel Women in STEM – Sharing Ideas & Initiatives A mini-conference titled “India and Israel Women in STEM: Sharing Ideas and Initiatives” was held online on November 24th, 2021. Ambassadors’ from both the countries were present in the conference. Experts from India and Israel highlighted the need for changes in the socio-cultural environment while deliberating on ways of achieving gender parity in the field of Science, Technology, Engineering and Mathematics (STEM). The deliberation suggested that the two governments need to play a major role in generating enablers to allow greater women’s participation like joint programmes that connect incubation centres in the two countries and setting up incubation centres for women. It was proposed that S&T could become a change maker in society by introducing flexible work times, and gender-neutral pays to enhance women participation in STEM. The society, system (Government policy), support from family & work area and self-motivation could help enable women empowerment. Provision of suitable tools and guidance to women can also help them reach their full potential as entrepreneurs.

Italy Following recommendations of the Joint S&T Committee, India-Italy joint call for proposals was launched inviting new research proposals for Mobility of Researchers, Significant Project, and ‘Networks of Excellence’ aimed at creating long-term sustainable interactions based on existing infrastructure, with significant impact on one priority research. In total over 360 proposals, a total of 13 proposals for Mobility of Researchers; 5 proposals for Significant Research and two Network of Excellences were agreed to support from both sides. Secretary DST and Italian Ambassador in New Delhi signed a new Executive Programme of Cooperation for 2022-24 to jointly fund these proposals selected against the call.

Japan Under the India-Japan Cooperative Science Programme joint call for Proposals was issued by the Department of Science and Technology (DST) and Japan Society for the Promotion of Science (JSPS), Japan for inviting joint research projects and workshops carried out by Indian and Japanese researchers on the mutually agreed areas of i) Physical Sciences ii) Chemical Sciences iii) Life Sciences and Agriculture iv) Mathematics and Computational Science v) Astronomy and Earth Science vi) Materials and Engineering vii) COVID-19 related (preventive technologies, Artificial Intelligence applications, Screening

and diagnostic testing). DST and JSPS have jointly supported 20 research projects and 3 workshop proposals. A new call was launched in 2021 wherein 147 common joint research project proposals and 7 workshop proposals were received against the call.

India Japan Nobel Laureate S&T Seminar Series

The 11th India-Japan Science and Technology Seminar titled, “**India Japan Nobel Laureate S&T Seminar Series**” was held in collaboration with the Department of Science & Technology (DST), Government of India (GoI) and The Japan Society for the Promotion of Science (JSPS), Government of Japan (GoJ) on December 06-07, 2021 in virtual mode. The event was coordinated by Indian JSPS Alumni Association (IJAA) in association with SreeChitraThirunal Institute for Medical Sciences and Technology, Trivandrum. It commemorated the 70th Anniversary of India-Japan Diplomatic Relations & 75th Anniversary of Indian Independence. The inaugural address was given by the Ambassador of India to Japan and Ambassador of Japan to India. The event had two keynote addresses by Prof. Tasuku Honjo, Nobel Laureate 2018 and Prof. K Vijaya Raghavan, Principal Scientific Adviser to the Government of India.

Mexico A high-official meeting between the Department of Science and Technology, Government of India and the National Council for Science and Technology (CONACYT), of the United Mexican States was held on August 18, 2021 to discuss new opportunities and future India-Mexico S&T collaborations. Both sides highlighted their priority areas Health; Human Security; and Energy in the coming years. Both sides also expressed their interest in re-new or extend the duration of the existing Programme of Cooperation.

Netherlands

India-Netherlands Joint Working Group Meeting: India-Netherlands Joint Working Group (JWG) meeting was held virtually on 22nd September, 2021. In the meeting, various opportunities for partnership under new instruments were presented by DST, DBT and NWO. Upcoming areas of collaborations like Key Enabling Technologies, Space Technology, Cyber Security, Green Hydrogen, and Visiting Doctoral programme were recommended.

India- Netherlands Roundtable meeting on Water: India- Netherlands Roundtable meeting on Water under Indo-Dutch WAH (Water, Agriculture and Health) Agenda was held on 12th July, 2021 in virtual mode and was attended by experts from India and Netherlands. Discussion was done on the Indo-Dutch flagship water programmes, thematic priorities, knowledge and innovation related to WAH. The modalities required to stimulate cooperation and the connection of innovation ecosystems i.e. bilateral calls were also discussed.

Philippines The first Joint Working Committee Meeting (JCM) on Science and Technology between India and Philippines was held on July 08, 2021 virtually. Both sides agreed to strengthen cooperation in the area of Agriculture Biotechnology, Health & pharmaceutical Science especially in diagnostic and vaccine studies, Material Science and Information

Technology through focussed R & D joint projects, workshops and exchange of researchers. A joint Call for R & D project is announced in November 2021.

Poland 19 projects selected for funding under bilateral exchange of scientists between India and Poland between DST and Polish National Agency for Academic Exchange. Due to COVID-19, all these projects are extended for one year.

Portugal The Portugal side showed their interest in the India-Portugal industrial R&D projects during the 5th Session of India-Portugal JEC which was held on 8-9th April 2021 at UdhayogVihar, New Delhi.

Russia

- DST and Russian Science Foundation (RSF) Joint call 2021 launched on 15th March 2021 inviting active Indian and Russian scientists / researchers to submit proposals for Joint Research Project in the areas of Smart transport and telecommunications; Smart healthcare and medicine; New Materials; Plant and Animal Bio-Technology; Clean Energy; Artificial Intelligence; and Safe Food. A total of 293 projects received against this call.
- On the occasion of Russian President Vladimir Putin and Indian Prime Minister Narendra Modi met for the 21st India-Russia Annual Summit in New Delhi, India on December 6, 2021, a new Roadmap for Science, Technology & Innovation (STI) Cooperation for next 5 years was concluded by Head of the International Cooperation of the Department of Science & Technology for the Ministry of Science and Technology, Government of India and Director of the Department of International Cooperation for Ministry of Science and Higher Education of the Russian Federation. The Indo-Russia Roadmap for science & Technology is a continuation and development of the Integrated Long-Term Program (ILTP) of cooperation in the field of science, technology and innovation between the Government of the Russian Federation and the Government of the Republic of India dated December 21, 2010.

The Roadmap is aimed to boost innovation related engagements between the two countries and focus on commercialization of technologies and full cycle support joint projects for economic and societal impact. Both countries will also explore supporting creation of International centres for Innovative Entrepreneurship & Inter Cluster Interactions to improve Technology Partnerships. The following themes have been identified for potential areas of cooperation: (i) Agriculture and food science and technology; (ii) Blue economy, marine industry and ocean resources; (iii) Chemical science & technology; (iv) Engineering sciences; (v) Energy, water, climate and natural resources; (vi) Health and medical technology; (vii) Life sciences and biotechnology; (viii) ICT, applied mathematics and data science and technology; (ix) Material science & technology; (x) Physics and astrophysics; (xi) Polar research; and (xii) Quantum science and technologies.

- A due diligence meeting on the final selection of three projects under the India-Russia Joint Technology Assessment and Accelerated Commercialization Programme between Foundation for Assistance to Small Innovative Enterprises (FASIE) and DST was conducted. The 2nd call was announced in October 2021 with a deadline to submit proposals by 11th February 2022.

South Africa Supported 25 ongoing joint projects in the areas of indigenous knowledge systems, Agriculture Biotechnology, Astronomy etc. Support was also extended to approved 10 projects against last Call in the area of Renewable energy & agriculture biotechnology especially.

South Korea A new multi-disciplinary joint R&D Network Centre focused on Environmental Monitoring Cyber Physical System with participation of IIT Indore, IIT Roorkee, IIT (BHU), IIT Kharagpur on Indian side and Incheon National University, Korea University and Sookmyung University on the Korean side was established. Support extended to ongoing Joint Network centre in the area of Robotics and Computational Materials. 24 Joint research Projects implemented in the areas of (i) Engineering Sciences (ii) Renewable Energy (iii) Green Mobility (iv) Materials Science & Technology (v) Health & Medical Sciences and (vi) ICT Convergence.

Sri Lanka A meeting with Sri Lankan partners was held on 15 Feb 2021 at the virtual platform to exchange the review grades of both the sides. The Department of Science and Technology (DST), Government of India and the State Ministry of Skills Development, Vocational Education, Research & Innovation, Government of the Democratic Socialist Republic of Sri Lanka has launched a joint call for proposals in the areas of (i) Food Technology; (ii) Plant based medicines; (iii) Metrology; (iv) Space Research & Applications; (v) Robotics & Automation; (vi) Industrial Electronics; (vii) Renewable Energy; (viii) Waste Management; (ix) Information and Communication Technology; (x) Any other project with national relevance (with Justifications) in August 2019. A total of 09 projects and 03 workshops were agreed for the joint funding out of the total of 193 received.

Sweden Under India Sweden S&T cooperation, there are two channels operated by both countries, one with basic R&D support and other focussing on more applied research with Swedish Research Council, Swedish Ministry of Education and Research and Swedish Ministry of Enterprise and Innovation (Vinnova) respectively.

India-Sweden Innovation Day 2021 India Sweden Innovation Day 2021 was organized on 26th October 2021 by the Embassy of India in Sweden. The event took place on both physical and virtual modes. Hon'ble Minister of State for Science & Technology & Earth Sciences Dr. Jitendra Singh and Hon'ble Swedish Minister for Business, Industry and Innovation Mr. Ibrahim Baylan from Sweden inaugurated the event.

Industrial R&D programme with Sweden A total of 06 joint projects have been sanctioned

in the areas of Smart Cities, IoT and Clean Technologies under the Industrial R&D cooperation with Sweden.



United States of America Science & Technology Cooperation between India and US is fostered under an umbrella Agreement on Cooperation in the field of Science & Technology. Bilateral S&T collaboration range from Mega Science projects, Neutrino Physics, Earth, and Ocean Science and to advance Clean Energy.

Emerging Technologies: Discussions on initiative for establishing collaboration between Technology Innovation Hubs in India with Scientific agencies in US is going on. After a series of interactive meetings with officials of Scientific agencies in India and USA, multi-stakeholder agency in USA (NIST, NSF, DoE and OSTP) led by National Science Foundation (NSF) and India (DST, MeitY, Office of PSA and NITI Aayog) led by DST came on a common platform for the proposed collaboration. Interdisciplinary Cyber Physical System and AI enabled smart connected cities emerged as areas of mutual interest. In the first phase, eight technology innovation hubs were considered for participation.

Energy Science & Clean Energy Technologies: Recognizing the need to address climate change, ensure mutual energy security and build a clean energy economy, India and the United States launched the Indo-U.S. Partnership to Advance Clean Energy (PACE) on November 24, 2009 under the Indo-US Memorandum of Understanding to enhance cooperation on Energy Security, Energy Efficiency, Clean Energy and Climate Change. Both sides have broadly shown interest to pursue the research tracks on Carbon Capture Utilisation & Storage (CCUS), Supercritical CO₂ Power Cycle, Clean Coal Technologies & Hydrogen in Phase III.

Neutrino Science & high particle physics: In the areas of Neutrino Science & high particle

physics, we are major partner of Fermi Lab in major new particle accelerator project at Fermilab - Proton Improvement Plan-II (PPI-II) 700-foot-linear accelerator which will power the long-term future of the laboratory's research program, including Long-Baseline Neutrino Facility (LBNF) and Deep Underground Neutrino Experiment (DUNE).

United Kingdom An India-UKIERI (UK India Education & Research Initiative) call for joint workshop proposals was announced in Cyber-Physical System, Water Management, Affordable health care, Advanced Manufacturing, and waste design. Based on scientific merit, the national priority of both the countries and the scientific strengths of the project coordinators, a total of 16 proposals were recommended for support out of 92 received. About 10 workshops (one Physical and 9 virtual) workshops were organized. Supported 54 ongoing joint research projects.

Uzbekistan A total of 23 Joint Research projects supported in the areas of (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.

Bilateral Industrial R&D Programme:

The bilateral Industrial R&D programmes are supported by DST and implemented through Global Innovation & Technology Alliance (GITA). Presently the active bilateral programmes are with eight leading countries including Canada, Finland, Israel, Italy, Republic of Korea, Spain, Sweden and UK. The industrial innovators from the two countries are encouraged to apply for the development of innovative product and technologies across a host of focus sectors selected as per the societal and technological needs of both the countries.

2.1.5 Ongoing Programmes and Calls

- **India-Republic of Korea** Joint R&D Programme: Call was launched on 01-Mar-2021 with priority sectors such as Future Manufacturing, Future Utilities, Digital Transformation and Biotechnology & Healthcare. 23 applications were received and currently undergoing Evaluation.
- **India-Sweden** Collaborative Industrial Research & Development Programme: Call was launched with priority sectors such as Smart and Sustainable Cities and transport systems, Clean Technologies, IoT and Digitization. 16 applications were received out of which 6 have been jointly recommended.
- **India-Spain** Programme of Co-operation on Industrial R&D: Call was launched with priority sectors clean Tech, Internet of Things (IoT), Digital Health and Medical Devices and Agro& Food Technologies. 8 applications were received. Joint evaluation is ongoing.

- **India-Israel Industrial R&D and Technological Innovation Fund (I4F):** Call for Proposal-8 was launched on 01-Sep-2021 and is currently ongoing. Priority sectors include Agriculture, Healthcare, Energy, Information and Communication Technologies (ICT) and Water.

2.1.6 Completed Projects

Four projects under the Industrial R&D programme with Israel, Canada and Italy have been closed. They are Autonomous water Pump for Irrigation, utilizing Solar Energy under India-Israel Programme with Indian Project Lead (IPL) Vyoda Private Ltd. and Israeli Lead Agrosolar Irrigation Systems Ltd.; Mission Control Intelligence: Enhancing Autonomy of Commercial Rover Missions under India-Canada Programme with Indian Project Lead (IPL) Axiom Research Labs Pvt. Ltd. and Canadian Lead Mission Control Space Services Inc.; Enhanced collaborative autonomous rover system (ECARS) under India-Israel Programme with Indian Project Lead (IPL) Bharat Forge Ltd. and Israel Lead Automotive Robotic Industry Ltd.; Gateway Device & Cloud Based Application Platform for Smart Factory under India-Italy Programme with Indian Project Lead (IPL) Nano Kernel Ltd. and Italian Lead NewEn S.R.L.

2.1.7 Multilateral and Regional STI programmes

BRICS STI- Cooperation Under India BRICS Chairship 2021, the 9th meeting of BRICS Science & Technology Ministers was hosted on 26th November, 2021. This meeting was preceded by the BRICS Senior Officials Meeting on 25th November, 2021. Science and Technology Ministers or their deputy attended the meeting from all BRICS countries. From the Indian side Hon'ble Minister of Science & Technology and Ministry of Earth Sciences, Dr. Jitendra Singh chaired the Meeting. The key deliverables of the meeting include adoption of three documents namely (i) BRICS Innovation Cooperation Action Plan 2021-2024 (ii) BRICS Science, Technology and Innovation Declaration (STI) (iii) BRICS Calendar of Science, Technology and Innovation activities 2021-2022.



Pic.: Hon'ble S&T Minister Dr. Jitendra Singh at 9th BRICS Minister Meeting

The innovation action plan envisages deepening the collaboration among the innovation ecosystem of BRICS countries. It would foster dialogue and mutual knowledge sharing; cross-incubation among startups and entrepreneurs and would help in capacity-building; soft-landing for overseas business developments. In coming 3 years a series of events and actions would take place in this regard.

The BRICS STI Declaration and associated Calendar of activities also include several other STI actions proposed to be carried out during 2021-2022 by all BRICS countries in coordinated manner. India would host five events in 2022: BRICS Start-ups Forum Meeting, Working Groups meetings of New and Renewable Energy & Energy, High performance Computing & Information and Communication Technology, Biotechnology and Biomedicine, Science Technology, Innovation Entrepreneurship partnership (STIEP). India has proposed to create BRICS Innovation Launchpad as a Microsite (Knowledge Hub) as a part of Innovation action plan.

BRICS Thematic Working Group meetings

5th BRICS STIEP Working Group Meeting: India hosted the 5th BRICS Science Technology Innovation Entrepreneurship (BRICS-STIEP) Working Group meeting was held on 29th – 30th September, 2021 in virtual mode. The main agencies from BRICS countries includes DST, Department for Promotion of Industry and Internal Trade (DPIIT), NITI Aayog (Atal Innovation Mission), Start-up India, MEA from Indian side. From Brazilian side, Ministry of Science, Technology and Innovation (MCTI), Ministry of Science and Higher Education (MSHE) from Russian side, from China side Ministry of Science and Technology (MOST and from South Africa side Department of Science and Innovation (DSI), South Africa participated.

The heads of delegations from BRICS countries presented the respective country's policy update and actions on innovation development. The discussion emphasized the value of leveraging each other's experiences to strengthen the innovation efforts and the need and importance of developing BRICS Innovation Action. India presented the draft BRICS Innovation Action Plan 2021-2024 which aims to foster dialogue among innovators, capacity building, cross incubation and facilitate soft landing of start-up companies in member countries. The idea of BRICS STIEP was mooted by India and a concept note in this regard was first presented during the 4th BRICS STI meeting in Jaipur in 2016. To build upon this, India has proposed the new BRICS innovation action plan 2021-2024 which was well appreciated by BRICS Countries appreciated.

BRICS Astronomy Working Group Meeting India hosted the seventh meeting of BRICS Astronomy Working Group Meeting online on 19-20 May 2021. The BRICS Astronomy Working Group (BAWG) provides a platform for BRICS member countries to collaborate in the field of astronomy. From Indian side the Inter-University Centre for Astronomy and Astrophysics (IUCAA), Pune and Department of Science and Technology (DST), Government of India coordinated the meeting. More than 50 participants including researchers, academicians

and government officials participated from all five countries. The key scientific institutions participated from BRICS countries include Tata Institute of Fundamental Research Mumbai, Indian Institute of Astrophysics, Bangalore, National Center for Radio Astrophysics Pune, Delhi University from India; National Laboratory on Astrophysics; Brazilian Center for Research in Physics, National Institute for Space Research from Brazil; the Institute of astronomy of the Russian Academy of Sciences, Russia; National Astronomical Observatories, Chinese Academy of Sciences, Chinese Academy of Sciences, China; The African Astronomical Society, South Africa. The members of the working group indicated future directions of research in this area such as building network of intelligent telescope and data network, study of transient astronomical phenomena in universe, Big Data, Artificial Intelligence, Machine Learning application to process the voluminous data generated now a days due to enhance multi-wavelength telescope observatory.

BRICS Biotechnology Biomedicine Working Group Meeting 25th -26th May: Fourth BRICS Working Group meeting on Biotechnology and Biomedicine was hosted online from May 25-26, 2021. More than 60 participants including researchers, academicians and government officials participated from BRICS countries.

DST and DBT reiterated its commitment for co-investment of resources including funding for supporting BRICS multilateral projects. Each BRICS country shared their experiences in fighting against Covid-19 and their strengths, milestones and achievements in the field of Biotechnology and Biomedicine highlighting research activities. The members of the working group suggested future directions of research collaboration among BRICS countries in the areas such as Antimicrobial Resistance, Artificial Intelligence and Digital Health Medicine, Non-Communicable Diseases, Neurological Disorders, Agro-biotechnology, Food and Nutrition, Cancer, long Post-COVID Challenges and Complications including Molecular Pathogenesis of COVID-19 virus.

High Performance Computing (HPC) and Information Communication Technologies (ICT) Working Group Meeting 27th -28th May, 2021: Fifth BRICS Working Group meeting on High Performance Computing (HPC) and Information Communication Technologies (ICT) was hosted and organized online from 27-28 May, 2021. More than 50 participants including researchers, academicians and government officials participated from BRICS countries. The key scientific institutions participated from BRICS countries include Department of Science and Technology (DST), Ministry of Electronics and Information Technology (MEITY), Centre for Development of Advance Computing (C-DAC) from India; National Laboratory of Scientific Computation (LNCC), Brazil, SenaiCimatec, Research Institute in Brazil, Research Computing Center, Moscow State University (RCC MSU), Russia, Guangzhou University, Sun Yat-sen University from China. And Department of Science and Innovation, South Africa, National Research Foundation (NRF), South Africa, South African Weather Service, South Africa.

The members of the working group suggested future directions of research collaboration

among BRICS countries in the areas such as HPC and weather-Climate-Environment Applications; Application of Supercomputers to Drug Design, “AI+HPC” based Precision Medicine and Public Health particularly for fighting Pandemics, Geoinformatics for Sustainable Development.

BRICS 2021 Call for Proposal A total of 334 project proposal was received against the BRICS 2021 call. and screening of these proposal is under process in the 10 different thematic areas.

BRICS Young Scientist Conclave: Department of Science and Technology (DST), Government of India and National Institute of Advanced Studies hosted the sixth BRICS Young Scientists Forum from 13-16 September 2021. This year, the Conclave focused on three themes: Healthcare, Energy Solutions and Cyber Physical Systems. For the theme healthcare, there were a total of 27 participants, from Energy Solutions there were 26 participants and 22 participants in the discussion on Cyber Physical Systems. There were also 20 participants in the competition for the Innovators’ Prize from all the BRICS member countries.

The Adjudicators unanimously selected Jiang Li as the third prize holder, Junyi Gao as the second prize holder and Joao Pedro de Goes Novochadlo as the winner of the Innovators’ Prize competition.

BRICS S&T Working Group meeting: Despite challenges posed by COVID-19 pandemics, the BRICS S&T Working group met (virtually) 7 times to discuss the ways and means for furtherance of the BRICS STI Cooperation. They prepared agenda, implementation plan and executed more than 20 thematic meetings and high-level official meeting including BRICS SOM and Ministerial Meetings during India’s BRICS 2021 Chairship in close coordination with MEA Calendar of activities.

Further the Working group was instrumental in bring 10 funding agencies on common platform for supporting BRICS 2021 call for proposals. India presented the draft declaration of ministerial meeting which highlights various scientific achievements including thematic meetings and events organized during India’s BRICS Chairship.

STI Cooperation with European Union

A meeting between Hon’ble Minister for Science & Technology Dr. Jitendra Singh and EU Ambassador Mr. Ugo Astutoled European delegation was held on 13 October 2021. Stating that India and European Union’s collaboration represents aspiration of two billion people, Hon’ble Minister called for reinforcing bilateral strategic partnership and developing a shared approach at the multilateral level to address global challenges. Referring to Prime Minister Narendra Modi’s exhortation that the ultimate aim of all scientific endeavour is to bring “Ease of Living” for common man, he said that both India and the EU must deepen cooperation in the areas such as health, agriculture, water, renewable energy, biotechnology, electric

mobility, ICT, AI, robotics, and environment. Dr Jitendra Singh noted with satisfaction that India is closely collaborating with the European Union in the mission innovation programme which is currently led by the EU. He said India is closely involved in shaping up Mission Innovation 2.0 where the focus will be on the development of time-bound missions with clear deliverables and resource commitment. Noting that the European Union has recently launched “Horizon Europe (2021-2027)”, which is a planned seven-year scientific research initiative, and is approaching Indian scientific agencies for its participation in Horizon Europe. He also flagged that the concerns on issues related to IPR sharing, scope of the joint call, signing of a model grant agreement, and joint evaluation are addressed at the satisfaction of both the sides.



Pic. Hon. S&T Minister Meeting with EU Ambassador led delegation.

Both sides agreed that IPR, data-sharing and materials/equipment transfer would be done as per relevant provisions in India-EU S&T Agreement and principles and policies of IPR. The EU Ambassador also thanked Singh for India's support for protecting the Antarctic environment by co-sponsoring the EU's proposal for designating East Antarctica and the Weddell Sea as Marine Protected Areas (MPAs) recently.

India-EU Workshop on Water: India-EU online workshop on wastewater treatment, reuse, and demonstrations of latest state of art affordable technologies in the Indian field conditions was held. The workshop was organized under one of the India-EU water projects supported by the Department of Science & Technology (DST) and the European Commission. More than 150 researchers; representatives from the industry; end-user like civic bodies, NGO; DST officials participated in these workshops.

Four India-EU research and deployment projects (PAVITR, LOTUS, PANIWATER, SARASWATI 2.0) were implemented. These projects are targeting the design, development, and deployment of wastewater treatment technologies suitable to Indian conditions. One of the projects is working on the development of a sensor for real-time water quality monitoring in the pipe distribution system and tanker water supply.

Shanghai Cooperation Organization (SCO) STI Cooperation:

An online meeting of the permanent working group on scientific and technical cooperation of the Shanghai Cooperation Organization (SCO) Member States was held on 8 December 2021. During the meeting, the member states discussed and finalized the draft Action Plan on scientific and technical cooperation in priority areas between the SCO Member States (2022-2025) which would be presented for consideration for approval at the forthcoming Session of Heads of ministries and departments of science and technology of the SCO Member States.

The priority areas for collaboration include emerging medical/Biotechnology, Electronics, Energy, modern agriculture technologies for precision farming and; organising online conferences on usage of emerging technologies.

Indian Ocean Rim Association (IORA) The first meeting of the Indian Ocean Rim Association (IORA) Working Group Science Technology and Innovation (WGSTI) was held online on 30th September 2021. The member countries participated in the meeting are as follows: Commonwealth of Australia, People's Republic of Bangladesh, Union of Comoros, French Republic, Republic of India, Republic of Indonesia, Islamic Republic of Iran, Republic of Kenya, Republic of Madagascar, Malaysia, Republic of Maldives, Republic of Mauritius, Republic of Mozambique, Sultanate of Oman, Republic of Seychelles, Republic of Singapore, Federal Republic of Somalia, Republic of South Africa, Democratic Socialist Republic of Sri Lanka, United Republic of Tanzania, Kingdom of Thailand, United Arab Emirates and Republic of Yemen.

The meeting reviewed the status of implementation of WGSTI Work Plan 2020-2021 and finalized the draft inputs for IORA Work Plan 2021-26 for adoption by the IORA Council of Ministers. The meeting agreed that a new work plan that is aligned to the 2nd IORA Action Plan (from 2022) need to be drafted. The meeting agreed to constitute an ad hoc Sub-Committee of members to prepare a first draft of the WGSTI work plan for 2022-2026. India and South Africa volunteered to serve in the ad hoc Sub-Committee

India-ASEAN S&T Cooperation program 21 new collaborative R&D proposals in the abroad areas of Bio-medical related to Covid-19 disease, ICT & Artificial Intelligence and Cyber physical systems; and Nanotechnology & Material Science were sanctioned for a period of 2 years' duration. 24 Research and Training Fellowships were awarded to ASEAN professionals for carrying out their research work at various Indian Institutes. About 10 new R&D proposals and 15 new fellowship applications have been received and are being

technically evaluated by various Expert Committees for support under ASEAN-India S&T Development Fund.

2.1.7 Human capacity building/ overseas exposure visits

India Science and Research Fellowship (ISRF) Programme As a part of India's initiatives to engage with our neighbouring countries to develop S&T partnerships, DST has launched India Science and Research Fellowship (ISRF) Programme for the Afghanistan, Bangladesh, Bhutan, Maldives, Myanmar, Nepal, Sri Lanka, Thailand researchers to work in Indian Universities and Research Institutions in 2015.

This year, a total of 66 applications were considered from researchers of Afghanistan, Bangladesh, Bhutan, Maldives, Myanmar, Nepal and Sri Lanka, which were reviewed by a Panel of Experts. Based on research proposal, experience, academic merit and publication record, 40 candidates were recommended for the award of India Science and Research Fellowship (ISRF) under Call-2019.

Review meeting on India Science Research Fellowship An online review meeting was organized by Department of Science and Technology (DST) in collaboration with Indian National Science Academy (INSA) on India Science Research Fellowship (ISRF) on 16th June 2021. The previous ISRF awardees of different neighbouring countries like Bangladesh, Nepal, Myanmar, Sri Lanka etc and mentors of various research fields from prestigious Indian Institutes have participated to share their experiences, views and suggestions for the improvement of the fellowship programme.

DST-ICTP Ramanujan Prize: The UNESCO-ICTP Ramanujan Prize of US\$ 15000 for Mathematics which is supported by DST has been awarded to Prof Dr Neena Gupta, Indian Statistical Institute (ISI), Kolkata for her work on research on algebraic geometry and commutative algebra. Prof. Gupta is the third Indian woman to receive this award. The award shall be conferred by ICTP, Trieste Italy in February 2021 in virtual mode in presence of eminent personalities across the globe.

2.1.8 Other Engagements

Technology Summit 2021: The Department of Science & Technology, Government of India, in partnership with the Confederation of Indian Industry (CII), co-organized the 27th edition of the DST- CII Technology Summit from 16th – 17th December 2021 over a digital platform with Netherlands, Brazil, Canada, Russia as partners. The summit was attended by 60 speakers and 700 participants from technology experts, government, academics, Industry, and startups from India, the Netherlands, Russia, Brazil, Canada, and many other countries to engage in high-level technology leadership dialogues to explore technology & business partnerships and thereby boost innovation, investment, and trade. More than 100 B@B meetings were held over a period of 2 days.



Global Indians in S&T (GIST) Meet: A hybrid GIST meet focussed Education, Aahar Kranti and Agriculture was organised as a part of the India International Science Festival-2021 (IISF-2021) during December 11-13, 2021. During the Meet Diaspora from different part of the world deliberated upon the **focussed areas to develop vision for new India.**

Interaction with Indian Diaspora: Interaction of Secretary with Indian Diaspora at USA was held on 20th Aug 2021. Secretary DST, along with 11 Vice Chancellors of various US universities, ambassador of India at USA, Science counsellor, Chairman UGC and DST officials have joined the meeting and discussed the way forward to connect Indian diaspora with Indian researchers along with promotion and development of S&T.

41st Session of the UNESCO General Conference

The DST participated in the **41st Session of the UNESCO General Conference held during 9-24 November 2021 in virtual mode and contributed in discussions in finalizing the UNESCO's recommendation on "Open Science"**. Secretary, DST also participated in the high-level round table on the role of science, technology and innovation in a sustainable and resilient recovery from the current pandemic.

DST participated in the twenty-fourth session of the Commission on Science and Technology for Development held in virtual mode from 17 to 21 May 2021. The Commission addressed two priority themes: (a) Using science, technology and innovation to close the gap on Sustainable Development Goal 3 on good health and well-being; and (b) Harnessing blockchain for sustainable development: prospects and challenges. Participants included representatives of Governments, international organizations civil society, and the private sector.

2.1.9 Bi-national Centres

Indo-French Centre for Promotion of Advanced Research (IFCPAR/CEFIPRA)

The Indo-German Science & Technology Centre (IGSTC)

IGSTC together with German Federal Ministry of Education and Research (BMBF) and the Department of Science and Technology (DST) has conducted two Financial Committee and two Governing Body (GB) meetings.

The evaluation of the Indo German Science and Technology Centre (IGSTC) for its continuation beyond 2022 are carried out by the evaluators of both sides. IGSTC evaluation committee interviewed the Governing Body members, IGSTC German office, Co-Chairs, and PIs of both sides. The committee made preliminary results of online Survey on 2+2 Projects. The report strongly recommended continuation of the centre and advised for wider advertisement of its activities. The detail report is being circulated to all the GB members of the IGSTC.

IGSTC launched new Programs like: i) Industrial Fellowships- On 11th Foundation day of IGSTC, Secretary DST announced the industrial fellowship program on 14th June 2021 for Indian Ph. Ds and Postdocs to work in the German Industrial setup. A total of 20 fellowships were recommended in the year of 2021-22, ii) Women involvement in Science and Engineering Research (WISER)- The WISER program was launched by Indo German Science and Technology Centre (IGSTC) on 24th November 2021 to support woman scientist holding regular/long term research position in Academia or research Institutes/Industry involvement in the IGSTC program through lateral entry. In this program, there is neither requirement of Break-in-Career nor any age limit, iii) Paired early career in applied research (PECFAR), iv) Project on innovative technology/transformational research, v) Project on Computational Modeling, and vi) Director's fund [Small Immediate Need Grants (SING)]-Director can be vested to the tune of around Rs. 40 lakhs per year to meet any urgent requirements for funding a program, idea or a matter of scientific relevance needing quick approval/decision.

IGSTC had launched its Call 2020 for 2+2 projects in the overall thematic area of "Additive Manufacturing" with the following subtopics: 1. New materials for additive manufacturing 2. Printed and wearable electronics 3. Large scale additive manufacturing 4. In situ process monitoring and control 5. 3D printing processes for biomedical devices and implants. IGSTC received 82 proposals.

A joint virtual workshop on artificial intelligence (AI) was organized by the IGSTC together with German Federal Ministry of Education and Research (BMBF) and the DST on 6th-7th September.

The Indo-US Science and Technology Forum (IUSSTF)

The 21st Governing Board (GB) Meeting of the Indo-U.S. Science & Technology Forum

(IUSSTF) was held on 15th April 2021 virtually, under the Co-Chairmanship of Professor Ashutosh Sharma, Secretary, Department of Science & Technology, Government of India, (India Co-Chair) and Dr. Jonathan Margolis, Deputy Assistant Secretary, Bureau of Oceans and International Environmental and Scientific Affairs, U.S. Department of State (U.S. Co-Chair). The 22nd Meeting of the U.S.-India Science and Technology Endowment Board (USISTEB) was held on 12th April 2021 under the Co-Chairmanship of Indian and the USA representatives.

New Call: In December 2021, the United States-India Science & Technology Endowment Fund (USISTEF), in partnership with Social Alpha, announced a call for Ignition Grants titled **Technology-based Energy Solutions: Innovations for Net Zero** to select and support new technologies that address climate change and clean energy challenges. The objective of the Ignition Grants program is to identify and support “technology showstoppers” - promising joint U.S.-India S&T based entrepreneurial initiatives that address the development and implementation of new technologies, tools, and systems to tackle climate and clean energy challenges in the areas of Next generation Clean and Renewable Energy, Energy Storage and Carbon Sequestration.

2.1.10 Strategic Initiative in Artificial Intelligence (NEW):

On the 17th of March 2021, IUSSTF launched the U.S. - India Artificial Intelligence (USIAI) initiative, a platform for key stakeholders from both countries to discuss key challenges and barriers to adoption of AI, identify opportunities for R&D collaboration, and recommend modes and mechanisms for catalyzing partnerships. Over the course of the year five roundtables were organized under the broad theme of Trustworthy AI. They were Trustworthy AI for Social Good: AI technologies in the Indian and U.S. contexts; Principles of Trustworthy AI: Comparing Western and Non-Western conceptions of fairness and AI ethics; Trustworthy Security Systems (Biometrics); Institutional Trust; Federated AI and Computational Trust.

2.2 National Mission on Nano Science & Nano Technology

Nano Mission in its new avatar as “**National Programme for Nano Science and Technology (NPNST)**” with vision to promote and develop applied projects with potential products for national development. A new Infrastructure Development for Nano Technology is now being jointly pursued by DST along with other Ministries/ Agencies that include M/o Electronics & IT (MeitY), DBT, ICAR, ICMR, & other funding Departments/ Agencies. Department had funded Nano Applications & Technology Development Programmes including Joint Industry-Institute Partnership Programme, International Collaborative Programmes in Nano S&T, two Nano Technology based Incubators and Domestic PDF programme for Human Resource Development in this area through Fellowships thereby catering the Government Initiatives like Innovate India, Make in India, Startup India and Swatch Bharat Missions.

The support under Nano Mission, extends to create skilled human resources, projects related

to Nano Science and Technology and building infrastructure of Nano S&T Labs at several Institutes spread across the country.

In recent years, the programme is focusing more on creating suitable environment to attract technology relevant projects. This is being achieved through an active dialogue with the Industry either by co-funding partially the industry sponsored relevant projects in Nano S&T or by supporting incubators and start-ups in the area in close consultation with other Innovation Programmes in DST and other Departments/ Ministries. Also identifying feasible technologies and funding prototype development with Industrial involvement and transfer them to start-ups or collaborating industry.

BASIC RESEARCH PROMOTION

We have supported few new individual scientist-centric R&D projects during 2021-22.

Some prominent R & D areas supported under Nano Science included:

- *New Facets in Perovskite Nanocrystals and their Heterostructure*
- Chiral plasmonic nanogap platforms for giant THz circular dichroism
- DNA Aptamer Conjugated Nanoprobes for REACH chemicals recognition
- *Lattice dynamics calculations and density functional theory-driven phonon Boltzmann transport equation solver for nanoscale thermal transport properties prediction of strongly anharmonic semiconductors Application to type-I inorganic Clathrates*
- *Development of Novel Eye Drops of fixed dose combination for Effective Ocular Delivery*
- *Double encapsulated nanocomposite granules for the staged delivery of herbicides and growth stimulant to control Striga, a parasitic weed in Sugarcane*

Based on the discussions in the Nano Mission Council, we had advertised a “Call for Proposals” in three thematic areas namely:

- i. Nano Technology in Agriculture
- ii. Nano in Energy and Environment
- iii. Quantum Materials – with novel properties and applications

We received a huge response to this call and we received 120 proposals against i., 199 proposals against ii. Above and 59 proposals for the iii. Out of these, Expert Committees having an Expert from ICAR, NABI and IIFCO's Centre for Research in Nano Biotechnology at Kalol and Academic experts screened-in 20 proposals in i; 10 proposals in ii and 22 proposals in iii. After critical evaluation, finally, 3 proposals in NT in Agriculture, 3 in Nano in E&E and 11 in Quantum. 2 proposals from same Institute were asked to be merged before

recommending. All three proposals in Agriculture last year along with 4 proposals in Quantum Materials have been supported.

Thematic Proposals

We also reviewed **34 proposals** in Nano Science that included On-going proposals as well as Completed proposals. The Review Committee rated **2 as A ‘Excellent’, 8 as B+ ‘Very Good’, 5 as B ‘Good’, 7 as C+ Fair, 4 C Satisfactory, 1 C- Just Satisfactory & 4 D-Not Satisfactory. 2 projects were closed 1 as per the Co-PIs request, since the PI had expired. 1 project was asked to be closed due to non-performance.**

This year we have supported so far 5 proposals in Quantum Materials and all three in Energy & Environment. We plan to support all proposals in Quantum Materials by releasing small General grant this year with grant under Capital in next FY.

TECHNOLOGY DEVELOPMENT

The main aim of the new Scheme NPNST is to drive Technology and Applications Development and this year we have funded so far 11 new proposals in this area. Under thematic unit of Excellence, three ‘Energy and Environment’ projects were sanctioned and one technology business incubator (TBI) unit is established at INST Mohali. The TBI is aimed to cater the Nanobio start-ups and targeted to deliver luminescent ink, drug delivery system and nanotherapy products. It is expected to be running as self-sustained entity towards completion of the project.

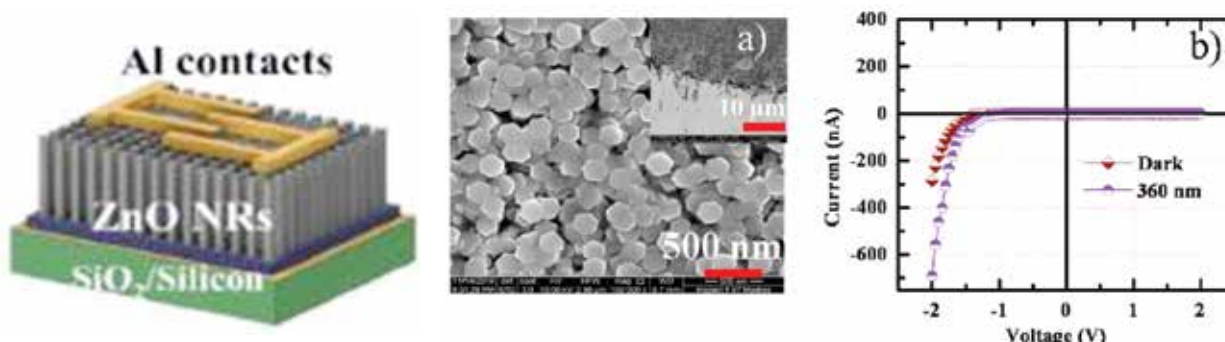
The following **Energy & Environment** projects are sanctioned aiming specific deliverables:

- **Nanostructured Materials for Next-generation Energy Conversion and Storage Devices** – focused on delivering pouch or large formats batteries with an energy density of > 150Wh/kg and 200 cycles with 80% depth of discharge.
- **Photochemical and Electrochemical Processes in Assembled Molecules and Nanomaterials: Implications of Electric Field and Coherence in Photovoltaics** – intended to address the energy transfer at single particle level of plasmonic platforms and photophysical and electrochemical materials-based devices.
- **Organic-Inorganic Hybrid Nanomaterials for Non-Conventional Energy Technologies** – focused on delivering prototypes in DSSC, smart glass technologies, energy saving conductive coatings.

Under Nano technology scheme 46 ongoing and completed projects were reviewed, and also 11 new projects were recommended for funding in 2021. The demographic projection of new projects receiving grants is shown below:

Selected research highlights from projects funded under Nano S&T:

1) ZnO nanorods based UV detectors demonstration



Projects Reviewed during the year:

During the period 2018-19, based on the decision by NSAG, a separate review Com

- (a) FESEM image of ZnO nanorods (b) I-V characteristics of ZnO/p-GaN heterojunction in dark and under illumination.

The photo-responsivity and photo-detectivity values of as-fabricated device were calculated to be 350 mA/W and 3.5×10^{11} Jones, respectively at 360 nm excitation wavelength and at very low excitation intensity $\sim 1.79 \mu\text{W}/\text{cm}^2$ which is rarely observed in the literature.

2) Diatom solar panels for biofuel production

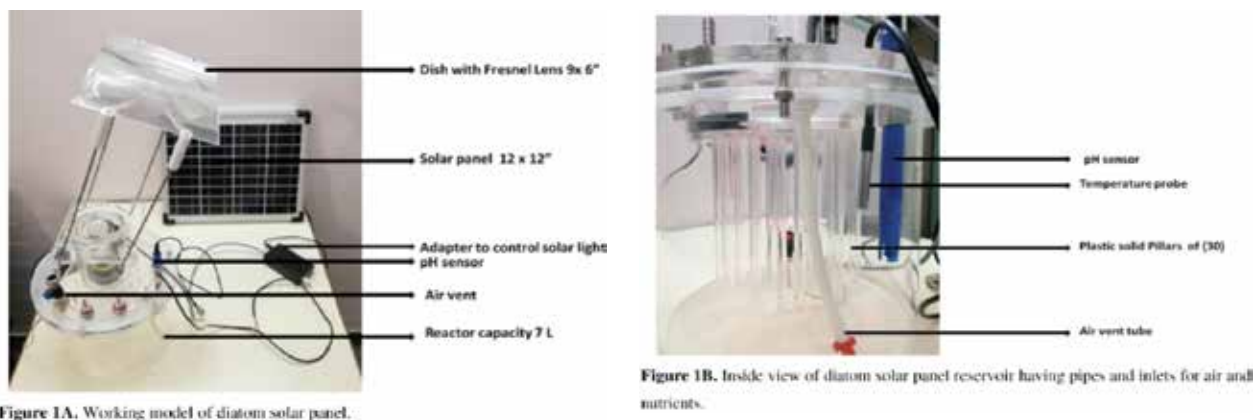


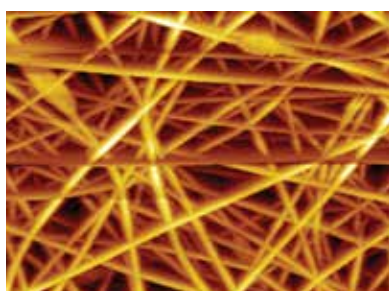
Figure: Left - Optimized structure of Biotin-Trp-Trp and Aleuritic-Trp peptides. Right - Microstructure of dye sensitized solar cell via doping Ag NP. Source: Journal of Molecular liquids 249 (2018)

Diatom has abundant oil content therefore it could serve as an alternative source for rapidly depleting fossils fuels. In this project it has been demonstrated developing Ag nanoparticle on the Diatom surface that can be used as dye sensitized solar cell. The process follow of Ag NP fabrication is shown in the Figure – 3. Also there is an effort to produce biofuel from Diatoms

via harvesting sunlight energy by using portable mobile units. Currently the prototype is being worked out and in the process of patenting the design.

3) Nanotechnology for Agriculture – 3 Updates of Sanctioned projects:

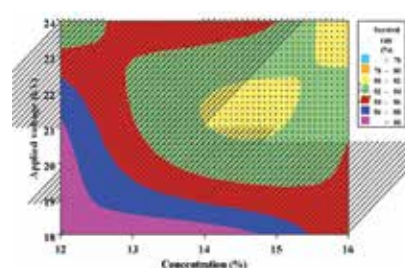
- (a) ICAR-National Dairy Research Institute, Southern Regional Station, Bengaluru (Lead Centre) and ICAR-NDRI, Karnal (Cooperating Centre) :The experiments carried out revealed that the encapsulated probiotic cultures in electrospun pullulan-based nanofibres are safe for food applications. One publication is already out (Food and Beverage Processing. Vol. 7 (10), April, 2021.)



AFM of pullulan-*L. rhamnosus* loaded electrospun fibres



Electrospun pullulan- prebiotic-lyoprotectant fibres loaded with *L. rhamnosus*



Optimization of electrospinning of *L. rhamnosus*

- (b) Researchers at IIT Delhi & IIT Hyderabad have done risk assessment and maximum allowable concentration for two selected copper nanoagrochemicals without posing human risk and plant toxicity(Figure). Further, the developed two-way coupled model incorporating the first-order heteroaggregation kinetics fits the observed breakthrough curves reasonably well for the co-transport of clay colloids -viruses, bacteria - graphene oxide nanoparticles, and clay colloids - graphene oxide nanoparticles. Two publications are already out.

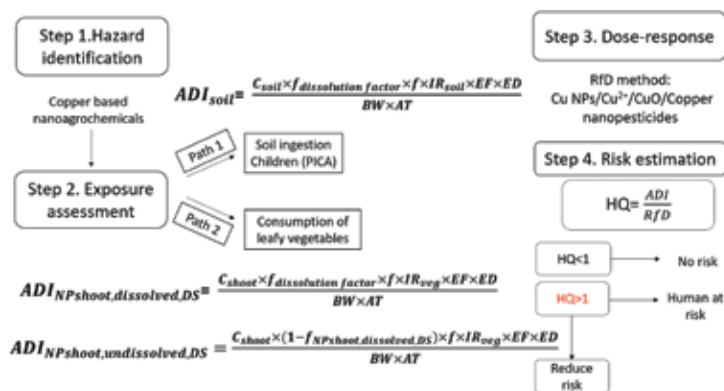


Figure: Schematic showing proposed framework for estimating risks due to nano-agrochemicals ("NanoAgroChemRisk" hereafter)

Some Notable achievements from On-Going projects

In vitro studies carried out by Researchers at Tripura & Jamia Millia University showed that Zinc Oxide Nanorods, and Cu doped ZnO NPs are able to kill 95% *Pseudomonas aeruginosa* (WHO Critical Priority microorganism) & 99.8% *Staphylococcus aureus* (bacteria isolated from patient with wound infection). Zinc Oxide Nanorods show excellent biocompatibility *in vivo* mice studies.

Researchers at Amity, Gurgaon are utilizing a nanobionic approach for enhancement of plant photosynthesis and growth by augmenting chloroplast mediated photon absorption

Synergy with other Departments in Nano-Technology

- **DST** along with **DBT, ICMR, CDSCO** was involved in finalizing two Guidelines which were released last year. These are as follows:
 - o **Guidelines for Evaluation of Nanopharmaceuticals in India along with ICMR and CDSCO**
 - o **Guidelines for Evaluation of Nano-Based Agri-Input and Food Products in India**
- DST also partnered with MeitY in a Project entitled “**Nanoelectronics Network for Research & Applications (NNetRA)**” being implemented by IIT Bombay, IIT Delhi, IIT Madras, IIT Kharagpur and IISc Bengaluru. The project is for a period of four years with the vision of making India “knowledge rich” in Nanoelectronics.
- Under NNetRA following are the achievements:
 - o Supported for developing Nano Technology from TRL – 3/4 to TRL – 7/8 i.e. ready for technology transfer. So far, 17 Technologies in five areas Agriculture, Healthcare, Safety, Devices, and Environment have come up.
 - o Gas Sensors for H₂, O₂, NO₂, N₂H₂ have been developed at IISc and deployed at SHAR, ISRO for the validation of complete sensor system and user feedback for further improvements. Continuous monitoring of deployed sensors is being carried out for possible reliability issues.
 - o Around 80 soil moisture sensors have been deployed at various fields to generate data base and reliability.
 - o Prototype of Monolithic Microwave Integrated Circuits (MMICs) and RF modules for strategic and high-end applications using GaN High Electron Mobility Transistors (HEMTs) is being developed at IITB.
 - o A prototype of ultrasensitive Magnetic field sensors based on (Super Quantum Inter-

ference Device (SQUID) along-with the associated electronics has been developed at IITD. A MoU with Dr. K.S. Krishnan Geomagnetic Research Laboratory, Jhunjhunu, Prayagraj, Uttar Pradesh has been signed for measuring magnetic moment of rocks by using the developed SQUID sensors of 1-0.1nT range.

Quantum Materials projects:

a. Achievements under the project titled **“Emergent Phases in 2D Quantum Materials & Heterostructures” Achievements** include theoretical investigations of van der Waal’s optical metasurfaces consisting of graphene and hBN carried out for the application of biosensing of multiple analytes in the mid-infrared (MIR) region. Phonon polaritons of hBN in the presence of graphene showed increased sensitivity to detect small amount of number of molecules (390 for CBP and 1990 for nitrobenzene), thus creating a highly sensitive optical biosensor. (Ref: **“Tunable van der Waals optical metasurfaces (VOMs) for biosensing of multiple analytes.” *Optics Express* 29, no. 16 (2021): 25800-25811**) The plasmon-phonon hybridization behaviour between anisotropic phonon polaritons (APhP) of orthorhombic phase Molybdenum Trioxide (α -MoO₃) and the plasmon-polaritons of Graphene layer forming a van der Waals (vdW) heterostructure was investigated. It was found that in-plane APhP shows strong interaction with graphene plasmons lying in their close vicinity, leading to large Rabi splitting. (Ref: **“Tunable phonon-plasmon hybridization in α -MoO₃–Graphene based van der Waals (vdW) heterostructures.” *Optics Express* 29, no. 21 (2021): 33171-33183.**

Tight-binding calculations of lattices were studied with pyqula, a python library to compute tight-binding model (i.e. effective continuum model) in different dimensionalities and various twist angles for quantum-lattices. Initially, the moiré pattern and band structures of twisted bilayer graphene (TBG) at different twist angles (0.9° below magic angle, 1.1° at magic angle and 21.78° above magic angle) were studied. Two isolated flat bands per *spin* and *valley* appear near the charge neutrality Fermi energy, supporting the Bistritzer-MacDonald (BM) model of the TBG band structure.

b. Achievements under the project titled **Atomically thin Photonic Devices as Hosts of Single-Photon and Entangled Photon Pair Emitters and Single-Spins for Quantum Sciences and Technologies** include:

- Managed to come-up with a set of parameters which gives us a single layer of nanoparticles, and single isolated nanoparticles on top of the substrates as well as on the 2D Materials flakes deposited/transferred on the substrates (see Fig. 1(a) of the attachment).
- The Group has also come-up with a New non-destructive optical technique for imaging the nanoparticles using the Raman signal emitted from the substrate underneath of the nanoparticles (See Fig. 1(b) of the attachment). This method would show us a diffraction-limited spot for an isolated nanoparticle.

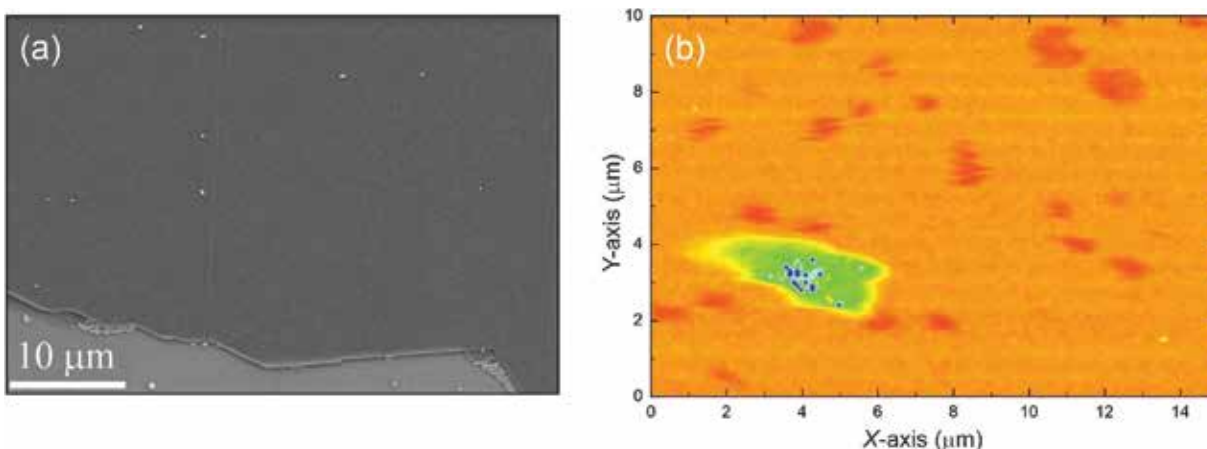
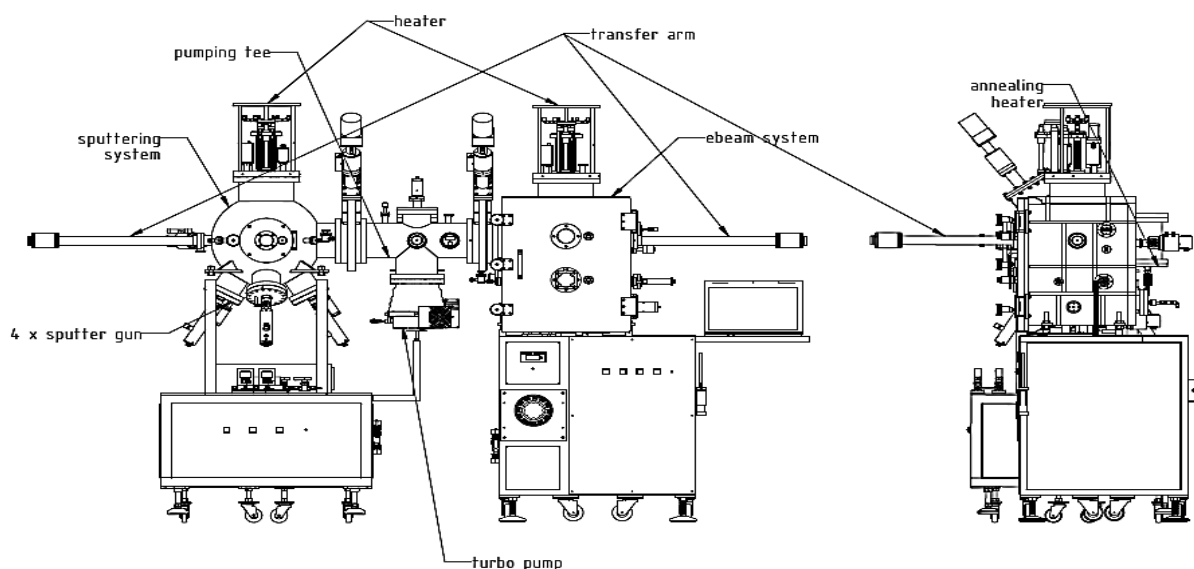


Figure (a) SEM image of a h-BN flake (dark grey) on top of a substrate (grey), showing single and isolated SiO₂ nanoparticles (white spots). **(b)** Space map of the intensities of the Si Raman peaks, showing the locations of isolated/grouped nanoparticles (red) from a different substrate. It also shows a WS₂ flake (green).

c. Achievements under the project titled “Tuning of Magnetic Skyrmionic spin structures in ferrimagnetic nanostructures for data storage applications” include:

- A custom design of the chamber has been finalized as shown below. The purchase of the deposition chamber along with its components is under process.



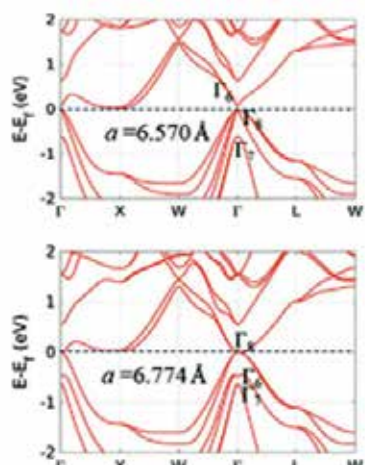
- Calibration of deposition parameters for GdFe, Fe and MnGa thin films to obtain perpendicular magnetic anisotropy has been initiated using the available set up in the institute. The main aim was to narrow down the parameters required for future depositions once the chamber is availed. The magnetic and structural behaviour of the

films as a function of thickness at room temperature (RT) as well as above RT have been studied. Basic characterization such as MOKE, XRR, XRD and VSM were performed to characterize the samples.

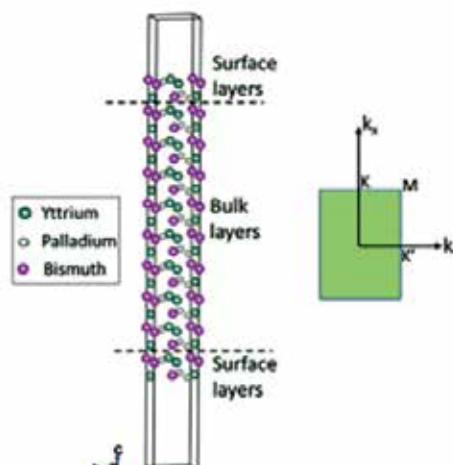
d. The project titled “**REPd/PtBi Thin Films- A Multifunctional Experimental Platform for exploring Topological Quantum phenomena and**” aims to develop a materials science platform for topologically protected quantum materials, by combining the Weyl fermionic electron states & magnetism

Several of the *oriented* (RE)PdBi thin-films have been grown by PLD technique. The bulk ingots were prepared using a laboratory-developed *rf*-melting unit (previously developed under DST’s Indo-Hungary project).

- DFT calculations to show band inversion on application of lateral strain in the lattice constant of the chosen particular RPdBi alloy. Lattice structure of semi-infinite (110) oriented slab of YPdBi with vacuum on both sides is estimated.



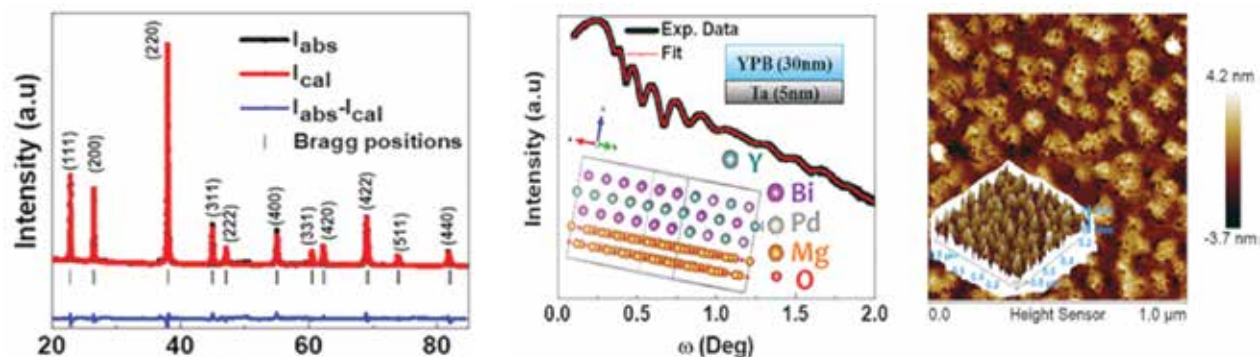
Scientific Reports (2022) 11:16101



<https://doi/10.1038/s41595-021-95598-z>

RF induction melted bulk alloy is used as the target for depositing ~ few tens of nanometer RPdBi films on MgO(100)/Ta(5nm)

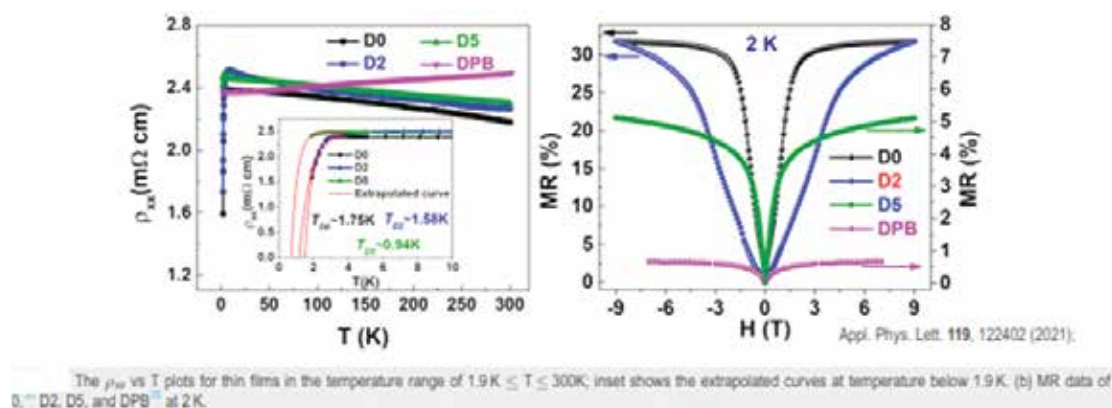
- Structural / microstructural characterizations are performed to determine the structure, surface and interface roughness of the film and the tensile strain on the film is estimated



Scientific Reports (2022) 11:16101

<https://doi/10.1038/s41595-021-95598-z>

- Magneto transport measurements are done to demonstrate non-trivial 2D surface states in the film. The Berry phase associated with charge carriers in the film leads to the weak anti-localization effect and application of a magnetic field tends to lift the destructive interference of electron wave functions between the two time-reversed paths, leading to a positive magnetoresistance.



The magnetic-field dependence of the conductivity for the weak anti-localization effect is calculated using Hikami, Larkin, and Nagaoka model. All the films investigated until now show $\alpha \sim 0.5$ and the phase coherence length L_ϕ for electron-electron scattering $\sim T^{-1/2}$, confirming the 2D topologically non-trivial surface state

- The quantitative information about the dimensionality of the Fermi surface and non-triviality of the material system was calculated from the Berry phase as extracted from the quantum oscillations (Shubnikov-de Haas (SdH)) of the conductivity data at low-temperature and high field magnetic field. Fitting of the data to the Lifshitz-Kosevich formula yielded Berry phase $\sim \delta$.

Publications that have resulted out of the work until now are:

- 1) Anupam Bhattacharya, Vishal Bhardwaj, Brajesh K Mani, Jayanta K Dutta and **Ratnamala**

Chatterjee, “Strain-tunable triple point Fermions in diamagnetic rare-earth half-Heusler alloys” **Nature Scientific Reports**, **11** (1), 1-8 (2021)

- 2) Vishal Bhardwaj, Anupam Bhattacharya, Shivangi Srivastava, VladimirV. Khovaylo, JhumaSannigrahi, Niladri Banerjee, Brajesh K. Mani & **Ratnamala Chatterjee** “Strain driven emergence of topological non-triviality in YPdBi thin films.” **NatureScientific Reports** **11**, 7535 (2021)
- 3) Vishal Bhardwaj, Niladri Banerjee, **Ratnamala Chatterjee**, “Structural and transport properties of 4f-electron (Dy) doped $Y_{1-x}(Dy)_x$ PdBi topological semi-metallic thin films”, **Appl Phys. Lett.** **119** (12), 122402 (2021).

INTERNATIONAL COLLABORATIONS

The **Indian Beamline for Nano Science and Technology at PETRA-III, DESY, Germany** has entered its Phase II in 2020, based on the experiences gained in the Phase-I. The duration of Phase-II is for 5 years and we have got 758 days of Beamtime for Indian to use it. The experiment so far has been successful for such samples that can be delivered to JNCASR. Right from the inception of this project, large fraction of beamtime to new users and as a result the number of synchrotron users in material research has increased almost 3-times and several high-quality PhD thesis-work have been completed. At present users from 64 research institutes across India avail this facility. Ninety five high “quality papers” have been published from the 450 beamtime-days in Phase-I.

Apart from this, MOUs have been signed with KEK Photon factory, Japan for use of Photon beams by the Indian Scientists and many of our scientists who have experiments to be done on this have been supported for their visit to Japan. The five-year period of this collaboration was extended within the sanctioned cost till 31.03.2022. The proposal for its extension into phase II is also in consideration.

DST also has collaboration with Rutherford Appleton Laboratory (RAL), UK in January, 2015, for supporting Indian Scientists interested in using the ISIS facility for research in Nano Science & Nano Technology area. Under this a support, there is a commitment for India’s contribution towards development of India motivated beamline “ZOOM” at a cost of 2 million pounds and some funds for Rs 635 lakh under Recurring expenditure for various heads. Indian Scientists and the UK Scientists are now working together on the DPR for Phase-II.

COVID RELATED PROJECTS: Last year 6 projects were supported in 6 Institutions with Industries as partners. All the six Institutions have successfully developed the masks and transferred the technology to their partners. The following are the details of each of them:

Tribo E Mask by CeNS, Bangalore: Aesthetically acceptable, breath friendly triboelectric face masks: Design, fabrication, testing & technology translation

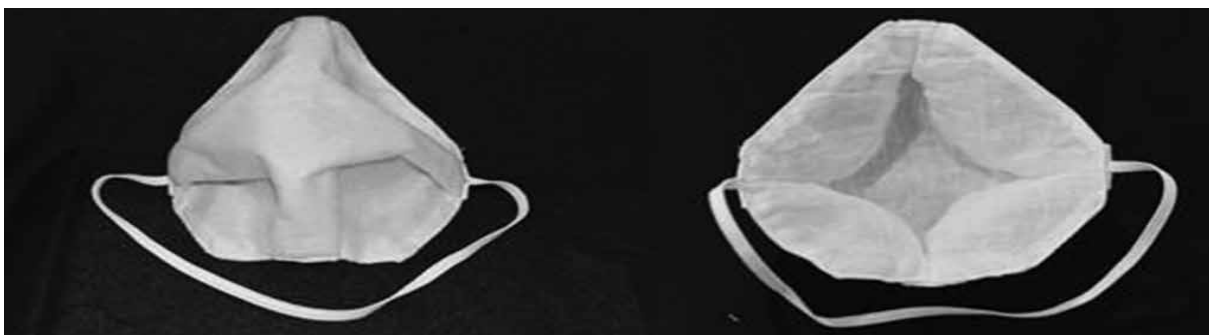
The mask holds electric charges and are expected to restrict the entry of infections but without any external power based on the phenomenon of electrostatics. The team went on to develop a unique design for the mask and have already filed the patent for this.

The face mask designed by the CeNS team has published the comfort aspect built-in along with utility. (Energy Technology 2021, 2100614 DOI: [10.1002/ente.202100614](https://doi.org/10.1002/ente.202100614))

The team has transferred the mask design and technology to Camellia Clothing Ltd., a Bangalore based garment company. The company has launched the commercial product in August 2020 as 3BO mask and these are available in India through various e-commerce platforms.

The salient features of the facemask that had been developed are as follows:

1. Overall filtration efficiency ~ 65%
2. 18% enhancement in filtration efficiency when the layers are rubbed
3. Maximum enhancement can be achieved by 30 s of rubbing
4. The charges retain for a couple of hours
5. These masks have a quality factor ~ 25, whereas the standard commercial N95 mask has a quality factor ~ 2
6. These masks are highly breathable – suitable for prolonged uses
7. The snug fit design causes almost no fogging on the glasses and there is no sound distortion
8. Bacteria filtration efficiency > 95%



Development of Self-disinfecting Copper-coated Face Mask (COP-Mask) to Combat COVID-19 at ARCI

ARCI, in collaboration with the Centre for Cellular & Molecular Biology (CSIR- CCMB) and M/s. Resil Chemicals Pvt. Ltd., Bengaluru developed a '**Nanoparticle Copper-coated Antiviral Face Mask (COP-Mask)**', that is self-disinfecting.

Copper oxide with silver (CuO-Ag) nanoparticles of ~ 20 nm are synthesized by a Flame Spray Pyrolysis (FSP) processing facility and stable nanoparticle suspension is prepared by optimizing the solid loading and pH. Uniform coating of the aqueous suspension on the cotton and polyester fabrics with good adhesion has been achieved with a suitable binder.

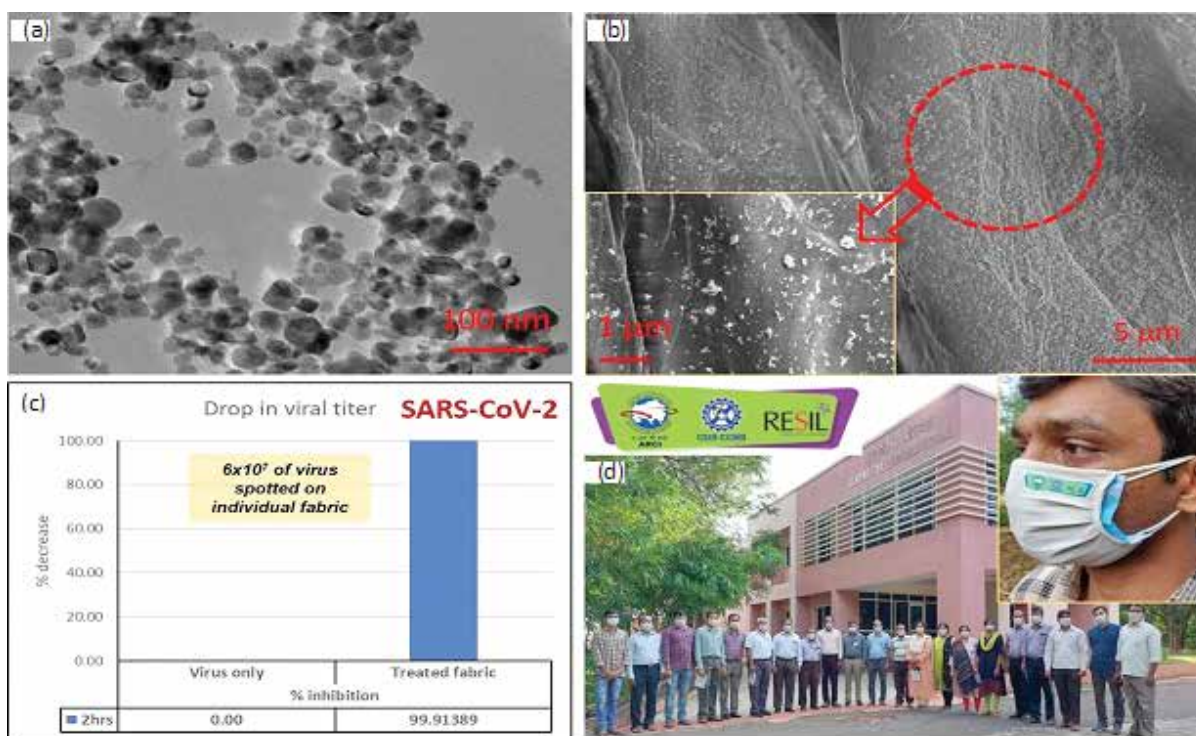


Fig. (a) TEM image of CuO-Ag nanopowders, (b) FE-SEM image of nanoparticle coated fabric, (c) COP-Mask fabric exhibiting an efficacy >99.9% against SARS- CoV-2 and (d) Demonstration of COP-masks at ARCI

In order to make it cost effective, it is advised to use a single layer copper coated fabric, which can be used as an outer-layer of the primary mask so that the protection is maximized against virus transmission. The self-disinfecting antiviral **COP-Mask** can be used multiple times.

Industrial partner M/s. Resil Chemicals Pvt. Ltd., Bengaluru is now in the process of production of such masks.

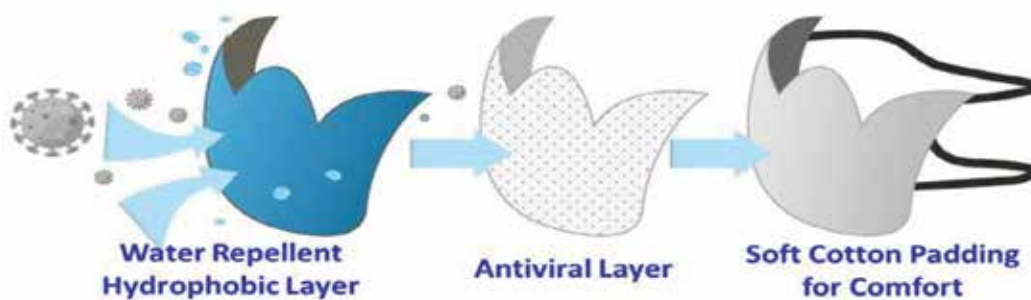
iii. **N9 blue nano silver and its nano composites as antiviral nano coatings for protection against COVID-19 virus at IIT Delhi**

The product has been developed in the form of a sprayable liquid that can create high quality durable, transparent coating on all kinds of porous and non-porous surfaces, such as masks, coveralls, metal knobs and railings, plastic buttons, bags and sheets, wood products, glass surfaces, etc.



iv. Organic-Inorganic Hybrid Nanocoatings for Disposable Masks: A Formidable Arsenal against Pathogenic COVID-19 at Jyothy Institute of Technology- Bengaluru

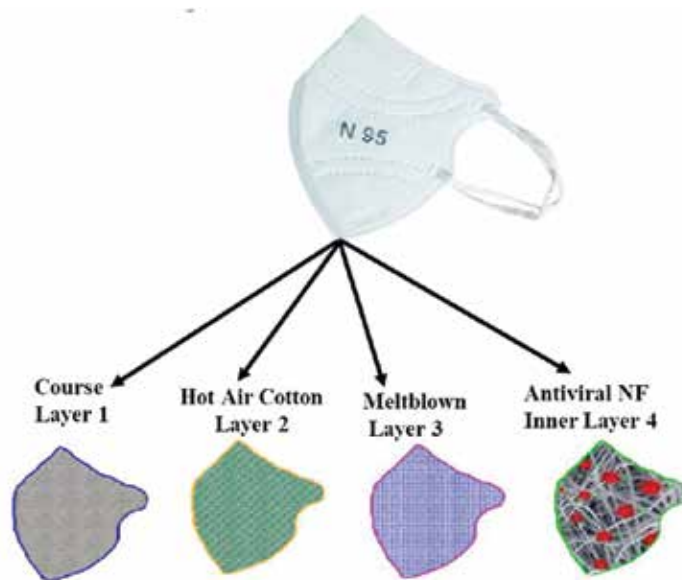
The product has been successfully developed and characterized for various parameters ranging from material properties to durability, in vitro to in vivo and inhalation toxicity to permeation. The Industry partner M/s. Medisys played a crucial role in branding and marketing the product. With the support of the industry partner, the nanocoated antiviral masks branded as “Aayudh” were sold to more than 7000 customers which included individuals, religious organizations, corporates, government offices, advocates, teachers, and many more.



v. Development of scalable and reusable N95 and N99 mask with enhanced antiviral/antibacterial property at IIT Kanpur

The objective of the proposal is to design a N95 facemasks based on nanofibers made

from polymers (Polyacrylonitrile (PAN), Nylon6(PA6) and Polyethylene Terephthalate (PET) and Polyvinyl Fluoride (PVDF)) possessing antiviral/bacterial agents (e.g. inorganic antiviral/bacterial nanoparticles and organic antiviral/bacterial molecules). In this regard, the group has fabricated N95 face mask made with Electrospun PAN nanofibers and ZnO nanoparticles. It is worth to note that the mask is reusable after washing with water and have good breathing compatibility. Further, the process developed is scalable. This project is done in collaboration with E Spin Nanotech Pvt. Ltd, Kanpur a start-up company incubated from Nanoscience Center, IIT Kanpur.



Digital photograph of N95 face mask made with nanofibers and nanoparticles

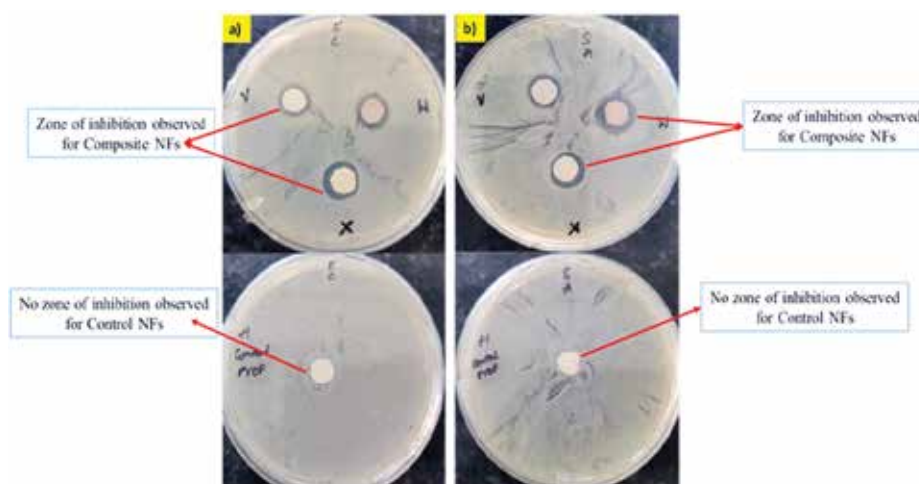
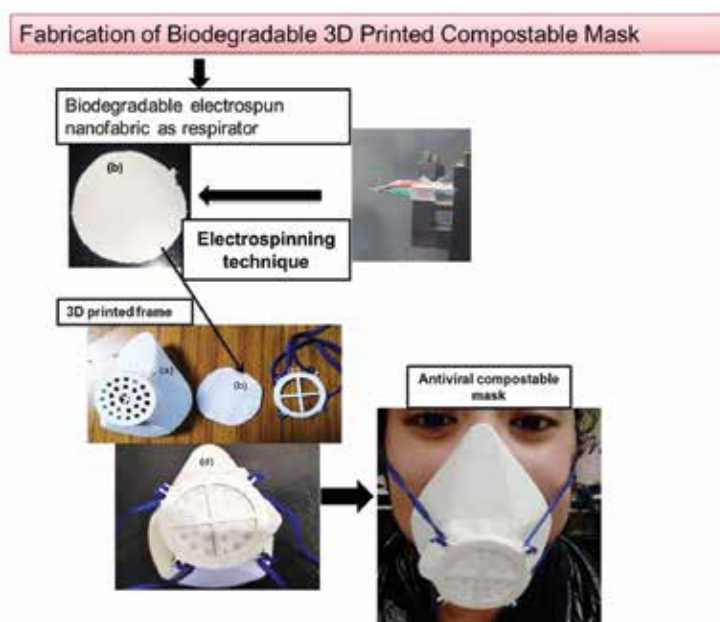


Figure: Antibacterial properties of PVDF composite nanofibers and control nanofibers. Digital images of the culture plates with inhibitory zones against a) *E. coli* b) *S. aureus* after 12 hrs incubation

vi. Project Title: Large Scale Production of Reusable and Compostable Cellulose-Nanocrystals Formulated Nano-Coating based Anti-Viral Masks and Coverall Suites for COVID 19 Patients and Health Workers at IIT Guwahati with Industrial Collaborators Aditya Birla Science and Technology Company Private Limited; GLOCAL3D Labs Private Limited, AYAPPA Nagar, Tiruchirappalli, Tamil Nadu; Biocograd Technologies Pvt. Limited, Nalbari, Assam, India – A Start-up in Assam.

Antiviral Compostable Mask

3D printed bio-degradable polymer-based facemask and nano-fabric respirators has been made via electrospinning technique. Additionally, in order to incorporate functionalities into the nano-fabric respirators, antiviral biopolymer molecules have been electro sprayed converting them into antiviral masks. Therefore, the proposed strategy of preparation of compostable/biodegradable antiviral facemasks would promote environmental sustainability and would tackle the problem of facemask disposability by alleviating the problem of one time use of masks. In the study, the reusable and washable nano-fabric respirators are found to have more than 97% efficacy rate against viruses, thus making it truly antiviral



(a) 3D printed frame, (b) nanofabric respirator (c) clip to fix respirator (d) antiviral compostable mask

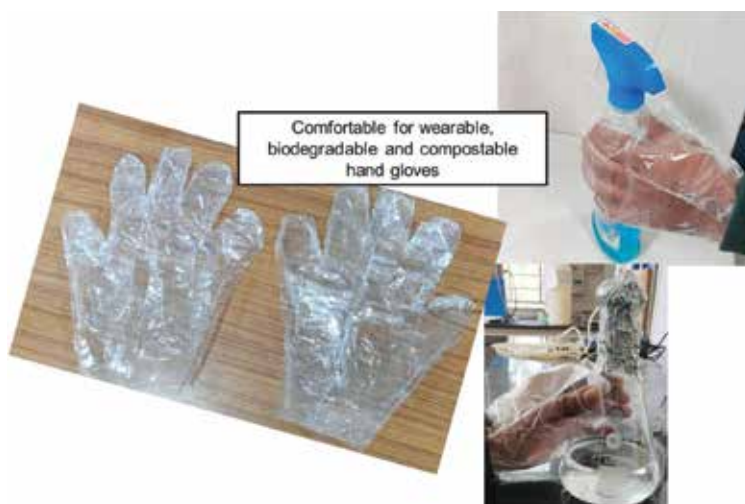
With due help from collaborators, antiviral biopolymer molecule has been added into conventional cream manufacturing process which has effectively converted into an anti-viral cream. This will not only act as a moisturizer for the skin but is also expected to give protection from viruses to reduce the inter-personal transmission. It is non-toxic and compostable after service life.



Antiviral biopolymer m based antiviral cream display (IITG EnviroCream)

Antiviral Compostable Hand Gloves:

With the increase in awareness arising from the COVID-19 pandemic, utilization of single-use or multiple-use hand gloves has been popularized and has been of massive importance. People are being expected to continue using them even after this pandemic recedes. It is utmost important that the gloves used by surgeons as well as common people, are ensured to be free from viruses. Hence, compostable films have been developed through unique antiviral master batches having antiviral activity



Antiviral Biodegradable and compostable PLA hand gloves.

2.3 Mega Facility for Basic Research

This scheme 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. Department of Science and Technology (DST) is partner with Department of Atomic Energy (DAE) in many of such projects. Under this scheme, several important developments took place during the year, which are described project-wise below.

Indian Participation in Compact Muon Solenoid (CMS) Experiment at the Large Hadron Collider (LHC), European Organization for Nuclear Research (CERN)

Indian researchers are participating in this exciting physics experiment at CERN which involves 33 Indian scientists and 80 PhD students and Post-Docs from 15 research groups. India-CMS institutes continued R&D activities and detector prototyping for High Luminosity-LHC upgrade of key components of CMS detector, Outer Tracker (OT), High-Granularity Calorimeter (HGCAL), Gas-Electron Multiplier (GEM) detector, Trigger and Electronics. Delhi University group continued work towards OT sensor qualification being certified sensor qualification center. CMS-HGCAL project published first results on physics performance of its prototype, where India-CMS HGCAL group made significant contributions. In addition, contributions were made by India-CMS members towards the studies of efficiency and calibration of sub-detectors. India-CMS members made contributions to many important physics results published in 2021 by CMS collaboration, using the data collected during LHC Run-2.

During the year, CMS published about 70 collaborative physics and technical papers in Journals, out of which India-CMS members contributed in 17 publications. India-CMS members also contributed to 2 CMS physics analysis summaries, published 16 reports in Conference proceedings and 5 Journal papers on detector R&D. The output also includes 16 Analysis and Detector Notes and 11 PhDs.

India-CMS members held Level-2 Co-Convener positions and 4 PhD students held Level-3 Co-Convener positions in various groups within CMS collaboration, 1 India-CMS faculty member became Technical Coordinator of CMS GEM project. 2 PhD students won CMS Award for role in the HGCAL test beam program and Dr. Seema Sharma, India-CMS Member, got elected as Fellow of Indian Academy of Sciences, Bengaluru for her research work primarily related to CMS activities. Financial approval process for next phase of funding support advanced further during the year.

Indian Participation in A Large Ion Collider Experiment (ALICE) at CERN

Indian researchers are participating in ALICE experiment at CERN and Solenoid Tracker

at RHIC (STAR) experiment at **Brookhaven National Laboratory** (BNL), USA. Indian participation involves 46 Indian scientists and engineers along with 55 PhD students and Post-Docs from 15 research groups.

The detector upgrade activities for Muon Station and R&D for Forward Calorimeter (FOCAL) detector were initiated during the year. The installation of detectors for ALICE 2nd Muon Tracking station got completed.

During the year, Indian researchers were joint authors in 40 collaborative research publications from ALICE and 21 research publications from STAR experiment. One publication in Physical Review Letters with significant contributions from Indian groups on the search for Quantum Chromodynamics (QCD) critical point was highlighted by the collaboration in news releases. The project also resulted in 5 PhDs and 3 Master's theses during the year. 1 School was organized on online mode in which 90 persons were trained. 2 collaboration meetings of the Indian research groups were organized in online mode in which 90 persons participated. Prof. Bedangadas Mohanty, India ALICE-STAR Spokesperson, received the prestigious INFOSYS prize in Physical Sciences for his role for investigations of the nuclear force. The next phase of funding support for the project was granted during the year.

Utilization of Worldwide Large Hadron Collider Computing Grid (WLCG) Grid Infrastructure for CMS and ALICE projects

Throughout the year, the Regional WLCG continued supporting the scientists and researchers from 30 Indian institutions and also global CMS and ALICE researchers to process the voluminous data obtained from CMS and ALICE experiments. Both Tier-2 Centres at Mumbai and Kolkata continued running almost 24X7 and average 90% availability and reliability. During the year, computing resources equivalent of 16000 cores and 17 Peta Bytes of storage were provided to WLCG. Kolkata Tier-2 Centre successfully completed about 2.7 million ALICE jobs during the year.

In addition to Tier-2 Centres, efforts were made to adopt new paradigms of artificial intelligence-enabled computing for experimental high energy physics. Both Tier-2 groups and Panjab University established Graphics Processing Unit (GPU) infrastructure for initiating the studies using Convolutional Neural Networks (CNN) for particle classifications. During the year, Mr. Brij Kishor Jashal, TIFR was appointed Member of WLCG Grid Deployment Board and Level-2 Convener for CMS Monitoring and Analytics Committee.

India's Associate Membership of CERN

India became Associate Member State of CERN in 2017. This enabled participation of Indian Industries in CERN activities. During the year, efforts continued to connect Indian Industry with CERN procurement processes. Several Indian Companies submitted market survey documents during the year. The companies include, Micropack Limited, HiQ Electronics

Pvt. Limited, Starwire India, Saarloha Advanced, Mishra Dhatu Nigam Limited and Micro Precision.

An Indian industry, Polycab signed Agreement with CERN for supply of flexible low-voltage multicore copper cables, valuing up to Rs. 30 crores in coming three years after successful qualification of its products and Company. During the year, Polycab received 41 orders worth Rs. 7.6 crores and executed 15 orders worth Rs. 2.2 crores.



Fig. 1: Cables sent to CERN (Polycab, Vadodara)

During the year, another Indian industry, INOX India received additional order for supply of 19 vacuum vessels, test bench for magnet flanges and service module jumpers. The vacuum vessels were under fabrication during the year.

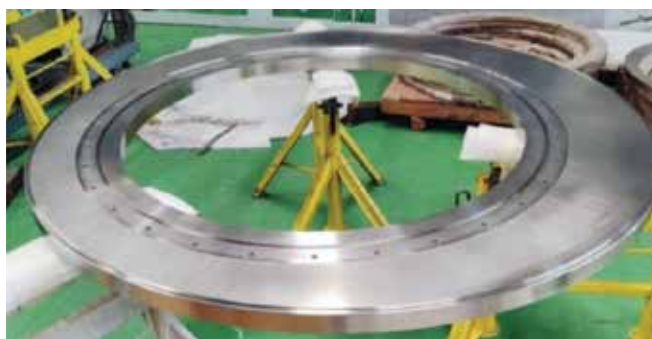


Fig. 2: Vacuum vessels under fabrication (INOX India, Vadodara)

Also, INOX India qualified in market survey for cryogenic helium distribution lines after successfully completing the concept and installation feasibility study. The bid is expected shortly.

During the year, another Indian Industry, Metallic Bellows supplied 150 metallic bellows to CERN after passing stringent helium leak test and life cycle test.



Fig. 3: Bellows for High-Luminosity Cryomagnets (Metallic Bellows, Chennai)

Also, Metallic Bellows supplied 105 prototype flexible hoses to CERN, designed for 25 bar, 2-293 K and 150 mm bend radius after passing stringent helium leak test.



Fig. 4: Flexible hoses for HL-LHC magnet interconnections (Metallic Bellows, Chennai)

Another Indian industry, Cadillac Filters received an order worth Rs. 6 crores for design, supply and installation of two modular ISO7 Clean Rooms, to be used for assembly and testing of CMS HGCAL detector modules.

India@CERN Industrial Event was organized during the year on online platform in which 14 Indian industries participated.

Indian Participation in the Construction of Facility for Antiproton and Ion Research (FAIR) at Darmstadt, Germany

India is participating in construction of FAIR project as a Founder-Member partner. Support towards the facility continued during the year and implementation of the project in the country gained further momentum. The civil construction work gained further momentum at the project site in Germany. During this year, civil construction of SIS100 accelerator tunnel and Hall for Compressed Baryonic Matter (CBM) experiment completed while remaining construction work continued in full swing. During the year, India fulfilled additional cash contribution commitment to FAIR.

During the year, work towards Indian in-kind accelerator and detector items, progressed further. After successful tests, 37 Power Converters from Electronics Corporation of India Limited (ECIL), Hyderabad including two prototypes for SIS100 accelerator were shipped

to FAIR, Germany, making the total number to 164. Another Indian in-kind component, 22 Ultra-High Vacuum Chambers manufactured by Vacuum Techniques (P) Ltd, Bengaluru were shipped to FAIR, Germany while 34 more such units have been manufactured which are under testing.



Fig. 5: Flag-off Ceremony of 22 UHV Chambers to FAIR, Germany

On the experiment front, Indian researchers continued making progress towards development of detector systems for two major experimental set-ups i.e., CBM and Nuclear Structure, Astrophysics and Reactions (NUSTAR). Two large-size Gas Electron Multiplier (GEM) chambers, made in India were installed in mini-CBM experimental set-up in Germany and data was obtained with varying intensity beams.

During the year, 1 GEM chamber and 1 Resistive Plate Chamber (RPC) were tested at Gamma Irradiation Facility. On nuclear physics area, two Indian groups continued work towards building components for DESpec Germanium Array Spectrometer (DEGAS) and Modular Neutron Spectrometer (MONSTER) experimental set-ups. These components would be used in upcoming experiments using SIS18 beams.

India's Participation in the Thirty Meter Telescope (TMT) Project

India is participating in the construction of TMT project as a Founder-Member partner. Support to this project continued during the year. R&D and prototyping activities for supply of in-kind components from India continued in the country.

During the year, India-TMT Optics Fabrication Facility (ITOFF) was taken over by Indian Institute of Astrophysics (IIA), Bengaluru where installation and commissioning of Coordinate Measuring Machine (CMM) completed and training of personnel on the same was initiated.

The development of Hex Cutting process on sub-size roundel glass blank was successfully completed by Indian Industry, Optica, Bengaluru.

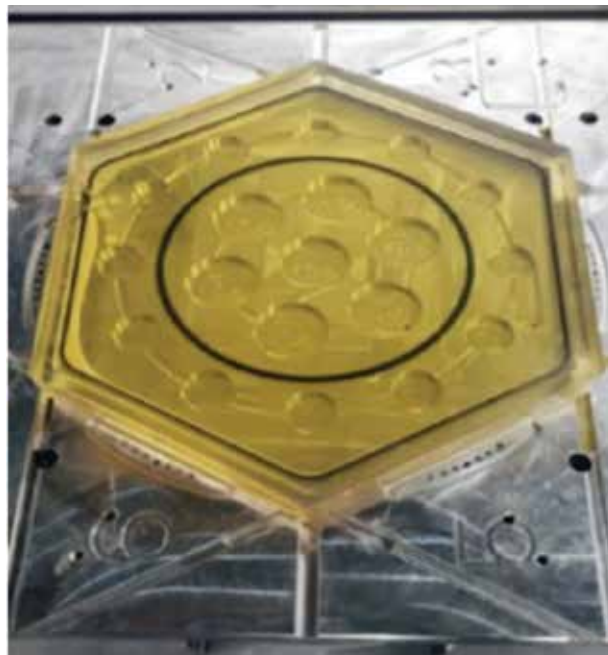


Fig. 6: Hex Cutting Process on sub-size roundel glass blank

Training of two personnel on Stressed Mirror Polishing started at Coherent, USA.

Segment Support Assembly (SSA): TMT requires a total of 600 SSAs. Contract was awarded to Larsen and Toubro (L&T) for manufacturing 10 SSAs under Production Qualification Phase (PQP) followed by 90 SSAs subject to qualifying in PQP. The manufacturing of 1st set of Primary Mirror Assembly (PMA) was completed and its readiness review is planned shortly. For reducing costs and avoid single point failure, India-TMT took up manufacturing of individual components of SSAs at a number of industries.

Central Diaphragm: Development of prototype central diaphragm continued. First set of central diaphragms expected to be completed shortly.

Warping Harness Cables (WHC): Agreement for production of 100 sets of WHC was signed during the year. Fabrication of 9 WHC sets from three Vendors (Amphenol, Sika and Trasccon) for prototype round completed. One set (Amphenol) shipped to TMT Project Office (PO) for inspection while two sets (Sika, Trasccon) expected to be shipped shortly.

Actuators: P3 Actuator Prototype Work Package Agreement was signed during the year. Technical and commercial evaluation of vendors for their manufacturing phase was completed and 2 vendors (out of 4) were selected for this phase wherein 20 actuators will be manufactured.

Edge Sensor Work Package: Gold coating Process development Work Package was signed during the year. ARCI Electroless Gold coating process optimization completed on trial coupons and work started for implementing this process on TMT sized block as part of coating process development phase. Machining process development was completed at Optica, Bengaluru and End-Item Data Package documents were submitted to TMT PO.

M2/M3 Coating Plant: Its conceptual design successfully completed during the year.

Observatory Software (OSW): Prototyping of one of OSW modules, Data Management System Science (DMS.SCI) completed and delivered during the year.

Common Software Maintenance Work Package was completed with major release v4.0.0 during the year.

Executive Software (ESW) Development for Phase-1 with minor release v0.3 during the year. ESW Phase-1 work completed with close-out expected shortly.

Infrared Guide Star Catalogue Phase-III Work Package, completely being developed in-house completed and a prototype User Interface (UI) was developed for the same.

OSW Operation and Maintenance Work Package started and work continued. OSW successfully passed the in-kind review of TMT partners that included cost, schedule and risks review as part of preparation for NSF funding proposal consideration.

Telescope Control System (TCS): During the year, the team successfully implemented proof-of-the-concept for Pointing Kernel Assembly, a major subsystem of TCS.

Wide Field Optical Spectrograph (WFOS) - Conceptual Design Phase-3: India-TMT is one of the core team contributing to design and development of WFOS. India-TMT continued working on designing two major mechanical sub-systems for TMT-WFOS, Grating Exchange System (GRX) and Camera Articulation/Rotation System (CRS). Multiple design concepts were studied for GRX, out of which one design concept meeting the requirements is undergoing further optimization. For CRS, a design concept similar to Keck-KCWI Camera Rotation system has been designed.

India-TMT is also developing Instrument Control Software, opto-mechanical design of the calibration system for WFOS. India-TMT also designed electronics architecture for WFOS. The conceptual design phase of WFOS would be ending shortly and Tier-A review is planned in next 3 months.

HROS Opto-Mechanical Design: India is spearheading the efforts for design and development of HROS, a second-generation high-resolution optical spectrograph. So far, the team has concluded optimization of optical design of HROS, like atmospheric dispersion corrector and K-mirror which are part of HROS pre-slit optics, beam compression using prisms, multiple collimator and combination design to reduce optical aberrations as in-house activity.

Mechanical layout and space envelope have also been worked out. The team is looking into various possibilities of feeding light from M3 to HROS. The team also had discussions with TMT-Scientific Advisory Sub-Committee on 2 occasions on HROS science goals, optical design and optimization aspects.

On the civil construction aspects, the same could not start at Mauna Kea. Negotiations with protesting native Hawaiians groups are continuing. The delay in civil construction resulted in further cost escalation. In order to bridge the funding gap, TMT project made a request to National Science Foundation (NSF), USA seeking funds. During the year, US Astro-Decadal Survey ranked ground-based US-Extremely Large Telescopes (including TMT project) as very high priority. This would pave the way for NSF funding for the TMT project.

In addition to developmental works, the project also resulted in 1 scientific and technical publication while two are under submission, 3 PhDs were ongoing and 8 Talks/Posters were presented by project human resource on different aspects of the project.

The project involved 14 Indian industries and 24 project staff including 15 Project Engineers/Scientist and 2 Post-Docs.

Indian Institutions-Fermilab Collaboration in Neutrino Physics

Indian researchers are participating in ongoing neutrino experiments at Fermilab, USA which includes 15 faculty members, 18 PhD students and 2 Post-Docs from 9 research groups across the country. During the year, a Remote Operations Centre for NOvA Data Acquisition was set up in Chandigarh and NOvA shifts were carried out remotely from the country.



Fig. 7: Remote Operations Centre for NOvA Data Acquisition

During the year, output from the project included 12 collaborative research publications, 17 research publications, 18 Talks/Posters at Conferences, 2 PhDs, training of 20 project human resources and 4 other students.

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

India had established XRD2 and XPRESS beamlines at Elettra Facility. The utilization of these beamlines for carrying out research in macromolecular crystallography and high-pressure physics by the Indian scientific community continued on modest scale due to pandemic. During the year, 14 Indian proposals were allocated beamtime on XRD2 beamline. 1400 crystals were sent to XRD2 beamline and 711 data sets were collected from them. The output included 11 research publications and benefits to about 30 Ph.D. students and Post-docs. Also, 8 experiments were performed by Indian users on XPRESS beamline.

Low-Energy Accelerator-based Research Facilities at Kurukshetra University and at Allahabad University

Support to both the facilities continued during the year. However, the pandemic affected utilization of both these facilities. During the year, ion irradiation experiments were performed at Kurukshetra University using Ar^+ beam on different targets in energy range of 80-150 keV. The output included 6 research publications, 3 Conference papers and 2 PhDs.

Establishment of Laser Interferometer Gravitational-Wave Observatory (LIGO) project.

The 3rd Detector of LIGO is being established in Hingoli District in Maharashtra. From seed funding granted by DST, various auxiliary activities were continued which included, hiring of technical staff, related accommodation and transport, establishment of computational infrastructure for collection and analysis of seismic and weather data. During the year, Cabinet Note for the project was considered by the Empowered Technology Group, chaired by Principal Scientific Adviser to Government of India. The financial appraisal of the project advanced further.

2.4 Climate Change Programme (NMSHE & NMSKCC)

DST has been entrusted with the responsibility of coordinating two national missions on climate change as part of National Action on Climate Change (NAPCC). 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) Division is implementing these two national missions.

2.4.1 Major Achievements and progress during 2021-2022

New Initiatives: New initiatives/projects commence during 2021-2022

Vulnerability Profiles for India: State and District Level

Vulnerability indicates the parameters to which people or their valuable things are susceptible to and their adverse impact of climate change on different socio-economic and biophysical parameters. DST along with its partnering institute have developed a common framework and methodology on vulnerability as per guidelines of IPCC, 2014 to arrive at a comparable vulnerability profile of Indian Himalayan Region (IHR). Following the success of the previous work, initiatives on vulnerability assessment was extended for the entire country to develop national level vulnerability profile for India using a common methodological framework and similar indicators with a focus on climate change. During the year report on '**Climate Vulnerability Assessment for Adaptation Planning in India Using a Common Framework**' was released by Hon'ble Secretary DST. This is the first ever report of all-India state-level and district level vulnerability maps. In addition, with the concept of cooperative federalism, common framework for assessing the climatic vulnerability was used by all the states in India to develop their own district-level vulnerability maps. The report is expected to help the states to update their revised State Action Plan on Climate Change (SAPCC).

The findings identify the most vulnerable states and districts in India with respect to current climate risk and the main drivers of vulnerability and the results of state-level vulnerability indices varying over a small range: 0.42-0.67. The states with a relatively high vulnerability are Jharkhand, Mizoram, Orissa, Chhattisgarh, Assam, Bihar, Arunachal Pradesh, and West Bengal, mostly in the eastern part of the country, requiring prioritization of adaptation interventions.

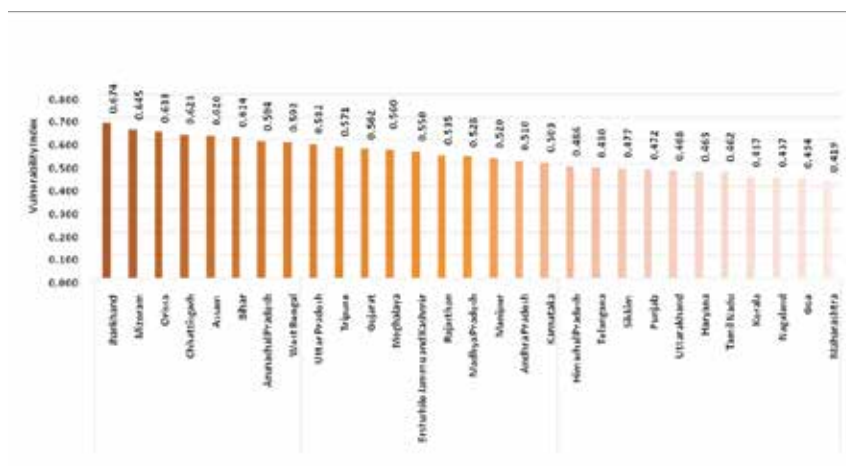


Figure 1: Vulnerability indices of the Indian states, their categorization, and corresponding ranks

National Mission for Sustaining the Himalayan Ecosystem

Under the mission, six (06) Thematic Task Forces (TF) have been set up to scientifically assess the socio-economic and ecological consequence of global environmental change by

carrying out research in the 6 thematic areas viz.; Natural & geological wealth; water, ice, snow, including glaciers; micro flora & fauna, wildlife & animal population; forest resources & plant biodiversity; Himalayan agriculture and traditional knowledge.

Phase II of three Task Forces:

During the year, proposals for IInd phase of task forces on Forest Resources and Plant biodiversity, wild life and animal population and Himalayan Agriculture were developed by national organizations viz. GBPNiHE, WII and ICAR resp. in consultation with various experts and stakeholders. The proposals are evaluated and supported during the year to upscale the work carried out in Phase I, implementing adaptation strategies along with the newly identified zones and take the interventions to next level utilizing the knowledge generated in phase I.

In the 1st phase, these 3 TFs successfully worked on specific objectives and attained significant technical achievements. **TF3 Forest Resources and Plant Biodiversity** was coordinated by G.B. Pant National Institute of Himalayan Environment (GBP-NiHE), Uttarakhand developed Database of plants (i.e., trees, shrubs, wild edibles, alien plant species, lichens, threatened plants) of the IHR; Compiled the literature on the Himalayan biodiversity of the past 200 years; established Long-term Ecological Monitoring (LTEM) and 2 Global Observation Research Initiative in Alpine Environments (GLORIA) sites for detecting the changes and trends in forest composition, plant species richness and diversity, forest community structure w.r.t. environmental change over the years; assessed vulnerability of the IHR forests and documented People's perception on climate change and impacts. 01 National Workshop and 27 training programs on Capacity and skill building of diverse group of stakeholders with 1800 stakeholders on forest resource management and biodiversity conservation were done. 864 Human resource trained, 32 peer reviewed research papers published; 14 students enrolled for PhD, out of which 07 students awarded Ph. Degree.

Task force IV Micro Flora and Fauna and Wildlife and Animal Population which is being coordinated by Wildlife Institute of India, Dehradun was primarily engaged in assessment and monitoring the climate change impacts on Wildlife Species and Ecosystems in the Indian Himalayan Region. Under the project, a bibliographic database comprising of 5,042 articles on wild fauna and microflora of the Indian Himalayan Region (IHR) are developed. The study brings forth the first-ever records of six mammal species from the state of Uttarakhand viz. the Tibetan argali *Ovis ammon*, Tibetan sand fox *Vulpes ferrilata*, woolly hare *Lepus oiostolus*, Eurasian lynx *Lynx lynx*, woolly flying squirrel *Eupetaurus cinereus*, and Pallas's cat *Otocolobus manul*. Changes in the timing of life-cycle events such as spawning in cold-water fishes, diel activity patterns in amphibians and seasonal movements in mammals and birds have been identified and related to climatic variables, thereby providing strong evidences to understand the linkages between phenological patterns and climate. The first-ever record of six mammal species from the state of Uttarakhand provided novel information about their current ranges

(Fig. 3). The indicator species like snow trout and musk deer in IHR have been projected to shift their distribution northwards and to higher elevations with a concurrent loss at their lagging edges in response to climate change as per consensus modeling framework (RCP 8.5-year 2050). Outcome of the projects are 38 publications, 6 proceedings, 7 PhD students, 5 capacity building programmes organized where 515 people were trained.

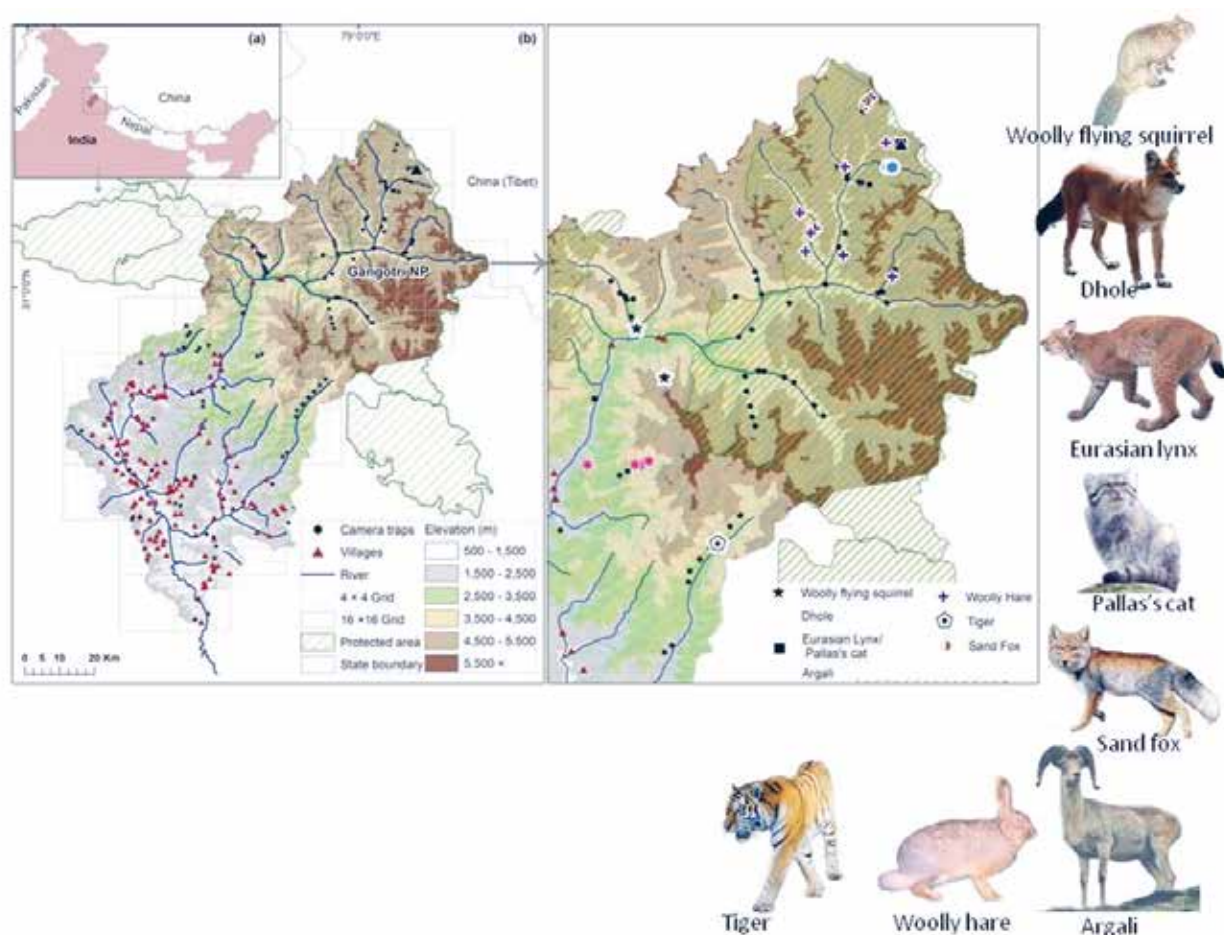


Fig.3 (a) Location of the Bhagirathi basin in Uttarakhand state, Western Himalaya, India. (b) Camera-trap locations and permanent human settlements along an elevation gradient in the Bhagirathi basin. (c) Location of some of the new records of species reported in this Study

Task Force on Himalayan Agriculture was focused towards Database creation, Monitoring for Ecological Vulnerability, Modeling and Simulation, Adaptation Policy Research, Pilot Studies for Revalidation of Climate Resilient Technologies. In the first phase TF has prepared around 115 maps/yield trends and graphs pertaining to the status of agro-ecosystems, climatic trends and vulnerability in the IHR. Regional disparity analysis of seasonal wetness across India was completed to understand the time dependency of precipitation anomalies for seasonal drought occurrence for seven homogeneous rainfall regions of India. In order to

assure food security in hills total 130 varieties of agricultural and horticultural crops and 17 breeds of livestock, poultry and fish breeds were introduced across the entire IHR at various pilot sites which has resulted in increase of the net returns. The task force has distributed seeds of different crops (1730.95 kg), seedling and saplings (13250 no.), bamboo (100 culms) and the rooted slips of lemon grass (1250) to the progressive farmers to cope with changing climate. 70 bird's eye chilli germplasm, 52 pole-type common bean landraces and 37 French bean landraces, 67 (Jhum) landraces of maize, 2 landraces of Capsicum Chinese viz., MN-1 and MN-2 were collected. A research report on 'Vulnerability of Agriculture in Indian Himalayan Region to Climate Change' is prepared. Outcome of the projects are; conducted 375 capacity building programs wherein approx. 16749 farmers/participated, 13 peer reviewed papers, 11 book chapters, 105 abstracts in Seminar/Conference/Symposia/Workshops published.

Phase II of 6 state climate change cell/centres (SCCCs) viz; Himachal Pradesh, Sikkim, Manipur, Mizoram and Tripura under NMSHE and Punjab under NMSKCC started during 2021. These SCCC are supported to enable scaling of the work done in phase-I and Conduct vulnerability assessment in lower administrative level i.e block and village level, Conduct sectoral vulnerability in the States, Incorporating the Vulnerability Risk Assessment in the SAPCC and aligning the states development activities to adaptation needs of the state and Continue building capacity of state officials on climate change adaptation programme through training and awareness programme and the sensitization and awareness of communities on Climate change will be carried out.

During the year, 4 meetings of the **Project Advisory & Monitoring Committee (PAMC)** on National Network Programme on Climate Change & Human Health, Aerosol, Climate Change & Coastal Vulnerability and Climate Modelling were organized to review the 51 projects under these network programmes. 30 projects were graded excellent and very good and were recommended to be taken up as major R&D programme. Outcome under the network programme includes 105 peer reviewed papers published with a cumulative impact factor of 181.

The 8th meeting of the re-constituted Expert Committee (EC) of CCP Division was held on 7th December, 2021 on virtual mode. In total, 14 new project proposals related to the State Climate Change Cells, MRDP and Climate Change Risk Assessment & Mapping were presentations by the PIs though On-line mode and detailed discussions were held. Based on the critical evaluation of the proposals by the Committee EC recommended 3 proposals for establishment of State Climate Change Cells-SCCC under NMSKCC for the States of, UT Chandigarh, Goa and Jharkhand for support with a budget ceiling of 3 crores for a period of five years. 2 proposals for MRDP under NMSHE namely, (i) Reconstructing the Late Quaternary paleohydrology of the Lakes in Trans Himalayan Ladakh by University of Ladakh (ii) Development of climate resilient and sustainable Agri-based systems for better food, feed, nutritional and livelihood security options to farming community of Cold arid region-Ladakh by National Dairy Research Institute, Karnal, Haryana for support with budget ceiling

of 3 crores for a period of three years and recommended 1 proposal for Climate Change Risk Assessment & Mapping at District & State Level, India titled “Climate Change Risk Assessment & Mapping at District & State Level, India” by Indian Institute of Technology (IIT) Mandi for support with a budget ceiling of 1.36 crores for a period of two years.

Executive Committee meeting on Climate Change (ECCC) conducted by Prime Minister Council for Climate Change (PMCCC): The 8th meeting of ECCC under the chairmanship of Principal Secretary to Hon’ble Prime Minister was held on 1st September, 2021 to review the progress made under the climate change missions launched by PMO under the National Action Plan for Climate Change (NAPCC) and aspects related to the Climate Change Conference of the Parties (COP-26) to be organized by UNFCCC. The technical activities and achievements under the two missions viz. NMSHE and NMSKCC being implemented by DST were presented and discussed in the meeting. Revision of the Mission documents for NMSHE and NMSKCC and their alignment with India’s Nationally determined contributions (NDCs) for the 2021-2030 period were done as per the observations in the First Apex Committee for Implementation of Paris Agreement (AIPA) meeting.

Capacity building: during the year training programmes on various aspects of Climate Change and Adaptation were organized under which around 1352 people were trained

2.4.2 Significant outcomes from the ongoing programmes Center of Excellence (CoE)

DST- Mahamana Centre of Excellence in Climate Change Research is established at Institute of Environment and Sustainable Development, Banaras Hindu University, Varanasi. The DST centre is mandated to do state-of-art research in climate change and its impacts on agriculture, water and health and also creating capacity building by organizing advanced trainings and workshops for students as well as professionals. During the year DST-MCECCR has made significant achievements in research with new observations like identifying **three new heat wave hotspots**, North-western, Central and South-Central India were identified as three new heat wave hotspots of India showing a spatial-temporal shift in occurrence of heat waves from eastern region. Accelerating decline in diurnal temperature range was observed in parts Indo-Gangetic plain, north-east, and central Indian region over 30 years which can put agriculture & health at risk. Similarly, in climate modeling the performance of the regional climate model RegCM4 is found satisfactory in portraying the spatio-temporal monsoon intra-seasonal variability (ISV) over India and simulates the onset and break phases (dry days) better than the active phases.

A new model was developed to assess the child morbidity due to selected infectious diseases and climate, found that each unit (1 °C) rise in max was associated with an increase in diarrhea and skin-disease whereas, a unit decline showed an increase in cold & flu cases ((Singh et al. 2021; Sci. of the Tot. Env.).

- The Centre has published **24** research papers with a cumulative impact of **74.71** this

year. Apart from the research, the center has also organized **4** training, workshops and initiated a **DST-MCECCR Lecture Series** for knowledge and capacity building of students by inviting lectures from distinguished scientists. The Centre's work has been represented at International and national platforms in around 16 conferences and seminars with 17 DST-MCECCR personnel trained in 13 different workshops & trainings. 17 master dissertation and 5 PhDs have been awarded during this year.

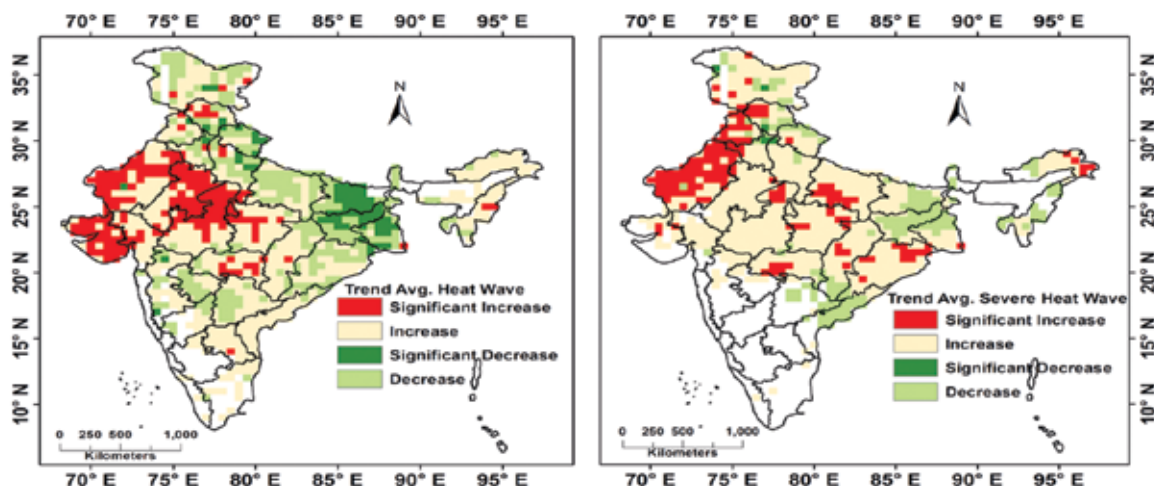


Figure: - 4 Northwestern, Central and South Central India emerge as three new Heat Wave Hotspots over India (Singh et al. 2021; International Journal of Climatology)

- **Divecha Centre for Climate Change (DCCC) at Indian Institute of Science, Bengaluru**

Optical pulses propagating through the atmosphere experience scattering and absorption losses imparted by gas molecules and aerosols and intensity fluctuations induced by atmospheric turbulence. Moreover, they are subjected to an increase in their pulse widths, as different wavelength components travel at different velocities. This leads to interference (overlapping of pulses) and sets a maximum limit to the reliable data transfer rate. While the absorption and scattering losses can be easily modelled and compensated, it is difficult to model the turbulent fluctuations. Under the project it was revealed that over and above these losses, aerosol-induced atmospheric heating leads to an additional broadening in optical pulses by modifying the turbulent fluctuations. A higher absorption of solar radiation by aerosols can lead to more pulse broadening and will reduce the anticipated performance and ultimately set limits on improving the efficiency of terrestrial as well as ground-to-satellite links.

- **DST-ICMR Centre of Excellence for Climate Change and Vector Borne Diseases at ICMR-National Institute of Malaria Research, New Delhi** is using a multi-disciplinary approach (meteorology, epidemiology, ecology and modelling) to provide evidence-based

research on climate change and Vector borne Diseases (VBD) transmission. During the year projected impacts of climate change on the distribution of dengue vectors, using machine-learning algorithm (Maximum Entropy Model), and revealed an extension in the range of *Aedes aegypti* in the Thar Desert in Rajasthan, and *Aedes albopictus* in the upper and Trans Himalayan regions by 2050s and 2070s have been done. Furthermore, multi-model machine learning algorithms are being developed to project changes in the distributions of the principal vectors of malaria in India – *Anopheles Stephens* and *Anopheles culicifacies*, because of climate change. Preliminary results indicate a significant increase in the distribution of *An. Stephens* in the western parts of India.

- **DST Centre of Excellence at IIT Kharagpur**

A comprehensive study was carried out on the impact of Sea Level Rise on Lakshadweep archipelago in a climate change scenario. Investigations identified the best-performing models for sea-level rise and made projections for different Islands in the Lakshadweep region. Projection mapping indicated that about 60%-70% of existing shorelines would experience land loss in Amini and about 70%-80% in Chetlat. The present work highlights that larger islands Minicoy and the capital Kavaratti are also vulnerable to sea-level rise and expected to experience land loss along 60% of the existing shoreline. Under all emission scenarios, sea-level rise effects have the most negligible impact on Androth Island. (Source: <https://pib.gov.in/PressReleasePage.aspx?PRID=1728293>). Studies are also ongoing on the assessment of Sea Level Rise and its implications along the major cities in the mainland of India.

Analysis of air-sea interaction over the Bay of Bengal region using data and numerical model indicates a significant change of about 99% increase in the accumulated cyclone energy, 8% increase in frequency, and 3% increase in the duration of total storms. The rate of growth is higher for very severe cyclonic storms. A notable shift was also seen in cyclogenesis locations over the North Indian Ocean region. In contrary to the global report on slow-down in cyclone translation speed, it is seen that cyclones in Bay of Bengal exhibited an increase in translation speed during the recent decade along with higher residence time, unlike the past historical cyclones. The study also developed suitable remedial measures for coastal protection due to extreme wind-wave activity. An appropriate model was developed for visco-elastic beds in coastal regions having heterogeneous sediment texture with vegetation interaction.

- **Centre of Excellence in Climate Studies (DST-CoECS), IIT Bombay** undertakes interdisciplinary, problem driven research and teaching for end-to-end analysis of climate change issues. During the year following studies were carried out:

- Coastal Vulnerability/Risk Maps for Indian coastal districts

(<https://doi.org/10.1016/j.jenvman.2021.112948>).

- Real-world fleet emission factors for carbonaceous aerosols to reduce uncertainty in vehicular emissions. (<https://doi.org/10.1016/j.aeaoa.2021.100113>; <https://doi.org/10.1016/j.uclim.2021.100955>)
- Studied aerosol Influences on Cloud Properties, Temperature and Rainfall Extremes over India and have also evaluated the aerosol cloud interaction parameter over India. (<https://doi.org/10.1016/j.atmosenv.2019.117237>; <https://doi.org/10.1002/joc.6783>).
- studied Feedback From Vegetation to Interannual Variations of Indian Summer Monsoon Rainfall (<https://doi.org/10.1029/2020WR028750>)
- working on land surface modeling using data assimilation (<https://doi.org/10.1002/qj.4021>; <https://doi.org/10.1029/2020GL087255>;))
- Transformation approach to climate governance is being used for the first time in the Mumbai context, and in India. The working of emergent groups – contribution to technical knowledge, adaptation, transformation, and climate / risk governance is studied for the first time in India. (<https://doi.org/10.1016/j.cosust.2021.04.002>)
- Attribution analysis is being performed that will help in augmenting disaster databases on losses specific to anthropogenic climate change.

Outcome of the project; **14** peer-reviewed research publications, **5** Proceedings in International conferences and **11** Reports/Monographs/Internal Publications are published. **12** high quality climate change professionals are being specially trained in CC Science.

- **DST-ICRISAT Centre of Excellence on Climate Change Research for Plant Protection (CoE-CCRPP):** Pest and disease management for climate change adaptation. This CoE develops a framework and create facilities to develop adaptation strategies) to increase resilience and reduce the vulnerability of agriculture in India at the local, regional, and national levels. This year following technical outcomes have been achieved:
 - Weather based forewarning models developed for predicting various pests and diseases (Pod borer in pulses, pink bollworm in cotton, brown plant hopper in rice and diamond back moth in crucifers). The model can predict (i) first appearance of pest/disease (iii) maximum pest/disease severity in cropping season (<http://ccrpp.iari.res.in/coe-pest/>).
 - Mobile applications (android based) have been developed to disseminate weather-based crop protection advisory for timely management of pests and diseases.
 - Visual basic for applications (VBA) tool developed to map the future pest/disease intensity/hotspots during 2030 and 2050 under RCP 4.5 and 8.5. Generated baseline and future climate files for 98 districts (11 states, 1600 grids, and 20880 files) of major

pulse growing areas in India to predict possible incidences of pest and diseases using seasonal climate forecast data and to draw relationship between climate events such as El Nino/La Nina on pest and disease incidences using long term climate data.

- Spatial and temporal distribution models (CLIMEX-DYMEX) predicts that rice brown plant hopper incidence will be increased under changing climatic conditions. As per the ILCYM models, diamondback moth of crucifers 'life cycle is reducing, and number of pest generations are increasing with the increase in temperature ($>30^{\circ}\text{C}$).

Capacity building to develop toolkit for effective pest disease management and outreach to various stakeholders, young researchers, and plant protection practitioners (An overall >2500 personnel, 38 research scholars).

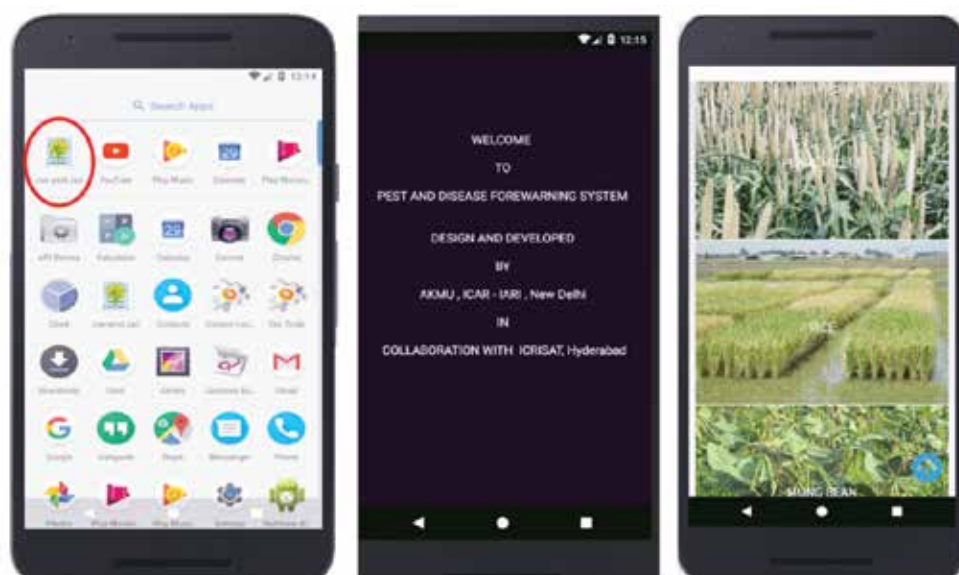


Figure: 7 Snapshots of mobile application –Decision support system (DSS) tool for predicting outbreak of various pests and diseases with control measures

2.4.3 Major R&D Programmes (MRDPs)

As part of NMSKCC deliverables, DST has supported 23 Major R&D Programmes at key knowledge institutions and universities in different areas of climate science and adaptation which are in different stages of progress. Some of the achievements under the program are:

“High Resolution Climate Modelling for Southern Peninsular India”, Cochin University of Science and Technology

Under the project modeling of the historic and near future climate over the SPI using Regional

Climate Model was conducted using ERA-Interim reanalysis data and MPI-ESM-LR model data for simulating historical weather. The study shows that the extreme weather events covering a large area across Southern Peninsular India increases for over the last thirty years which causes widespread heavy rainfall and drought events which may result in large-scale floods and shortage of drinking water. Monsoon rainfall over India shows the significant decreasing trend over the core monsoon zone, north-eastern parts, and southern parts of the west coast annually and seasonally

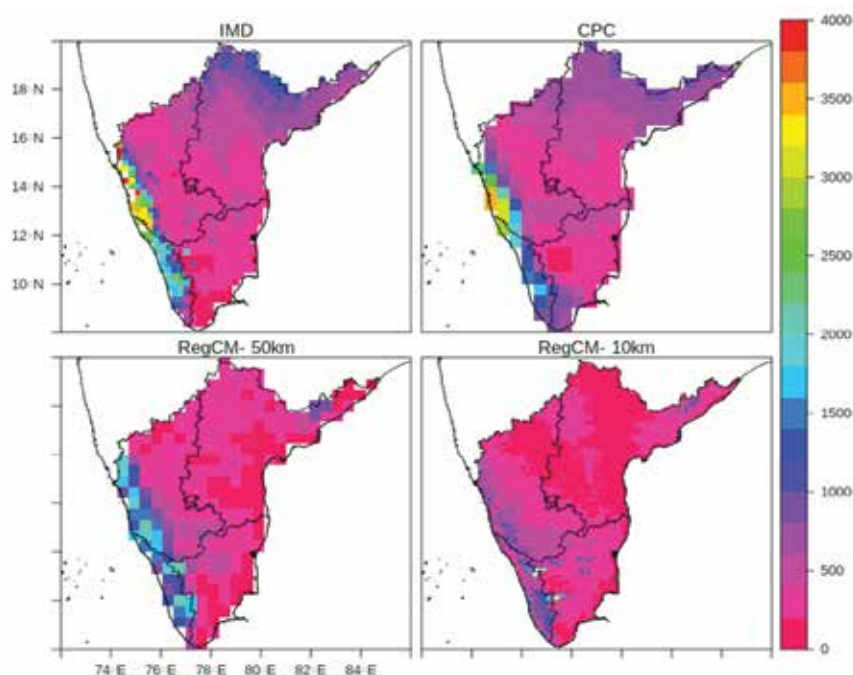


Figure: 8 the near future runs (2020-2050) with MPI-ESM-LR at RCP 8.5 scenario shows the clear sign in trends of monsoonal and post-monsoonal rainfall in the coming decades.

2.4.4 State Climate Change Cells (SCCC)

Kerala State Climate Change Knowledge

During the year study on the impact of climate change on future water availability in Chaliyar river basin using SWAT model by evaluating theCMIP6 precipitation datasets in simulating stream flow of Chaliyar river Basin were conducted. Flow Duration Curves were plotted for the basin which indicates heavy peak flows at the basin outlet in the future. The study is being extended to estimate the future water demand in changing climate to ensure proper management practices to meet the anticipated water demands.

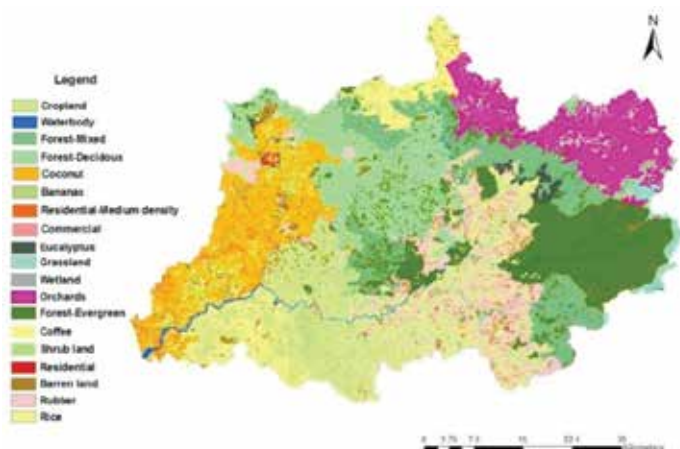
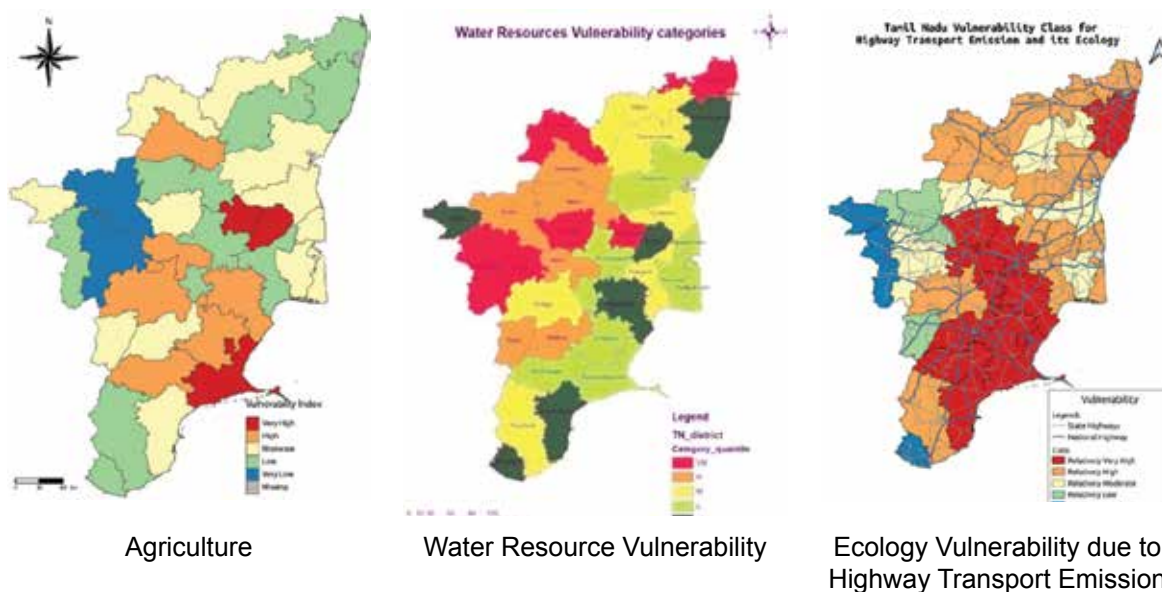


Figure 10: Land use map of Chaliyar River basin for detailed estimation of future water demand.

Tamil Nadu

The SCCCs worked on sectoral vulnerability assessment and have assessed District wise agriculture vulnerability, district wise water vulnerability assessment, and identified vulnerable district for the potential roadside tree plantation for the state of Tamil Nadu. www.tnsccl.co.in is the knowledge management portal developed based on the objectives of this project.



Odisha State Climate Change Cell

Under the project 35 indicators relevant to the State of Odisha were validated after discussion with concerned departments. The data required for vulnerability analysis study is being

collected. A case study has been carried out taking different available economic indicators. From the Study, it has been found that, Kandhamal is the most vulnerable and Bargarh is the least vulnerable district of Odisha when Economic category is considered.

Telangana State Climate Change Cell

Telangana State Climate Change Centre (TSCCC) has developed the Knowledge Portal on Climate Change, accessed at Web portal link: <http://eptri.telangana.gov.in:8080/tsccec/>. The web portal contains sector wise key issues, interventions and various initiatives of the State on Climate Change. Established network with various Institutes and Universities.

The District Level Current Climate Vulnerability Assessment of Telangana State

was prepared and the Centre has conducted 36 capacity building programmes for various stakeholders which were attended by 2435 participants comprising of officials from line departments, farmers, students, media, NGOs etc.

2.5 National Super Computing Mission

“National Supercomputing Mission (NSM): Building Capacity and Capability” was approved by Cabinet Committee on Economic Affairs (CCEA) on April 19, 2015 and is being jointly implemented by MeitY and DST with IISc Bangalore and C-DAC as the executing agencies.

MeitY has been engaged in indigenous R&D in HPC Components (including processor, server board, interconnect, cluster, and cooling system), HPC System Software, HPC Applications, HPC Solutions and Services, Big Data & Analytics and Quantum Computing along with design, development, and deployment of peta-scale computing machines across the country under NSM.

2.5.1 Supercomputing Infrastructure

Following systems were installed and commissioned under Phase-1 and Phase-2 of NSM:

IIT Varanasi	833 TF
IIT Kharagpur	1.666 PF
IISER Pune	833 TF
JNCASR Bengaluru	833 TF
C-DAC Pune (210 AI PF)	5.267 PF
IIT Kanpur	1.666 PF
C-DAC Bengaluru	833 TF

NABI Mohali	833 TF
IIT Hyderabad	833 TF
IISc Bengaluru	3.332 PF
IIT Roorkee	1.666 PF
IIT Guwahati	833 TF
IIT Gandhinagar	833 TF
IIT Mandi	833 TF
NIT Trichy	833 TF



Figure: PARAM Yukti at JNCASR, Bengaluru



Figure: PARAM Utkarsh at C-DAC, Bengaluru



Figure: PARAM Sanganak at IIT Kanpur



PARAM Seva



Figure: PARAM Smriti at NABI, Mohali

They were developed under 'build approach' and realized 'Atmanirbhar Bharat'. Current cumulative compute capacity of HPC systems installed under Phase-1 and Phase-2 is ~ 22 PF.

Substantial components utilized to build Phase-2 systems were manufactured and assembled within India and systems are built using indigenous software stack, which is a step towards the 'Make in India' initiative of the Government.

The infrastructure caters to computational demands of academia, researchers, MSMEs, and startups in areas like oil exploration, flood prediction and drug discovery among many others of national importance. It is targeted at ~100 institutions and thousands of active researchers, academicians on Nation Knowledge Network (NKN) - the backbone for supercomputing systems.

2.5.3 Development of building blocks under Phase-3

Under Phase-III, design and development of indigenous server node, interconnect switch, storage, and system software stack for next generation of HPC systems has been taken up.

Indigenous “Rudra” Server Platform

C-DAC's Rudra is a dual socket server platform based on Intel Xeon 2nd Generation Scalable Processor (Cascade Lake) supporting DDR4 Memory up to 3 Terabytes, 100G HDR InfiniBand NIC with two expansion slots for GPU and Trinetra NIC. It is designed for ½ width 1U for CPU only and ½ Width 2U dense form factor with GPU cards. 64 compute servers can be placed in one rack.



Figure: Rudra Server Platform

Baseboard Management Controller (BMC) firmware is used for the server management. The maximum supported Thermal Design Power (TDP) is up to 600W with air flow cooling. It is compliant to Open19 standard form factor for 1U and 2U and is aimed for multi-Peta FLOP clusters.

Rudra server platform is developed and tested with standard tools/benchmarks. Different interfaces on the board are validated using testing tools. Thus, the fully functional state-of-the-art Rudra board is ready to feed the requirement of a secure HPC platform in the market. It is first of its kind 'Made in India' to meet the HPC requirements including for strategic needs in the country.



Figure: Rudra based Pilot System

Indigenous HPC Network “Trinetra”

Trinetra-A platform (100Gbps, 3D Torus) has been qualified successfully on 15-node test cluster which has been validated using in-house stress testing applications, as well as industry standard MPI based benchmarks. Final trials included stress tests, mechanical, thermal, and functional aspects of design of Trinetra-A hardware and software with Rudra server platform. Tests comprised of in-house stress testing applications, as well as industry standard MPI based benchmarks (WRF, GROMACS, LAMMPS, OpenFOAM, NAMD).



Figure: Trinetra-B PCB

First prototypes of next generation Trinetra-B platform (200Gbps*10 = 2Terabits/sec full duplex, aggregate) are designed and developed.

Design and Development of Direct Contact Liquid System (DCLC)

In collaboration with IIT Mumbai, a modular PWC_A&IEC (Panel Water Cooler with Provision of Air and Indirect Evaporative Cooling) was designed and developed. Its effectiveness to handle 3 kW heat load generated from a DCLC based HPC system was demonstrated.

A 30 kW PWC_A&IEC has been designed and fabricated at Heat Pump Laboratory of IIT Bombay. It is based on the new extrusion design using single passage with provision to accommodate three tubes. The airside of the new design is identical to the earlier PWC_A&IEC extrusion; the waterside flow cross-section area and heat transfer area are increased to improve the overall performance.



Figure: 30 kW Panel Water Cooler developed at IIT

A modular Coil-on-Chip Liquid Cooling for processors, COC_LC, was designed to handle heat loads up to 360 W from a 50 mm x 50 mm base on chip. Its extrusion design, die development and assembly has been completed. A CFD model for COC_LC was developed to investigate its thermal performance for various configurations. The CFD simulations helped in optimizing the configuration of chip liquid cooling system.

HPC Processor “AUM”

Arm v8.4 Zeus based multi-core SoC is being designed. It uses Chiplet based architecture with 4-Chiplets in a socket (package) and 32-cores in each Chiplet, i.e., 96-cores in a socket.

With 10-TFLOPS (Double Precision) for dual socket HPC node, it is targeted for high-end infrastructure solutions. A complete SW ecosystem for HPC application development will be provided.

R&D projects supported by IISc

During end of 2020-21, IISc had supported 11 R&D projects, some of which were leading to Exa-scale computing. These projects were monitored after 6 months and we have closed 1 project being implemented at IISc since the PI left suddenly and the rest of the team did not have the necessary expertise.

The rest of the 10 projects are moving at a satisfactory pace. Support for 2nd year implementation has been released by IISc to 3 of the projects.

2.5.4 QSim - Quantum Computer Simulator Toolkit

QSim is one of the first initiatives in the country to address common challenge of advancing Quantum Computing research frontiers in India. With a GUI based workbench, it allows researchers and students to write, debug and develop quantum algorithms. Quantum systems are highly sensitive to disturbances from the environment; even necessary controls and observations perturb them. QSim allows researchers to explore Quantum algorithms under idealized conditions and helps to prepare experiments to run on actual Quantum hardware.

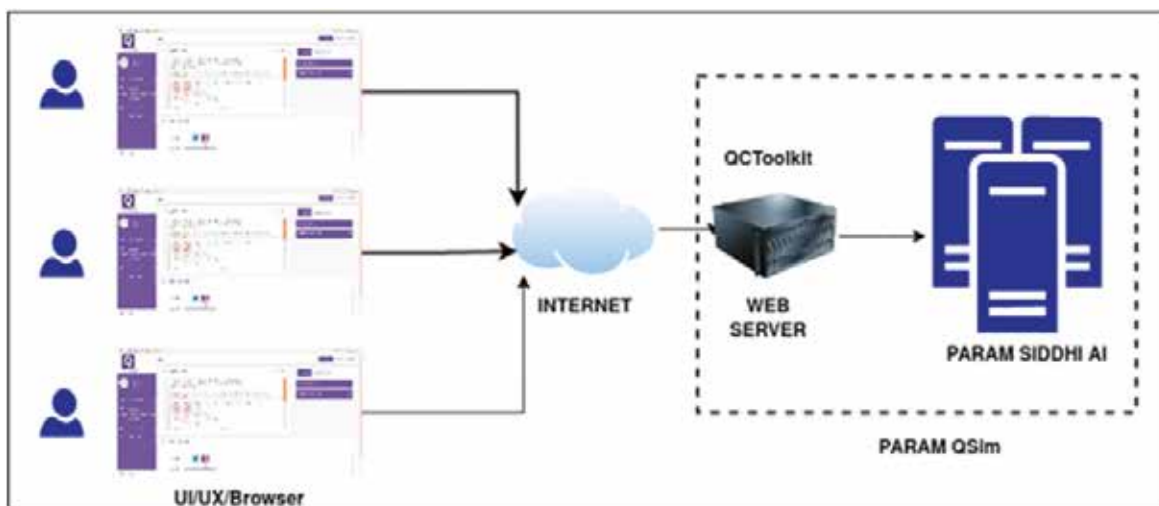


Figure: PARAM QSim Cloud

This project aims to design and develop a Quantum Network Simulator that can efficiently simulate the communication of quantum information over quantum networks. This simulation is carried out efficiently by integrating with a high-performance classical computing backend.

2.5.5 HPC System Software

System software stack on HPC systems under NSM comprises of C-Chakshu, CHReME, OSTicket, OpenHPC, Lustre, PARAvue, MVAPICH2, Intel Cluster Studio, GNU Tools, CUDA Toolkit and others.



C-DAC Automatic Parallelizing Compiler (CAPC) is a fast and effective solution for code parallelization by automatically converting a sequential C code to corresponding parallel code. It supports multiple target Parallel Languages – OpenMP 3.0/ OpenCL/ OpenMP 4.5.

Parallel Development Environment (ParaDE) helps to create parallel applications on HPC platforms. It enables users to just login to the environment and use all software on the cluster without the hassles of installation or configuration on the client machine.

HPC Application Porting, Optimization and Scaling

20+ applications from bioinformatics, molecular dynamics, climate modeling, weather prediction and disaster management along with DL software stack were ported, enabled, and optimized for the underneath architecture on HPC systems across NSM sites. Acceptance tests were carried out as per the NSM Mission document guidelines.

A FAQ Portal was developed and integrated in ticketing tool for quality support at Sites.

2.5.6 NSM Application Development Initiatives

Under NSM, various supercomputing applications of national interest are being developed and are at advanced stages of implementation. These are as follows:

- NSM Platform for Genomics and Drug Discovery
- Development of Multi Sectoral Simulation Lab and Science Based Decision Support Framework to Address Urban Environment Issues
- Early Warning System for Flood Prediction for River Basins of India
- A HPC Software suite for seismic imaging to aid oil and gas exploration
- Mathematical Programming in Parallel Laboratory (MPPLab) dealing with High Impact Applications of Optimization and Statistics (Big-Data) on Multi-Petaflop Systems

Apart from the above, IISc along with JNCASR had funded 93 Applications proposals in various specialized areas which include the following:

1. Computational Physics & Astrophysics - 19
2. Computational Chemistry - 12
3. Computational Life Sciences & Medicine-22
4. CFD and related Engineering Services - 33
5. HPC Applications with ML and AI - 7

2.5.7 NSM Initiatives in HRD

Along with deployment of supercomputing infrastructure, more than 11000 students, researchers, and faculties have been trained toward generation of HPC aware manpower. It has been accomplished through organization of Faculty Development Programs (FDP), Online courses for students, research scholars, industry professionals, Domain Specific Workshops, and Bootcamps and Hackathons in association with OpenACC. The courses are also available also on U-tube of IIT-Chennai where 1200 are regular subscribers and 12000 have visited and seen one or more courses. 4 Centres for HRD have been established at IIT-Chennai, Palakkad, Goa and Kharagpur and they have started delivering courses on line across the country on various aspects of HPC including parallel programming, CUDA language etc. A special course was also organized for the 4 countries from BIMSTEC with support from International Division. In this while 120 participants were from these 4 countries along with 400 participants from India.

2.6 Technology Fusion & Applications Research (TFAR) Programme

Technology Fusion & Applications Research (TFAR) Programme of Frontier & Futuristic Division (FFTD) is to boost research in emerging technologies. The TFAR programme, an initiative with Pan India applicability is being implemented at a total outlay of Rs. 250 Crore for a period of three years. The programme foster research for fusion, convergence and application of emerging technologies.

Following are thematic research areas under TFAR:

- a) Quantum Science & Technology Research Initiative (QuSTRI)
- b) Imaging Spectroscopy & Applications Research Initiative (ISARI)
- c) Epidemiology Data Analytics Research Initiative (EDARI)
- d) Indian Heritage in Digital Space Research Initiative (IHDSRI)
- e) Cyber Physical Systems Research Initiatives (CPSRI)
- f) Data Science Research Initiatives (DSRI)
- g) Internet of Things Research Initiatives (IoTTRI)
- h) Cyber Security Research Initiatives (CSRI)

All the above technologies under TFAR programme are continually evolving beyond the boundaries of single disciplines, thereby generating innovations.

2.6.2 Quantum Science & Technology (QuST): The Quantum Enabled Science and Technology (QuEST) is a one-of-a-kind networked programme to ramp up the R&D activities in quantum science and technology in order to usher in the so-called second quantum revolution in India. One of the main challenges in this area is the requirement of several hardware and technology platforms for developing quantum technology. To help with this, QuEST has four themes which focus on photonic (Theme-1), Nitrogen Vacancy & Magnetic Resonance (Theme-2), Ion-trap & Optical Lattice (Theme-3) and superconducting & Quantum Dots (Theme-4) technologies. QuEST facilitated a balanced synergy between experimental & theoretical groups in India. 51 number of R&D projects in a networked mode have been supported.

Following achievements made during the year:

- A. Quantum computation with NMR & solid state qubits like Nitrogen/Silicon vacancies:



Omega resonator for NV center fabricated at IISER Kolkata.



ODMR setup at IIT Madras.

- Microwave resonators are fabricated and characterized
- ODMR facilities setup / being upgraded
- Photonic crystal cavity is designed, fabrication is underway
- Charge-state-selective mapping of NV centers
- NMR characterization of temporal correlations and violation of Peres-Mermin inequality

B. Generation & characterization of entanglement

- NMR demonstration of entanglement localization via classical mediator
- Proposed an interferometric scheme to test the separability criterion
- Proposed optimal schemes for Gaussian state/process tomography

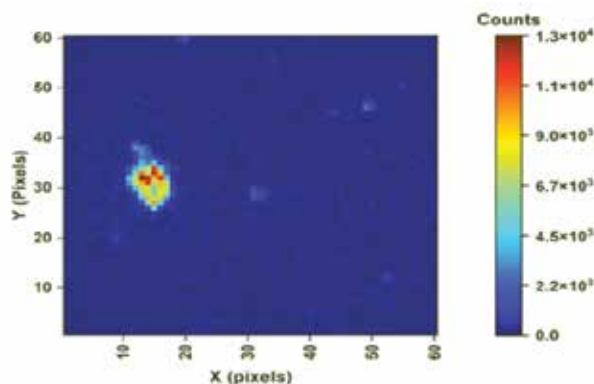
C. Development of decoherence mitigation strategies

- Model Hamiltonians with disordered/quasiperiodic potentials have been set up
- Coding developed to characterize localized/delocalized phases
- Proposed a method to detecting environmental correlations via correlated spectroscopy

D. Development of quantum sensors based on Nitrogen Vacancy Centers (NVC)

- a. Demonstration of high sensitivity NVC magnetic field sensor with temporal imaging (provisionally patented)
- b. Developed micro-PL setup with confocal scan

- c. Isolated nanodiamonds and measured its emission spectra along with confocal scan.



Fluorescence image of nanodiamond isolated at IIT Ropar.

E. Development of quantum enhanced and quantum inspired technologies.

- Demonstrated trapping & rotational control of nanodiamonds.
- Demonstrated population inversion in NV diamond for masing applications.

F. Ultra-cold & trapped atoms/ions.

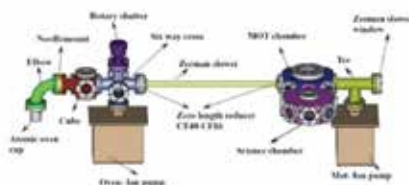
- Initiation of Four State of the art ultra-cold/ions based quantum simulators, sensors and quantum clocks' experimental setups at IISER-Pune, IUCAA Pune, IIT Roorkee and IIT Guwahati.
- Knowledge creation in theoretical Quantum Information Processing (QIP), quantum computing and error correction for direct applications in ultra-cold atomic/ionic platforms.



Strontium Atomic Clock and Quantum networking system at IISER-Pune



Design of the Ytterbium-ion trap quantum clock at IUCAA



Design of Ytterbium Atoms quantum simulator at IIT-Guwahati

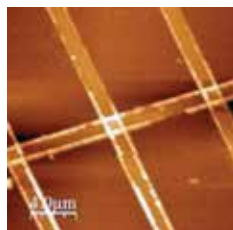
G. Quantum Technologies with superconducting & quantum dot devices:



Ring resonator coupler for superconducting qubits



2D microwave packaging for superconducting qubits

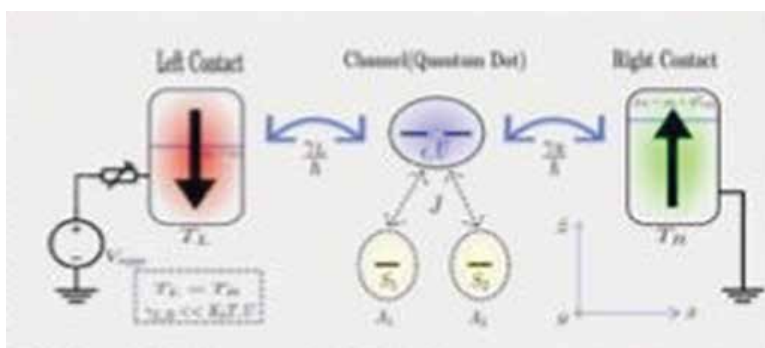


Oxide insulator test for quantum dots



Gate-defined double quantum dot system

- Development of quantum processors up to 4 qubits using superconducting circuit and semiconductor quantum dot technology
- Development of algorithms which demonstrate quantum advantage in small quantum processors
- Development of software tools for efficient mapping of quantum algorithms to quantum hardware
- Theoretical understanding of the information processing and computing capabilities



Steady-state entanglement switch

2.6.3 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. This programme has recently been completed and following are the major achievements:

- Establishment of one of the biggest reflectance spectral database (reflectance) with about 3000 well characterized, unique spectral and attribute data.

- Hyperspectral software for basic and advanced processing and parameters retrieval
- Capacity building among 36 Principal Investigators and About 70 young individuals who are in different stages of completing their PhD
- Development of application Methodologies/techniques involving spectral imaging in areas like off-road trafficability, plant health, snow characteristics and avalanche prediction, water quality, forest productivity etc.
- Online webportal and database management system
- Establishment of the state of the art instrumentation facilities
- About 100 Research Publications

2.6.4 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. Nearly 10 projects in a networked mode were supported so far.

Each of the three purposes has seen significant advancement. A variety of types of data-sets have been collated, analyzed, and communicated. COVID-19 became a new aspect in view of its relevance, leading to a desirable shift in focus. IGIB has been hosting the main COVID data portal in the country and some insights are being transferred to this effort. The portal is already operational and has seen usage. The results are discussed under verticals as envisioned:

The project had majorly three verticals

1. Mother and Child

Under this vertical different institutes were to curate, analyze and visualize the data applicable to mother and child health.

Data visualization methods were developed to test and disseminate the EDA data. INCLEN performed a landscaping exercise to collate the datasets /databases available in the domain of Maternal and Child Health & Nutrition was accomplished. However, the prediction models and data of North Indian cohort will be added in public domain. This data of less than 18 years of participants majorly has anthropometry, social and neuro-cognition data. IGIB will share the curated oscillometry data gathered from nearly 1000 school children which includes oscillometry values, spirometry and anthropometry data gathered as part of SOLID cohort. The normative equations from the data is under review and origin funded through Wellcome Open Grant, this dataset will be provided into the public domain through DST portal.

2. Vector Borne Diseases

CSIR-NCL, developed the Statistical models using different approaches (Regression, etc.) for temporal disease data based on information collected and received from other groups. However, the implementation of the model on the project website as an interactive tool is under progress. They also made models for Covid-19 trajectories and forecast and preliminary data with available sources for Leishmaniasis which are both now integrated in the platform. NIPER, CSIR IICT and CSIR- 4PI altogether completed Epidemiological studies, transmission dynamics and role of various climate factors affecting transmission of malaria in North East region of India. In addition, role of hydrological model to understand vector dynamics and malaria transmission and development of climate based seasonal forecasting system for malaria is also done. Integration of Artificial Intelligence (AI) techniques with spatial applications for identification of hotspots of malaria and evaluation and adaptation of forecasting system in malaria endemic regions of Northeast India is ongoing, although they have developed their web server to showcase the model. IITB and IIT KGP together developed a search engine that can accumulate the OSM information such as twitter on to a downloadable format to aid decision makers for on ground implementations. Also, the specific objective to monitor social media posts on several vaccines introduced in India in the recent years was done.

3. Non Communicable Diseases

AIIMS, New Delhi developed an algorithm for automatic data labelling for CT images with traumatic brain injury which is in process of Technologies developed/ Transferred / Commercialized. KEMHRC, Pune studied the evolution and relationship of insulin sensitivity and β -cell function in normal glucose tolerant (NGT) and glucose intolerant individuals at 6, 12 and 18 years of their life-course in young rural Indian Population and developed a model to show growth curves for longitudinal height data PMNS birth cohort and shared the same with NIT, Trichy. NCDIR, Bengaluru successfully collated the available data repositories on NCDs and Literature review on Disease Informatics is ongoing.

4. Web Platform

CSIR-CSIO and IGIB developed an open scalable platform for organizing and sharing public health data with integrated tools for better visualization and analysis for the health and diseases. For, MCH module; coordination with the other contributors for algorithm translation on the platform for visualization was performed with integration of module shared by SHARE India for their cohorts. Data tool with emergence of COVID to understand cases and model prediction for COVID 19 has also been integrated. Leishmaniasis module is integrated as a static page to represent the visual data. Algorithm translation and data cleaning is under process with the collaboration of NCL Pune. Malaria module is pending for development of API for integration on web platform. This although is available as a separate page.

2.6.5 Indian Heritage in Digital-Space Research Initiative (IHDS)

Indian Heritage in Digital-Space Research Initiative (IHDS): For promoting Indian cultural heritage, its preservation and presentation to the world by sponsoring technology-based projects under the scheme 'Indian Heritage in Digital Space'. The cutting-edge technologies developed and tested in these projects will have a positive impact to global efforts done in the digital preservation and archival of world heritage sites. Nearly 17 projects in a networked mode were supported.

Under water studies of submerged cities like Dwarka and Poompuhar: Underwater exploration scientists and Geoscientists, there remained several mysteries around Dwarka and Poompuhar as regards to its place of initial establishment, time series evolution and reasons and period/s of its extinction; so to say the holistic life history of such a leading port cities of maritime importance. The aim of this study is to bring out its life history covering its origin, later shifts/periods, aerial and time series evolution in multiple fronts of trade, culture, architecture and the reasons for its extinction, by networking over 12 academic institutions/ institutes in the country. Following are the achievements:

- Carried out Multibeam Echosounder (MBES) survey in about 800sq. km area in the offshore region of Poompuhar and initiated Sub Bottom Profiler survey(Fig.1)
- Experimental inhouse Remote Operated Vehicle (ROV) based underwater optical data collection in coastal waters, processing and algorithm development;
- Mapping of broad boundary of Poompuhar using IRS FCC, GEBCO&MBES data sets covering around 2500 sq. km. (Fig.3).
- The progress in Flood dynamics, Tsunamis, cyclones, storm surges, erosion and depositional dynamics from 20,000 yrs to 1000 yrs BP (Before present) and its impact over the extinction of Poompuhar from the analysis of IRS data, trial shallow boreholes, (Fig.4) in rivers and creek mouths, sedimentology

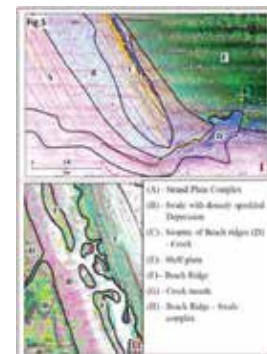
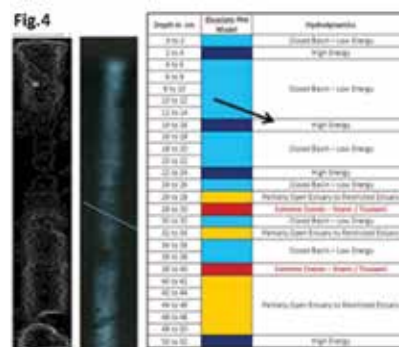
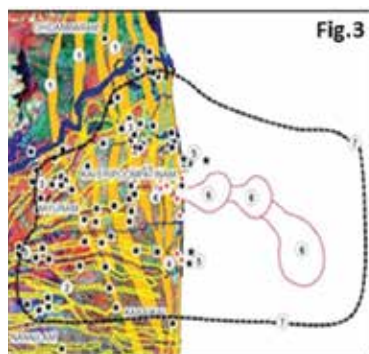
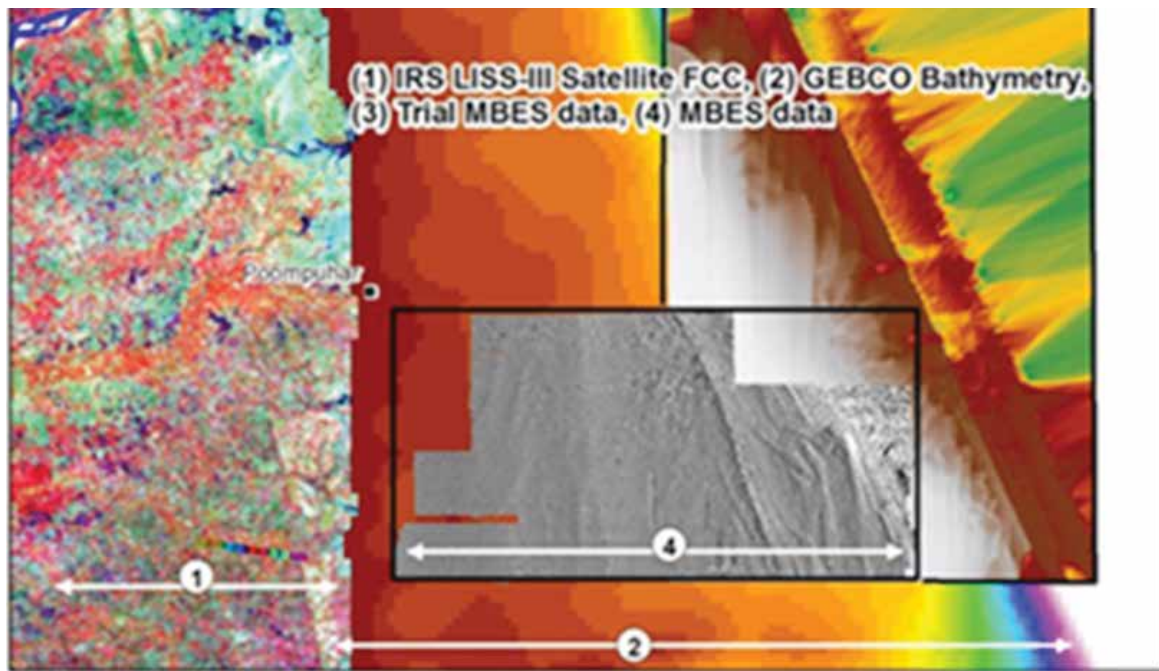
The following new discoveries were made:

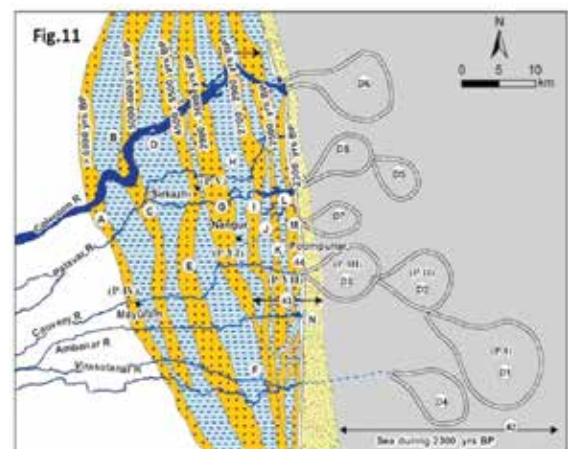
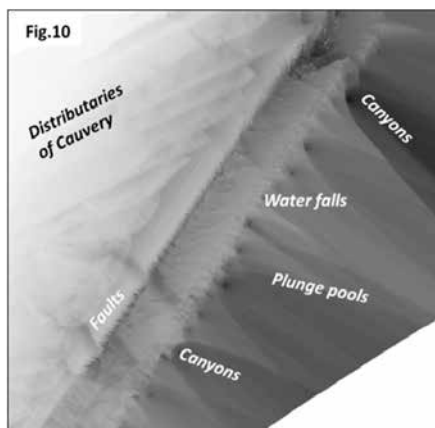
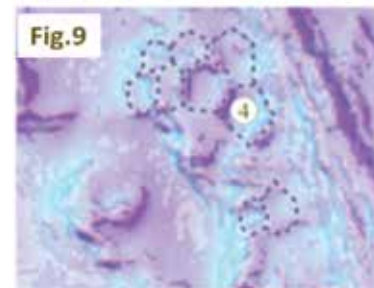
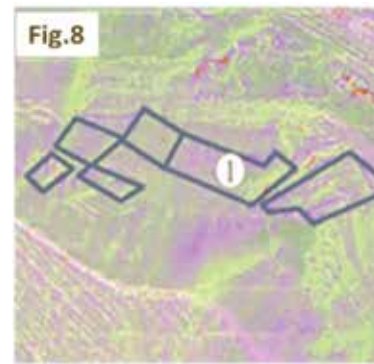
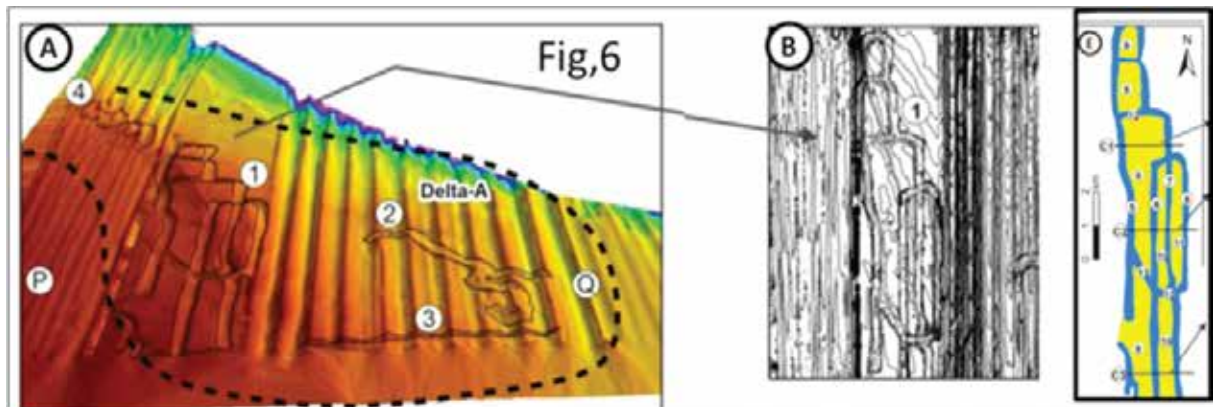
- Major submerged coastal ecosystem, around 30-40 km from the present Poompuhar coast (Fig.5) at depth of 40-50 m in the sea.
- Submerged Harbour (Fig.6A-C) and shipyard (Fig.7) of over 15000 years old at the distance of 30 km from the present coast of Poompuhar.
- Anthropogenic features like settlements (Fig.8), submerged salt pans, (Fig.9) etc. derived from digitally processed MBES data
- Possible seven stages of shifting of Poompuhar from 30-40 km in the offshore region in the east to Mayavaram in the west and establishment of present Poompuhar around

2500 years ago as the 7th resettled harbour city (Fig.11. D series -deltas, PI-PVII 7 locations of Poompuhar).

- Digital visualization, animation 3-D modeling, web portal development, preferential data mining and the semantic modeling have also progressed.

The project has made giant leaps in multiple directions and expected to bring out beeline of newer information on the life history of Poompuhar.





2.6.6 Data Science Research

A cluster project initiative has facilitated innovations from different domains to be grouped in a large framework. The cluster is quite successful and has produced about eighty (80) publications. A set of total twenty three projects is sub-grouped into the following five categories; and their outcome is briefed below.

Data Science

Random Projection (RP) based methods have been proposed that address a few issues within the same broad framework. In the first work, RP is used for an efficient, singular value decomposition inspired template matrix factorization and a geometric intuition is developed to understand why this approach works. The next work demonstrates the application of a block-wise randomized matrix factorization (RMF) algorithm for computing low-rank factorizations at a preset average fractional loss of Signal to Noise Ratio. This new scheme is shown to be more efficient in the context of the LLOID framework of the GstLAL search pipeline.

Deep Learning

The progress in this domain includes training of Deep Neural Network models with limited supervision, compression of deep learning models, and neural architecture search. An easy and faster way to model uncertainty in deep learning models has been proposed including neural ordinary differential equations and Generative Adversarial Networks for image generation. Also, cache optimizations for DNN loops have been developed using polyhedral compilation techniques. Secondly, DNNs like PointCNN, DGCNN, UNET (on projected LiDAR data) are being developed for semantic segmentation of the mobile LiDAR data. A SoP has been developed using open-source software for the labelling of actual field data sourced from the Indian industries. In another effort, an automated commentary system for tennis games was built. A deep learning-based model has been developed to generate a commentary for a given tennis video clip. The fourth group worked in the domain of photoacoustic signals, the reconstruction of photoacoustic images is done by adding a non-local means-based filtering step which improves the signal-to-noise ratio of 2.5 dB in the reconstructed photoacoustic images. An outlier detection model has been proposed using stacked auto-encoders to extract features and an ensemble of probabilistic neural networks to do a majority voting to detect the outliers.

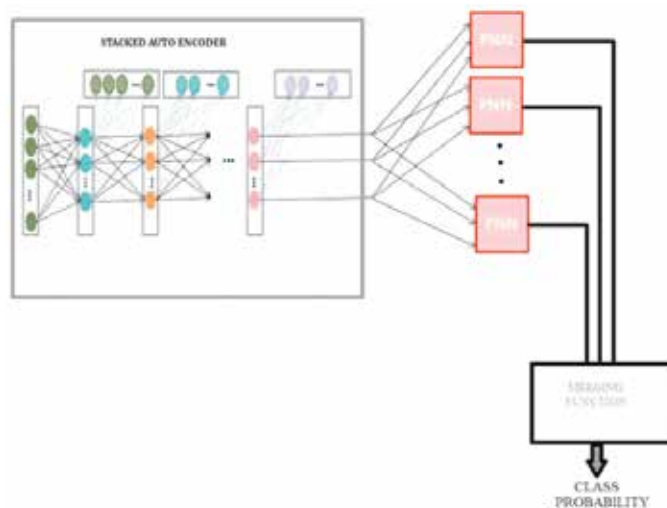


Figure. Architecture of the Outlier Detection Model

Bio-informatics

In this domain, first, a consensus-driven approach has been proposed to prioritize AD responsible genes. Graph Neural Network (GCN) and other graph embedding techniques have been applied to infer edges in partially reconstructed GRNs. Secondly, a model is being developed that can identify the root cause of specific diseases and will be able to identify the gene which is creating the problem. A few novel approaches have been proposed to handle the curse of dimensionality, multi-class classification and stability issues of threatening diseases on microarray datasets.

Social Network Analysis

A robust graph-based deep learning architecture has been proposed to detect node anomalies in static social networks. The decoder reconstructs the original adjacency matrix and feature matrix which are compared with each other to identify a node as an anomaly. In another work, a web interface has been developed for the user to interact with the Question Answering System. A multilingual chatbot is developed using RASA as the NLP library, as the cross-platform application development framework, and Django framework for server-side manipulations.

Applications

Multi-label Classification: Few models have been proposed for handling problems with multi-label data. A hierarchical tree-based classifier is built that handles class imbalance, simplifies decision space and preserves label correlations in the data. An autoencoder and extreme learning machine-based model performs dimensionality reduction (Figure 2). Another functional link network model increases separability to handle the complex decision space.

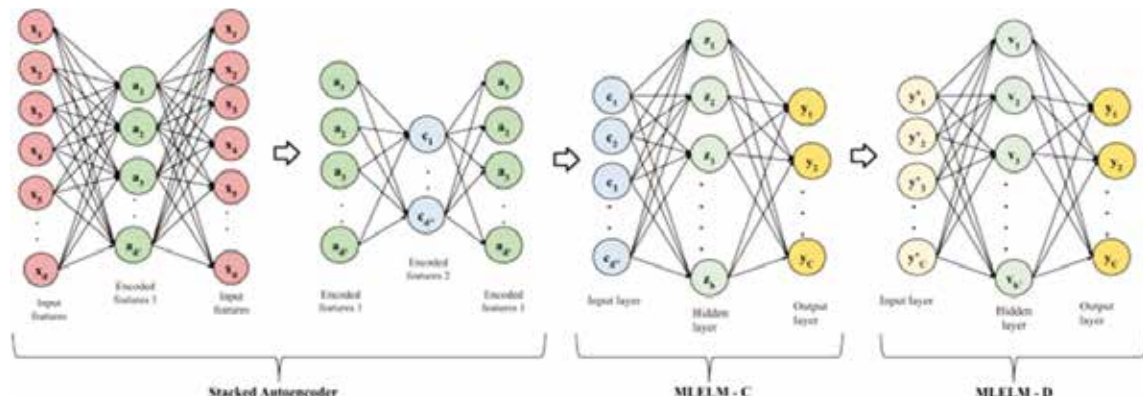


Figure 2: Architecture of the Autoencoder & ELM model

Emotion Recognition: An emotion recognition application is being built for the Odia language. The database for different dialects of the language is being recorded to create a total of 10000 samples from different artists of different regions of Odisha. Using the collected data, models have been trained and tested locally on web applications. Also, the front-end design of the android app has been completed.

Agriculture

Data collection for disease identification in tomato crops has been done. Currently, the explainable component is being explored using techniques such as GradCAM, to ensure that the model is robust and has no bias, and visualizing the highlighted segments of the leaf for each disease.

Astronomy

The first problem is related to galaxy morphology classification using various deep learning techniques. Two variants of Neural Ordinary Differential Equations (NODE and NODE_ACA) were tested to show that their performance is comparable to Resnet with a smaller memory footprint. For the second problem, Variational Inference (VI) has been explored as an alternative to Monte Carlo methods for regression and Bayesian model comparison. A new technique for Bayesian model comparison within ADVI known as posterior weighted importance sampling for evidence has been proposed.

Energy

The problems of demand and battery scheduling, energy trading and dynamic pricing in smart grids were formulated in the framework of stochastic games. A novel Deep Q-Network (DQN) approach has been proposed to solve these problems by creating two separate neural networks both working as ingredients to the same stochastic game.

2.6.7 Internet of Things (IoT) Research:

Cyber Physical System (CPS) is one of the fast emerging and most challenging technologies of the current decade. At the heart of CPS is Internet of Things (IoT) involving dense embedded sensors and actuators, interconnected through communication network, with computing in the network, or at the edge, or in the cloud. Internet of Things is expected to bring revolutionary advancement in the areas of Health Care, Smart Farms, Smart Grids, smart urban water networks, smart homes, smart factories, smart cities, smart traffic network etc.

Through a series of workshops, 32 number of R & D projects (17 Projects under Networked mode and 15 projects under individual category) have been selected under three different categories: **IoT Architecture, IoT for Smart Living and IoT Applications.**

2.6.8 Cyber Security Research

The cyber security research initiative is an attempt to define a national R&D agenda that is required to enable the country to get ahead of adversaries and produce the technologies. The current initiative is a platform to work together to foster R&D to evolve transformative solutions and address critical cyber security challenges, through partnerships among academics, Industry and Govt. Nearly, 19 projects under networked mode and 13 number of projects under individual category were supported under this theme area.

INNOVATION TECHNOLOGY DEVELOPMENT AND DEPLOYMENT

The umbrella scheme “Innovation, Technology Development and Deployment” focuses on strengthening the Science, Technology and Innovation (STI) ecosystem for the development of the nation. This umbrella scheme with its sub-schemes contribute broadly on capacity building for research and innovation, creating an ecosystem for technology development and adaptation of need-based technologies to address the identified societal challenges; research and technology-based solutions for India-centric challenges related to Water and Clean Energy etc.; nurturing and scaling up of innovative technology-based start-ups through institutional support and incubation; scientific awareness, communication, popularisation and scientific temper for all; development of geo-spatial solutions for sustainable socio-economic growth; translation of research into products and processes for greater economic and societal benefits.

3.1 Technology Development Programmes (TDP)

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. The sub schemes of TDP are:

- Advanced Manufacturing Technologies (AMT)
- Biomedical Device and Technology Development Program (BDTD)
- Device Development Program (DDP)
- Science and Heritage Research Initiative (SHRI)
- Technology Development Program (TDP)

- Technology Mission for Indian Railways (TMIR)
- Waste Management Technologies (WMT)
- Technology Enabling Centres (TEC) for Universities

Science and Heritage Research Initiative (SHRI): A call for proposals was launched including the areas such as Physical Space for Heritage, Digital Space for Heritage, Technologies for Textile Heritage, Traditional Agricultural Practices, Technologies for Tangible Heritage, Technologies for Intangible Heritage. Specific studies to understand the scientific phenomenon behind the degradation and preservation, etc. Around 800 proposals were received which are under process of technical evaluation.

Advanced Manufacturing Technologies (AMT): A call for proposals was launched after extensive stakeholder consultation encompassing areas like (a) Manufacturing of nano materials, electronic grade materials, smart materials, and metamaterials (b) Novel surface coatings and surface texturing (c) Robotics and automation (d) Precision Manufacturing (e) Advanced forming and near net shape processing (f) New and innovative manufacturing processes such as molecular manufacturing. On closure, 400 proposals were received. The compendium of the technologies developed under the program has been prepared for wider audience.

Technology Development Program (TDP): The call for proposals is launched in December, 2021 under TDP component with a focus on Construction, infrastructure and low-cost building Materials, Advance Materials & Processing, Agro-Product Processing and Agro-IT technologies (including Food processing technologies), Innovative Product Development, Technologies for Disaster Management and Technology for Product design and Development for Import Substitution.

Biomedical Device and Technology Development Program (BDTD): The Grand Challenge on “Nutritional Status” assessment was closed 31st March, 2021. On closure, 45 proposals were received and 7 have been recommended for funding after technical evaluation.

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. Two new projects on development of Hydrogen Fuel Cell Based Hybrid Power Train for Railways Vehicles and Acoustic Scheme for improved NVH Performance for Greater passenger Comfort in LHB Non-A.C Coaches have been initiated with Research Designs and Standards Organisation (RDSO).

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.

9TECs and 2 satellite centres are actively pursuing various activities as per mandate.

Hubs for Development of Biomedical Devices:

National Hub for Healthcare instrumentation Development (NHHID), Anna University has made some significant progresses especially in terms of taking the prototypes to market. The Hub is also noted by the media as revealed by the coverage of its activities in reputed national newspapers as featured articles. The major highlights are as follows:

ToT's & MOA's M/s Microbiological Laboratory Research & Services India (P) Ltd, M/s Jet Inks Pvt Ltd and M/sTriphase Technologies Pvt Ltd.

Patents: The patents were filed for pH sensitive colorimetric test for Bacterial identification from Liquid Medium Cultures and Enzyme containing Sanitizer Formulation.

COVID'19 Solutions: In order to provide the Solutions for COVID'19 NHHID developed the prototypes for Smart Thermometer, Au Sanitizer, Au Mask, Standalone Respiratory Support Devices and Ventilator, Usiru - Cpap and Bipap Non-Invasive Ventilator

INFANT MONITORING SYSTEM USING RFID: Soon after the signing of the MoU with Anna University, Directorate of Medical Education (DME) came up with an assignment to address the worsening problem of child theft in Govt. hospitals in Tamil Nadu technologically. Accordingly, NHHID has implemented an

TESTING & CALIBRATION: The Centre for Calibration and Testing of Medical Equipment, NHHID has catered to 17 Hospitals & 961 Equipment.

Hearing Camp were conducted by NHHID & MERF with newly developed Cost-effective software device at Siruvapuri Village, Tamil Nadu Anna University (CEG & MIT) Campus and Anna Gem Science park School respectively.



Fig: Hearing Camp Conducted in Anna University (CEG & MIT Campus for 4 days)

Biomedical Instruments and Devices (BID)Hub at Postgraduate Institute of Medical Education and Research (PGIMER), Chandigarh. The contribution of BID Hub in terms of Products/Prototypes/Services are summarized as follows:

BIOMEDICAL DEVICES TESTING: To date, at BID-Hub, A total of at least 270 overall medical equipment from various department of PGIMER, Chandigarh have been tested for their functioning. The Biomedical Hub further aims to increase in-house testing and calibration of other conventional devices used in a hospital.

IPR PROTECTION & SUPPORT: Biomed Hub has endeavoured to create an understanding of general IPRs like Trademarks, Patents, Copyrights and Designs, and unconventional rights like Indications, Product Varieties, and Topographies of Circuits and is working towards creating awareness and guide academic and non-academic staff of institutes in the region about practicing intellectual property rights (IPRs) especially patent. Individually, patent search services, patent filing, office action among others are practiced under the shadow of the BID-Hub, PGIMER, Chandigarh.

ABCD: Artificial Breathing Capability Device (Patent Grant: 381813) APPLICATION NUMBER:201811020643 The critical features that make this device different from a mere compression of SIB Bag are, controlling peak inspiratory pressure (PIP), ventilation rate (VR), and inspiration to expiration time (I:E) ratio, similar to what is done by a ventilator.

ABCD was tested non-stop for 60 days with 396 user combinations without any breakdown or failure. It is a safe, efficacious, and cost-effective option, which could be considered for adults and children in the context of ventilator shortages, especially during the COVID-19 pandemic around the world.



Fig: ABCD front and side view showing display screen and input keypad

MACHINE FOR PERFORMING DOUBLE VOLUME EXCHANGE TRANSFUSION

The first of its kind device for double volume exchange transfusion was successfully tested. The clinically-validated device will facilitate the Double Volume Exchange Transfusion, which involves replacing entire blood volume in infants in case of severe jaundice.



Fig: Double Volume Exchange Transfusion front view showing screen and keypad

Some leading demonstrable technologies from the completed projects are as follows:

1. **Biomass Mediated Value Addition to Fertilizer Industries Waste by CSIR-Institute of Minerals and Materials Technology, Bhubaneswar, Odisha.** The technology readiness level of the patented process “Biomass mediated conversion of acidic Phosphogypsum to alkaline potassium sulphur rich material (Application No. 201711022958) was enhanced for field deployment through this project. Technology has impact for alternative utilisation of phosphogypsum in acidic soils due to potassium addition from banana plants waste and change in pH. The demonstration will be done with industrial collaborator Paradeep Phosphate Limited, Paradeep, Odisha.

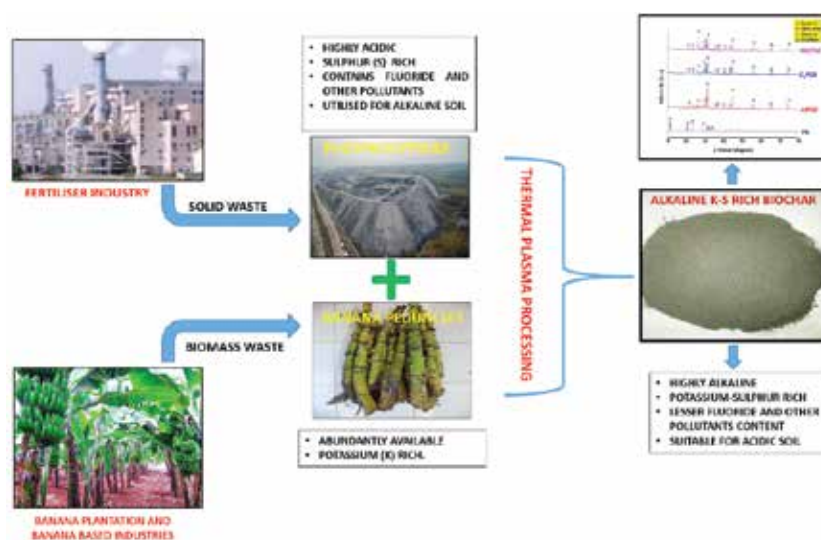


Fig: Graphical Representation of the Process

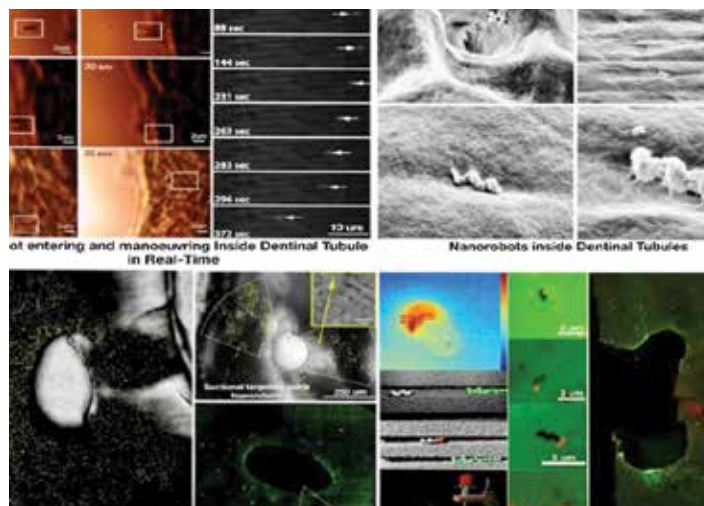
2. **‘OptMe’ - An opto-electronic sensing system for the detection of freshness in meat products by Velammal Engineering College, Chennai, Tamilnadu.** A portable optical sensing system for in-situ monitoring of freshness of meat products was developed with

a focus on simple to use and cost effective. The parameters of interest to understand the quality of food items are, CO_2 and O_2 . The food products, such as chicken, pork, fish and meat are tested and the handheld system will find the applications in house, restaurants, departmental stores and meat shops. An Indian Patent titled “Portable optoelectronic sensing system for the detection of food freshness”- Filed (201841037491 dated October 04, 2018). A start-up named ‘Emsensing Technologies Private Limited’ has been registered to pursue ‘commercialization activities’.



Fig: Portable optoelectronic sensing system

- Scaling up the Fabrication of Nanomaterials with Higher Degree of Complexity by Indian Institute of Science, Bangalore, Karnataka.** The system uses helical magnetic nanorobots capable of reaching the entire depths within the dentinal tissues to ensure a thorough cleaning by targeting antibiotic resistant (AMR) bacterial colonies using magnetic hyperthermia-based method that are not possible with current state of the art tools to prevent root canal failure. The proof-of-concept, early prototypes have been demonstrated.



4. **Development of an intelligent evaporative cooler for composite climate by Indian Institute of Technology (BHU), Varanasi, Uttar Pradesh.** A dual-mode evaporative cooler has been developed to provide thermal comfort cooling in varied climatic conditions. This two-in-one device can easily switch from direct evaporative cooling mode (suited for dry climatic condition) to regenerative evaporative cooling mode (suited for humid climatic condition) or vice-versa. The device consists of heat and mass exchanger, fan, water tank, pump and vane. By managing vane and exhaust fan speed, users can choose any mode as per requirement. This device eliminates the need for two different devices for same purpose. This device will be cheaper, breakthrough and easy for buyers to adopt and operate.

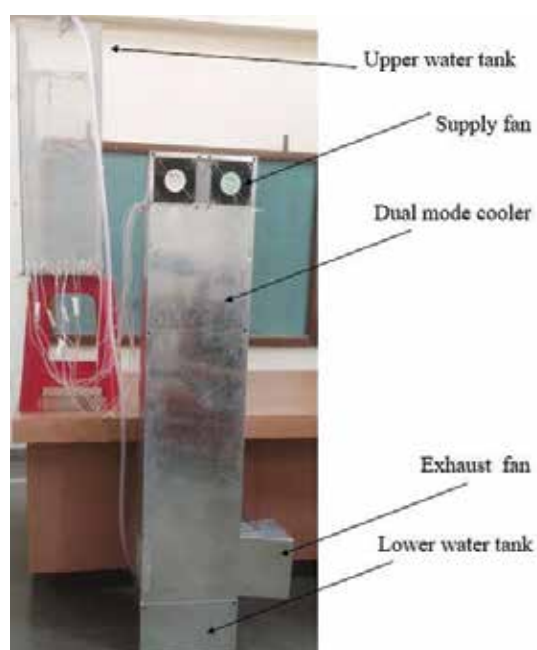


Fig: Photograph of invented dual mode evaporative cooler

5. **Development of a manufacturing technology of ceramic membrane with internationally competitive specification for diverse application and its demonstration in a pre-pilot scale operation.** The project aims at demonstration of production of indigenous ceramic membranes, having comparable quality parameters matching with internationally available ceramic membranes properties like high chemical, mechanical and thermal stability and implemented through partners CSIR-CGCRI, CSIR-NIIST and M/s Prism Johnson Ltd, Mumbai in a pre-pilot plant established for the manufacture of 19 channelled 1.2 m long, alumina based ceramic membranes for microfiltration. A clear water flux of 100-200 LMH is achieved through appropriate membrane layer depositions. The product developed is currently being evaluated for different applications. One such evaluation is carried out at Essar oil, Durgapur for oil water separation.

6. **Development of remunerative organic waste management systems for colder regions of India with the intervention of psychrophilic aerobic and anaerobic microbial consortia by CSIR-IHBT, SKUAST and CSIR-IICT, Hyderabad.** The indigenous bacterial formulations with cold tolerance, hydrolytic potential, and plant growth promotion properties were prepared for rapid degradation of organic waste and generation of enriched compost. Products like **Compost Booster**: formulations rapid degradation of organic waste; and **Enriched compost**: quality compost with PGP, were developed. Two SFURTI clusters, one each at Sikkim and Himachal Pradesh have been established using the technology to provide livelihood to 400 households. Anaerobic biogas plants have been installed in Gyalshing Municipal Council, Sikkim, and Nagar Panchayat Baijnath, HP. In-vessel and biogas plant trials have been initiated for improved biomethanation.



Fig: Bio digester (capacity 250 Kg/day) functional at Baijnath, HP and Gyalshing, West Sikkim

7. **Development of Value Added Geopolymer Aggregates using Iron Ore Mine Tailings - A Sustainable Solution by NITK, Surathkal, Karnataka** Production of well characterized geopolymer aggregates with sustainable utilization of mine tailings and industrial by products at larger scales will significantly help in reducing the impact on environment and potential health hazards. Also, this mitigates quarrying of natural aggregates from mines, in turn preserving the naturally available resources. Amount of utilization of aggregates has increased due to rapid infrastructure development across globe. However, availability of natural aggregates is very scarce and mining has led to serious environmental impacts. Hence, this technology has a greater potential and value in the technology transfer to construction industries.



Fig: Laboratory trial production of Geopolymerized Aggregates

8. **Tensiometer based automated IoT system for irrigation by National Institute of Technology, Shillong.** Two types of digital tensiometers have been developed in this project. One is based on the Image Processing technique and another one through pressure sensor technique. The developed tensiometer determined the soil moisture in terms of soil surface tension (unit is KPa). The data is sent to the cloud and the continuous data is stored in the cloud and the solenoid pump is automatically controlled by the cloud. The developed tensiometer has been deployed in the agricultural farmland of the East Khasi Hills (hilly irrigation farmland).

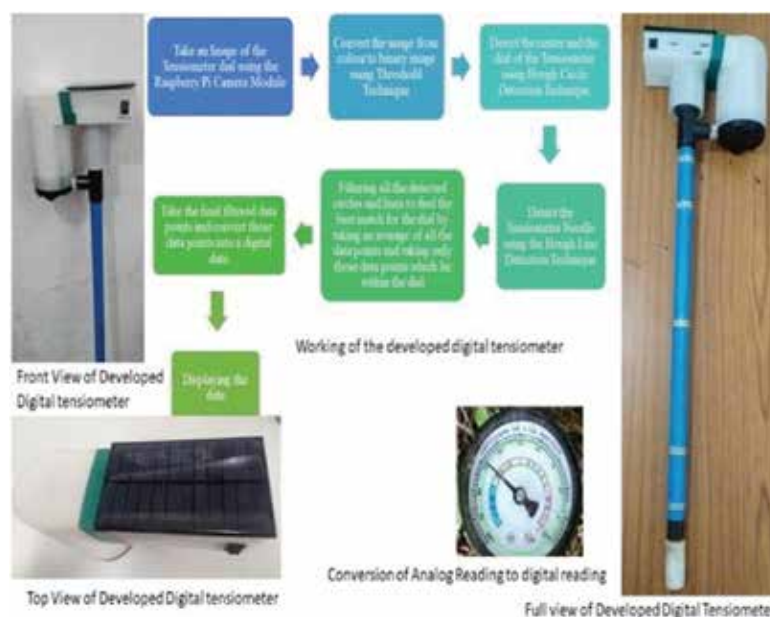


Fig.1. Digital Tensiometer based on Image Processing

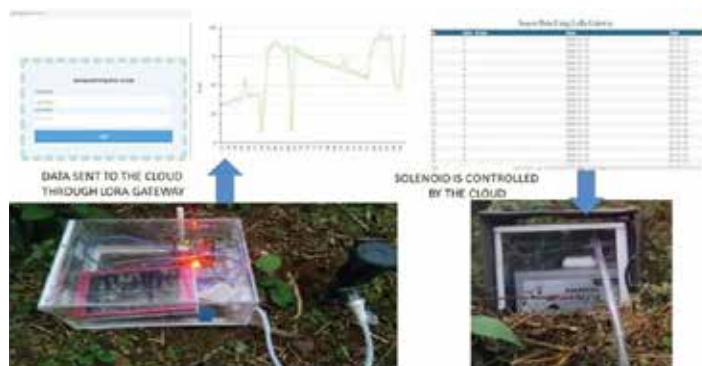
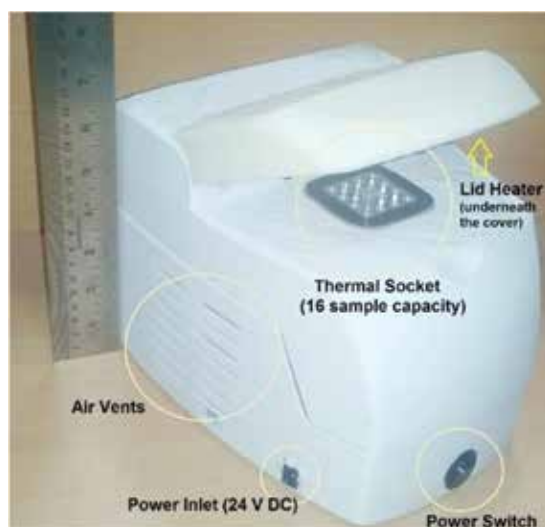


Fig.2. Digital Tensiometer using Pressure sensor

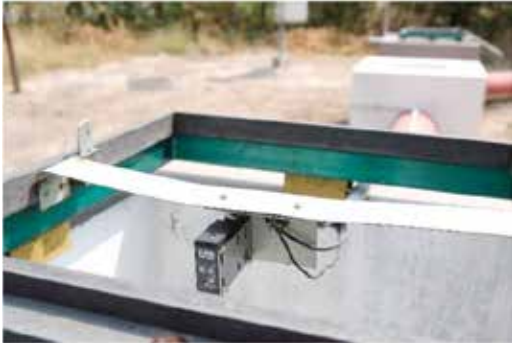
9. **Detection of Plant Pathogenic Fungi using Handheld PCR by Indian Institute of Science, Bangalore, Karnataka.** A set of two instruments have been developed for carrying out DNA-based pathogen detection. These low-cost, low-power, portable devices can be field-deployed for sensitive, accurate and possibly early detection of plant diseases, potentially cutting down crop losses and pesticide use. Technology has been developed at the pilot scale. Developed a portable thermal cycler (figure), a portable, battery operable fluorescence reader and a microfluidic DNA extraction method (along with the required microfluidic device). Technology transferred to *Shanmukha Innovations Pvt. Ltd.* for the purpose of Manufacturing and Compliance Testing etc.



The developed Thermal Cycler fabricated using 3D printing

10. **Design and Development of Sensor Based Sewage Block Remover and Management System by K.L.N. College of Engineering, Pottapalaym, Tamil Nadu.** The underground sewage management system is designed and fabricated to identify and remove the blocks in the sewage system without direct human intervention. A

wireless sensor network monitors and governs the entire sewage system. Sensors will transfer the data through Information & Communication Technology (ICT) for remote monitoring. For any unusual occurrences, the operator will take necessary actions using a mechanical remover system. The sewage slurry is sucked through a pump and stored in a tank and disposed of in a non-hazardous area. This innovation has been registered and published in IPR (Application No.202141026550A)



Sensor Arrangements in Man Hole
Portable Sewage Block Remover System



Portable Sewage Block



Control Panel



Sewage Inception Camera

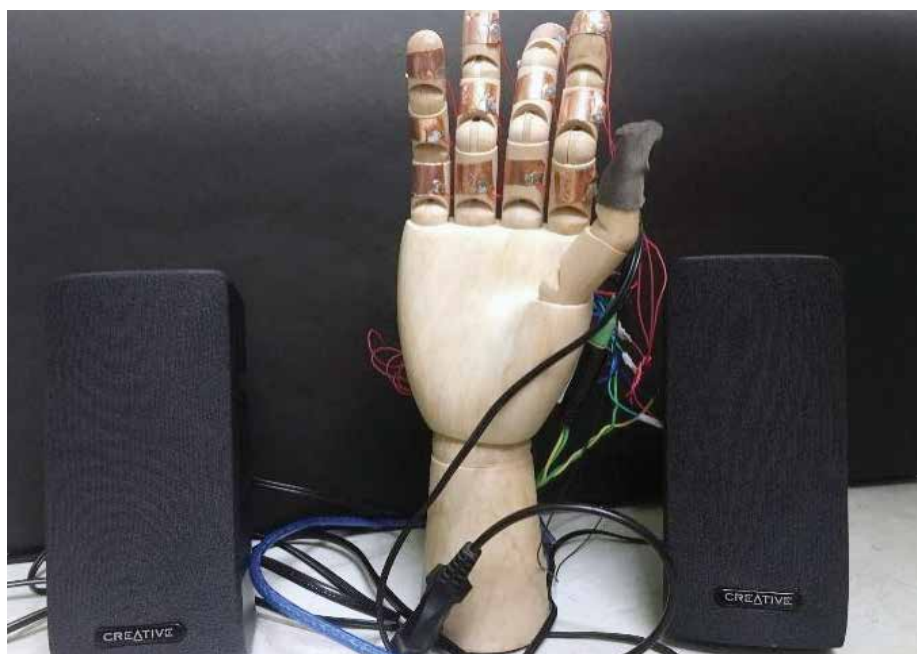
11. **C3 fields: Head mount portable device for Visual Field Perimetry by VIT University, Vellore.** The C3 Field Analyzer is an automated visual field perimeter to access visual fields. Visual Fields are important for several diseases that affect visual function of the eye, including Glaucoma, Neurological Field Defects, etc. C3FA is a head mount device that connects to a Tablet wirelessly. User wears a C3FA headset and the operator can operate the device – start or stop the test – through a connected Tablet. Users are asked to keep looking at center fixation and press a response button upon seeing any stimuli, but keeping eye fixated at center. It is based on the principle of virtual reality and can test one or both eyes simultaneously and independently. iVA is Intelligent vision Analyzer

is portable visual field analyzer, developed in collaboration with industry partner M/s Alfaleus for measurement of visual field abnormalities with more features.



Functional prototype of C3 Field Analyzer

12. **Speech assistive gloves for post traumatic care of people with compromised ability to vocally communicate by IIT Madras, Tamilnadu.** It is a glove based standalone voice communication device for assisting people with expressive aphasia and those with compromised ability to vocally communicate. No app needed to operate the device simple handworn device for easy communication.



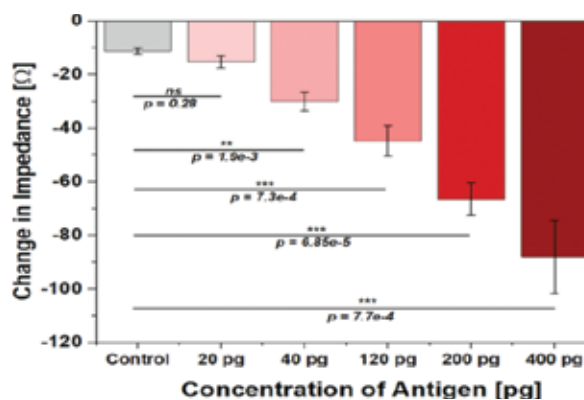
Speech assistive Gloves integrated with speakers

13. **Microfluidic device-based instrument for screening breast cancer using miRNA detection from the serum by PSG Institute of Advanced Studies, Tamilnadu.** Microfluidics based device for screening of breast cancer specific miRNA in serum using complementary probes. Validation and Testing is completed with spiked serum and ongoing for real samples.



Figure shows the instrument developed and the process for measuring the miRNA level, a. the initialization to choose calibration or miRNA measure, b. Patient details entry, c. the result. The instrument has 2 channels to display the miRNA levels of miRNA 21 (Over expressed) and miRNA 195 (suppressed).

14. **A Lab-on-PCB system for point-of-care detection of oral cancer biomarkers by Indian Institute of Science, Bangalore, Karnataka.** A multiplexed microfluidic microchip with inter-digitated electrodes capable of detection of oral cancer biomarkers in lymph node extracts through impedance sensing. The developed technology is label-free and the impedance sensing results can be obtained within 30 minutes; PCB-based devices are cost-effective and thus enables large-scale manufacturing for single use applications which is an important advantage over existing methods.



PCB-based point of care device

3.2 Technology Mission Division (CERI & WTI)

3.2.1 Clean Energy Research Initiative (CERI)

The overarching objective of CERI is to nurture S&T led breakthroughs to make clean energy affordable and accessible through strengthening Research and Innovation Eco-System for Clean Energy. CERI aims to:

- Support upstream end of research to generate advanced knowledge of potential application to clean energy.
- Accelerate India centric innovations developed around user needs.
- Promote national, bilateral and multilateral collaboration between industry, academics, utilities and other stakeholders to gain value for such connections.
- Create national research competence in Clean Energy through human and institutional capacity development.

During the year 2021-22, several new dimensions were added to the programme to accelerate the pace of clean innovations to meet national needs, which are as under:

Mission Innovation: Mission Innovation (MI) is a global initiative of 25 countries to dramatically accelerate global clean energy innovation. Participating nations had 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.

Mission Innovation Challenge #1: Smart Grids

India is one of the Co-led in Smart Grids Innovation Challenge. 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, IC1 also focuses on the aspects related to cross innovation.

Mission Innovation Challenge # 3: Carbon Capture Utilization and Storage (CCUS)

This challenge aims to enable near-zero CO₂ emissions from power plants and carbon intensive industries. DST has supported 19 multilateral projects in collaboration with MI partner country investing an overall amount of Rs. 18.5 crores.

- Under Mission Innovation (MI) umbrella, DST has supported 19 RD&D projects under IC#3 Carbon Capture Utilization and Storage (CCUS) partnering with 12 MI members countries, and all these required the participation of a representative from at least one MI member country. Funding aims to conduct research, development and demonstration to foster technology innovations to higher TRL levels that are technically feasible, robust and cost-effective.
- DST has supported a lab based MI-IC#3 research project to IIT Bombay for a systematic large-scale assessment for potential of CO₂ enhanced oil and natural gas recovery in key sedimentary basins in India. In this intervention, four different storage pathways with adequate potential have been identified: storage through CO₂ enhanced oil recovery

(EOR), enhanced coalbed methane recovery (ECBMR), storage in deep saline aquifers, and basalt formations.

- DST has supported MI project being led by Jawaharlal Nehru Centre for Advanced Scientific Research, Bengaluru for development of integrated technologies for CO₂ reduction to value added products. The project team has successfully developed an efficient, cost effective and chemical stable catalyst at pilot-scale for CO₂ reduction reaction. Pilot scale plant of 30 kg CO₂/day capacity to methanol has been operated successfully for a continuous period of 40 days. Successful integration has been carried out of all the unit processes. Novel catalysts have been also developed for the production of energy rich, high octane number hydrocarbon fuels from CO₂ to obtain selectivity of 80%.

Hybrid Membranes for Carbon Capture and Separation of CO₂

DST-CCUS has supported MI-IC#3 project to IISER Kolkata for development of Hierarchical Porous Covalent Organic Nanosheets and Nanosheets Based Hybrid Membranes for Carbon Capture and Separation of CO₂. The group has recently developed purely covalent bonded organic nanotubes (CONTs) with a hitherto unavailable structure via a novel bottom-up approach. These CONTs have also showcased photosensitizing ability which can convert the adsorbed CO₂ into CO (130-200 µmol g⁻¹ h⁻¹) upon irradiation of visible light (400-700 nm).

Combined Sorbent Catalyst Material (CSCM) for CO₂ Capture

- Another intervention has been supported by DST-CCUS to IICT Hyderabad for designing, synthesis and evaluation of Combined Sorbent Catalyst Material (CSCM) for CO₂ Capture. A dual, fixed cum fluidized bed reactor system has been designed based on theoretical calculations along with some preliminary experimental studies.
- DST-CCUS has supported MI IC#3 project to IIT Delhi for development of hierarchical novel catalyst for one pot conversion of CO₂ rich synthesis gas to Dimethyl Ether and scale-up Studies. In this intervention, the team has successfully developed a novel and economic catalyst for higher conversion levels of syngas rich in CO₂. A pressure swing adsorption column has been successfully designed and developed in-house for CO₂ capture studies.

Multilateral Accelerating CCS Technologies (ACT) Programme

DST has participated in the ACT#3 Call in collaboration with other ACT partnering countries in the area of CCUS for adapting the global practices and to promote translational research for transfer of technologies from low to higher TRL levels. In this programme, two multilateral CCUS consortia have been supported to IIT Kharagpur, IIT Bombay, GIIP New Delhi in partnership with Netherlands, Norway, Denmark, Germany, UK, USA etc.

Mission Innovation (MI) 2.0 - Green Powered Future Mission (2021-2030)

The next Phase of Mission Innovation (MI 2.0) has been launched jointly by all Member countries during 6th MI Ministerial held virtually at Chile during 31st May to 6th June, 2021. The Mission Innovation (MI 2.0) is based on the two interconnected components: The “Missions” and “Global Platform”. This Mission aims to demonstrate that by 2030 power systems in different geographies and climates, can effectively integrate up to 100% variable renewable energies, like wind and solar.

The Green Powered Future Mission is well proposed and in line with India’s national priority to incept high levels of variable renewable energy in the overall energy mix. DST, India is actively participating in the Green Powered Future Mission.

Mission Innovation (MI) 2.0 – Innovation Community on Affordable Heating and Cooling of Buildings (2021-2030)

As a part of Mission Innovation 2.0, India is co-leading the Innovation Community on low carbon affordable heating and cooling of buildings (IC 7) along with EC and the UK. Since its inception in May 2021, the IC 7 has received an overwhelming response. Canada, Australia, Finland, Morocco, Netherlands, Sweden, and Saudi Arabia have given commitment to work with the Innovation Community. In addition, IEA and RMI have agreed to participate as stakeholders. Developed an online repository to create a global innovation network on affordable heating/cooling technologies and a virtual resource platform for disruptive technologies.

Smart Grids

- Department of Science and Technology and European Union under EU-India Clean Energy and Climate Partnership invited the proposals for collaborative research projects aiming at smartly integrating a large amount of renewable energy in local energy systems with an amount to the tune of €9 million committed by European Countries under Horizon 2020 programme with matching grant from DST. Two projects have been supported under this call. The projects deal with integration of a number of energy sources/ vectors with or without local grid connectivity, computing the supply and demand requirements in real time basis, accommodate as many sources as possible and use of IoT for integration, distribution and monitoring. The demonstration units are proposed in different locations covering rural, semi-urban and urban environments.
- Establishing the Transmission System Operators (TSO) and Distribution Network Operators (DSO) coordination for performing various power system operations such as load flow, optimal power flow, contingency analysis, voltage stability and energy market. These operations are performed in a distributed manner with a little reciprocity of information between SO at the interfacing bus.

Research & Development on Clean Coal Technologies:

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) facility has been established to enable the design validation of 800 Megawatts AUSC steam Turbine rotors for certifying the long-term performance of Super alloy Monometallic and Bimetallic welded rotor with a total of 2000 startups (Hot+ warm+ cold) and 100000 hours of total steady state operation. This is achieved, through accelerated testing within 200 cycles and 10000 hours respectively. These power plants are designed to achieve an efficiency of more than 45 % with lesser coal consumption and reduced pollution levels by 15% per MW.

Cleaner Fuel

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 two major projects for development of 0.25 TPD and 1.0 TPD of methanol from high ash Indian Coal using Fluidized bed gasification pilot plant at BHEL, Hyderabad and Thermax Pvt. Ltd., Pune respectively. Designed and developed an indigenous methanol fuel processor (Fig. 1) with integrated heat recovery, reforming, water-gas shift and hydrogen cleanup steps.



Figure 1. Methanol fuel processor and methanol powered high temperature polymer electrolyte membrane fuel cell system prototype

Building Energy Efficiency

- Low carbon bricks (Fig. 2 a) are developed using construction and demolition waste using alkali-activated binders for energy-efficient walling envelopes to produce energy-efficient walling materials. These bricks do not require high-temperature firing, and will avoid the use of high-energy materials such as Portland cement.

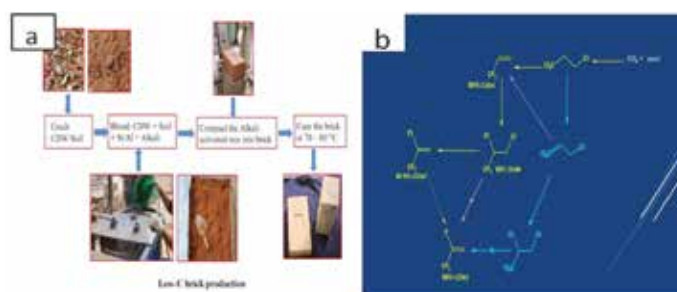


Figure 2. a) Alkali-activated low carbon compressed earth bricks b) Fig: Process routes for preparation of HFO-1234yf

- Developed processes for developing Hydrofluoroolefin (HFO) 1234yf. HFO-1234yf is the next generation refrigerant (Fig. 2 b) and it will replace the existing HFCs for refrigeration application in the coming years.

Materials for Energy Storage

Hierarchically Nanostructured Energy Materials for Next Generation Na-Ion Based Energy Storage Technologies & Their Use in Renewable Energy Systems

Project sponsored by DST –TMD under Material for Energy Storage (MES) program entitled “Hierarchically Nanostructured Energy Materials for Next Generation Na-Ion Based Energy Storage Technologies & Their Use in Renewable Energy Systems” being carried at the Indian Institute of Technology Kharagpur involved the development of new materials and energy storage devices that can be used for the construction of indigenous and cost-effective e-cycles for use in villages, semi-urban and urban areas. A typical prototype of e-cycle (Fig. 3a) that has been designed and constructed, as part of this project, is shown as below.

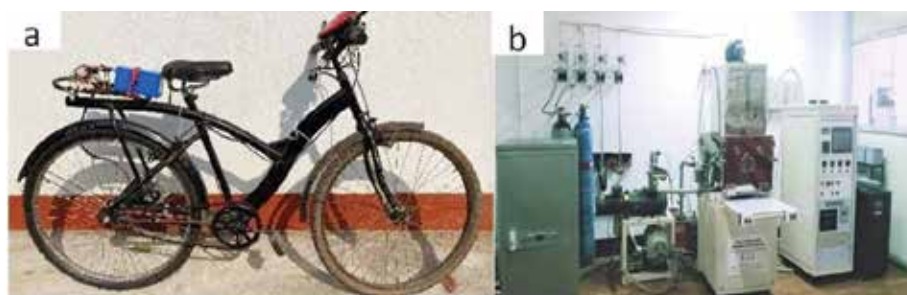


Figure 3. a) Prototype of e-cycle. b) Fabricated linear antenna based MWPECVD unit

Hydrogen & Fuel Cell

The Hydrogen and Fuel Cell program is focused to develop transformational technologies that reduce the cost of hydrogen production, distribution & storage, diversify the feedstock available for economic hydrogen production, enhance the flexibility of the power grid, and reduce emissions through novel uses of low-cost hydrogen. Seven projects are expected to reach pilot plant/application level demonstration in the coming months which include the demonstration of Hydrogen ecosystem for telecom sector- Solar to Hydrogen electrolyzer & 1-3 kW Fuel Cell, demonstration of 20 kW Fuel Cell system – Compressed H₂ storage tank 700 bar, development of seaweed-based biomass – Graphene-based electrocatalysts, development of Pd-Mg based alloys 2.5 wt% for Hydrogen sensor /storage, development of all types of alloys, MoFs - Hydride containers suitable for 2 and 3 wheelers, development of Electrocatalysts based on Polyoxometalates and Pilot-scale production of Biomass H₂ – 99.97% purity for PEMFC.

Solar Energy

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

Semitransparent Photovoltaic Thermal (GiSPVT) System for Agricultural Applications

The greenhouse integrated semi-transparent photo-voltaic thermal (GiSPVT) system is a unique agro-photovoltaic system, developed first time in India in remote area of Ballia, for crop cultivation along with electrical off grid power generation that has potential to be economical and friendly with environment and climate. A pilot test bed facility of 30kWp GiSPVT consists of six zone has been designed and constructed for vegetables production and off-grid electrical power production at Jawahar Nagar (Margupur) in Ballia district, Uttar Pradesh. The facility has zones with different photovoltaic packing factor and developed by Jamia Millia Islamia University along with Bag Energy Research Society. The test bed is equipped with basic measuring instrumentations namely solarimeter, relative humidity meter, lux meter, thermometers etc. In first level study, it has been found that the Packing factor area of 25% of semi-transparent PV module of GiSPVT is the best for production of bottle gourd and cucumber. The GiSPVT test bed is providing gainful scientific insights and training to farmers to enhance their productivity.

Incorporation of DLN in a solar cell structure as a replacement of Silicon Nitride

Efforts were undertaken to establish Diamond like Nanocomposite (DLN) as antireflection coating material for solar cell instead of conventional Silicon Nitride material for PV industry. A non-hazardous organic liquid precursor is used to deposit DLN instead of highly corrosive and toxic ammonia and silane for conventional silicon nitride preparation.

The MW-PECVD (Fig. 3b) is fabricated first time in our country with utilizing the expertise of M/S Omicron Scientific Ltd New Delhi and successfully demonstrated at Meghnad Saha Institute of Technology (MSIT) in collaboration with IEST Solar PV Hub, Shibpur in West Bengal. Though few accessories were purchased from abroad but in-house fabrication process of MWPECVD shows us there is 30% - 40% cost reduction in comparison to the imported one. The DLN film has been deposited on large area solar cell of area 156 mm X 156 mm uniformly. The films have been characterised by FTIR, Raman, FESEM, HRTEM and optical property has been evaluated by ellipsometer and UV-VIS-NIR spectroscopy. The film showed a good ARC property and high thermal stability. Successful development of large area Dielectric film, already demonstrated at MSIT is, thus, of great relevance for the EDS development. It is a step ahead for making “Atmanirbhar Bharat” in manufacturing of Solar Cell with low cost technology using MW-PECVD method.

Portable Stand-Alone Vaccine Refrigerator for Rural Off Grid Regions

Vaccines are sensitive biological products and need to be stored at a specified temperature to retain its potency. Failure to maintain at the specified temperature range leads to revaccination and other financial burdens to the government. This motivated the CDAC, Thiruvananthapuram to design and develop a portable stand-alone refrigerator of capacities 3 and 1.5 litres, which can be used to transfer the vaccines to off grid remote location and regulate the temperature range within 2°C to 8°C. The portable refrigerator consists of design and fabrication of various modules like refrigeration components, DC-DC Converter, Lithium-ion battery pack and communication module. The unit is powered by lithium-ion battery of 29Ah capacity and nominal voltage of 16.8V. The vaccine storage area is covered by thermal insulating material called polyurethane foam (PUF). Evaluated the thermal conductivity of PUF experimentally and found the value 0.0206 W/mK, which is much lesser than the glass wool or any other commercially available thermal insulators. Testing of refrigerator units, 3 litre and 1.5 litre capacity were carried out in an industry environment and evaluated the performance by running continuously for 13 hours. The total weight of the system is less than 7kg.

Other initiatives

During the year 2021-22 new projects were undertaken to develop laboratory led R&D equipment and systems to strengthen Atma Nirbhar Bharat mission that would help indigenization in Solar sector.

Conferences

DST-IITM Solar Energy Harnessing Centre (DSEHC) organized online conference “Recent Advances and Innovations in Solar Energy (RAISE 2021)”. The conference was structured to foster discussion between participants around the core themes in the areas of Photovoltaics (Organic Photovoltaics, Silicon Cells, Heterojunction cells, Tandem cells, Mechanical

processing of Si) Solar thermal (CSP, Solar Cooling, Solar desalination, Solar Thermal coating, Direct steam generation) Energy storage (Li /Na ion batteries, Flow batteries), and Solar Fuels (Photocatalysis, Electrocatalysis, Green Hydrogen). A dedicated industry session was held to get to know the latest technologies being commercialized in the solar industry.

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 initiative encompasses entire technology development chain to successively progress to higher technology readiness levels culminating into sustainable solutions. Some of the achievements made during the FY 2021-22 are as under:

Water Treatment and Management

Smart Device for Production of Ultra-Pure and Haemodialysis Grade Water: In DST-WTI project supported to CSIR-IICT, Hyderabad, the Membrane Separations laboratory has designed and fabricated a low-cost, compact system based on hydrophilized polyamide cascaded RO membrane configuration integrated with resin for production of Type II and Type III grades of ultrapure water of 25–40 L/h capacity for laboratory and biochemical applications besides a pilot plant of 100 L/h capacity for medical application viz., haemodialysis. The technology is transferred to Surya Medical & Surgicals, Nainital, while systems are also installed at Gandhi Hospital, Hyderabad and Coal Analysis Section at IICT.

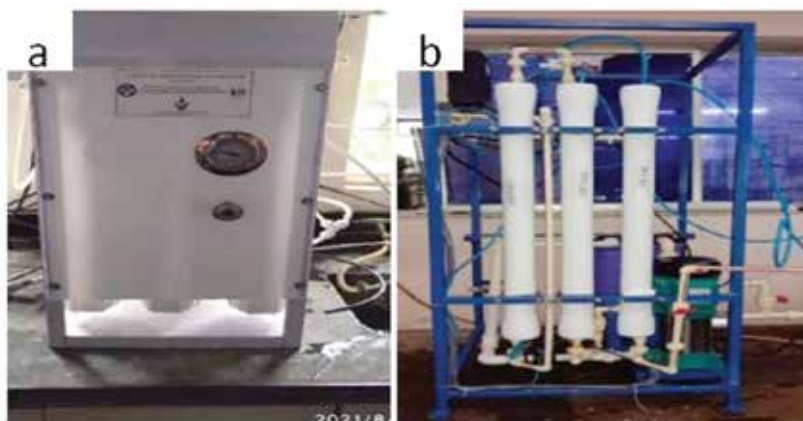


Figure 4. a) Photograph of 50 L/h capacity system for production of Type II grade ultrapure water and b) Photograph of 100 L/h Pilot Plant for production of Type III Ultrapure Medical Grade Water for Haemodialysis

Modern technology and Indian traditional knowledge combined to bring safe & healthy drinking water: DST has supported a Water Innovation Centre Technology Research and Education (WICTRE) project lead by IIT Bombay comprising of NCL Pune and other premier academic Indian institutions. In this intervention an innovative technology called SWASTIIK' based on cavitation has been developed and patented (Fig. 5 a) by NCL Pune. This technology can eliminate harmful bacteria, including antimicrobial-resistant bacteria, economically. It not only integrates Indian traditional knowledge of Ayurveda for complete disinfection of water but also may offer possible health benefits of natural oils.

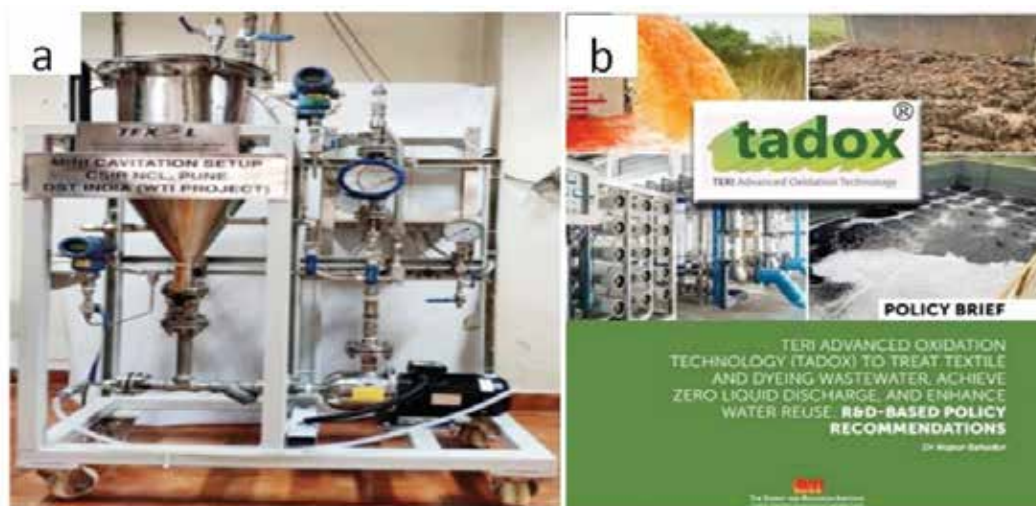


Figure 5. a) CSIR-NCL Cavitation Pilot Plant for Wastewater Treatment. b) TADOX® technology developed by TERI Gurugram

New advanced oxidation technology for enhancing waste water reuse at lower cost: A project lead by The Energy and Resources Institute (TERI), New Delhi, has developed a technology called The Advanced Oxidation Technology or TADOX® (Fig. 5 b) which 'can reduce less dependence and load on biological and tertiary treatment systems and help achieve Zero Liquid Discharge (ZLD). The technology has been adopted by an MSME Company to scale up to 10 Kilo Litre per Day continuous running plant in TERI Gurugram campus. TADOX® technology has been chosen for pilot trials and augmentation plan for identified industrial sectors under 'NamamiGange' Programme of the Ministry of Jal Shakti, Govt. of India. The Technology is at TRL 7 and ready for commercialization through field implementations and Technology & Trademark License Agreement.

Emerging, Heavy Metal Contaminants and Water Quality Analysis:

- A project to Birla institute of Technology and Science (BITS), Goa focused on Water Filtration, Advanced-oxidation and Capacitive-deionisation Treatments for removal of Emerging Contaminants in Water. The team has developed four UVC LED reactors and in this microbial disinfection has been achieved with 30L/hr capacity.

- CSIR-IICT's team has also developed a simple, inexpensive, hand pump operated hollow fibre ultrafiltration system (Fig. 6) that is easy to operate, has high mobility, occupies less space, and is lightweight. A total of 24 water plants were installed during recent floods in Karnataka, Maharashtra, Kerala, Bihar, Odisha, and West Bengal to provide clean and safe drinking water to approx. 50,000 people.



Figure 6. Hand pump operated hollow fiber ultrafiltration membrane systems for disaster management at various sites

- IIT Guwahati has designed and developed a water treatment plant (300 L/h installed in the school, Lathiabagicha Primary School) based on chemical less electrocoagulation technique. This plant is capable of treating Total Soluble Solvent (TSS), Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), Iron and Arsenic from contaminated drinking water to below BIS limit.

Instrumentation facility for accurately tracing toxic metals at very low concentrations:

DST has supported WTI project 'Fast Forward to SGD6: Acceptable and affordable water in secondary Indian cities (4WARD)' under its Urban Water Systems programme, awarded to a cluster of institutions (IIT Bombay, Tata Institute of Social Sciences, Amritha Vishwa Vidyapeetham, and IISc Bengaluru) and led by IIT Kharagpur, focuses on identification and alleviation of water quality and quantity related challenges faced by Tier-II Indian cities. In this consortium, a multi-instrument facility established at IISc, Bangalore to determine concentrations of metals and metalloids spanning a concentration range of ≥ 100 ppm to 10 ppt.

In situ phytoremediation of Chromium (VI) from polluted water sources: DST-WTI has supported a project to ICAR – Indian Institute of Water Management, Bhubaneswar for in situ phytoremediation of Chromium (VI) from polluted water sources for safe use of water for irrigation in Chromite mining area at Sukinda, Odisha. The team is devising a system for phytoremediation of Hexavalent Cr from water for use in irrigation purpose.

Water nexus with Food & Energy: DST has supported a WTI project for Water Energy Food Nexus (WEFN) for the development of Solar-Green house based hydroponic solutions with android mobile application of vegetable market for promoting agriculture extension and better livelihood generation of rural farmers and urban users.

Development of AI based DSS for improved crop water use efficiency: DST-WTI has supported project to Shiv Nadar University for development of AI based DSS for improved crop water use efficiency under deficit drip irrigation regime simulating climate change.

Water Distribution:

Innovative low-cost intervention dealing with water supply challenges in Maharashtra towns: The project supported to IIT Bombay and IIT Madras has come up with low cost 'Shaft with Multiple Outlets' as an intervention for improving the performance of existing piped water distribution networks. The intervention consists of a new strategy of optimal water supply operation by use of scheduling and decentralizing infrastructure. This low-cost intervention has been recommended by the Ministry of Jal Shakti for implementation in all the states as part of Har Ghar Jal under Jal Jeevan Mission.

Internet of Things (IoT) based Smart Water Supply and Distribution System in Coimbatore: A project to PSG College of Technology, Coimbatore along with Industrial partner SMINT TIQ Pvt. Ltd, Chennai under demand driven convergent water solutions in mission aims to implement Internet of Things (IoT) based smart water distribution system for equal distribution, reducing the vast gap between supply and demand, minimize the wastage of water, online monitor and control the quantity, quality, distribution network and water modelling with real-time data input. The pilot area "Cheran Nagar-Koundampalayam" coimbatore was allotted by CCMC for implementation and demonstration of the project.

River Water Quality Analysis

Water Quality determination in lower stretches of the River Ganga: DST has supported a WTI project to IISER Kolkata for water quality determination using novel methods of WQI index. The team monitored nine sites encompassing 59 stations along 50 kms stretch of the lower stretches of the River Ganga over two years to understand the dynamics of key environmental variables including forms of dissolved nitrogen along with biological proxies to assess the state of health of Ganga. The study has been published in '*Environment Research Communications*' (<https://iopscience.iop.org/article/10.1088/2515-7620/ac10fd>) recently.

Detection of Emerging contaminants including pharmaceutically-active compounds in River Cauvery: DST has supported a bilateral Indo-UK project to IIT Madras focusing on identification of pharmaceutical contaminants affect human health and the ecosystem over time. Emerging contaminants found in the Cauvery and Yamuna River systems include pharmaceutically-active compounds, personal care products, plastics, flame retardants, heavy metals, and pesticides, among many others. The environmental risk assessment has

shown that pharmaceutical contaminants pose medium to high risk to the selected aquatic lifeforms of the identified riverine system.

Desalination: New study to make seawater drinkable using carbon nanotubes-based membranes: DST has supported a WTI project to IIT Madras to identify the possible molecular mechanisms in water flow through a new nanopore geometry for desalination techniques to convert seawater to drinking water. The results of the study show extremely useful in the design of novel reverse osmosis systems that utilise carbon nanotubes-based membranes.

WTI Call 2021 on Desalination Technologies

A national Call for Proposals under Water Technology Initiative (WTI) for RD & D activities in the area of Desalination, efficient desalination systems and Test Beds & Pilot-scale demonstrations for emerging & futuristic technologies has received more than 300 proposals against the call on sustainable desalination technologies covering the Applied Research, Technology Assessment, Convergent Solution and Centre of Excellence (CoE) streams.

Bilateral Co-operations

Paper-based sensors detection Antimicrobial Resistance and related pollutants

DST has supported a bilateral Indo UK project to IIT Madras in collaboration with NERC/ EPSRC in which project team has developed low-cost fabrication of the robust Laser Printed-Microfluidics Paper-Based Analytical Sensors (Fig. 7) which will help detecting antimicrobials easily in the parts per million range. The novel strategy of combining adsorption-based pre-concentration using reagents that undergo a measurable color change enabled parts per billion level detection of antimicrobials. The process utilizes the easily available laser printer and hence offers tremendous potential for large scale sensor fabrication at low cost.



Figure 7. A novel microPAD fabrication method and device development method

Indo-Dutch collaboration on Urban Water Management

DST has supported a DST-NWO Indo-Dutch consortium “Water for Change. Integrative and Fit-for-Purpose Water Sensitive Design Framework for Fast Growing Livable Cities led by IIT Roorkee from and Delft Univ from Dutch side along with other consortia members such as MANIT, Bhopal; CEPT University, Ahmedabad; IIT Gandhinagar; CWRDM, Calicut. Field studies, multiple stakeholders’ interviews and City Atlases (Descriptive, Analytical, Projective), integral (cross-domain) problem trees and path-dependency analysis has been conducted for W4C case-study cities of Bhuj, Bhopal, and Kozhikode in partnership with local experts and government officials to further work on existing local and regional urban (water) challenges lying at the intersection between social-ecological-technological systems. Fit-for-Purpose Guidelines’ based on/for secondary cities in India is also being developed in bilateral mode.

DST in collaboration with the NWO has launched a bilateral programme on Cleaning Ganga and Agri Water with the objective of developing solutions and studying the impact of Agri interventions on the quality and quantity of water in Ganga river basin Hindon basin. In this programme, 3 bilateral programmes have been approved for further support and implementation to IIT Kanpur, IISc Bangalore, IISER Kolkatta in collaboration with Wagenigen Univ from Netherlands side.

3.3 National Geospatial Programme (NGP)

Initiated in 1982, the Natural Resources Data Management System (NRDMS), an interdisciplinary R&D programme has **evolved into National Geospatial Programme (NGP)** to catalyze the National Geospatial Ecosystem with the mandate of promoting geospatial science and technology, policy, solution, capacity building, entrepreneurship and international cooperation for sustainable socio-economic development at all levels of governance.

The progress made under various sub-programmes of NGP along with details of the various new initiatives are as under:

Geospatial Science Programme

National Programme on Geodesy: A National Centre for Geodesy, first of its kind is set up at IIT Kanpur in 2019 with support from Department of Science and Technology. NCG has been pro-active in organizing short-term courses and other training programs. With the COVID pandemic affecting travel and in-person meetings, NCG utilized it’s time for preparing course material and lecture notes for online courses, establishing its infrastructure named Geodesy Village (**Figure 1**).

Training programs Conducted: During 2021-22, NCG conducted various training programs, primarily short-term courses, and workshops. Information about the upcoming programs is regularly made available on the NCG website <https://www.iitk.ac.in/ncg/>. A two-day workshop

on ‘**The Present & Future of Satellite Gravimetry**’ at the National Centre for Geodesy’ was held on 18-20 November 2020. A Winter School on “Physical Geodesy and its Applications”, a two-week course for SOI officers covering various aspects of Geodesy; and a two-day course on “Geodetic Network Adjustment for High-Resolution 2D/3D Surveys for NSDI Application Development” were organized.

Academic activities: A new Diploma of **Indian Institute of Technology** (DIIT) program has been initiated from the current year. The program is offered for specialization in three different domains, i.e., **Geodesy, Navigation & Mapping, and Remote Sensing & GIS**.

Regional Centres for Geodesy: The idea of establishing Regional Centres for Geodesy (RCG) has been planned right from the start of the NCG. Six institutions, namely, IIT Bombay, IIST Trivandrum, IRS Anna University, IIT (ISM) Dhanbad, MNNIT Allahabad and MANIT Bhopal have been identified for setting up the RCGs.

R&D initiatives:

NCG has organized a two day online brainstorming session on “**Indian National Geodetic Infrastructure (INGReF): Current status and a way forward**” for defining an R&D action plan towards strengthening the national positioning infrastructure for supporting surveying and mapping. Experts from Sol, NGRI, SAC/ ISRO, NIO, RCI, MO-GSGS, INCOIS, IIT-ISM Dhanbad, and industry have attended the session. Four sub-groups on related aspects like (i) Horizontal datum, (ii) Vertical datum, (iii) Gravity datum, and (iv) Tidal datum, have been formed for guiding implementation of the activities.



Figure 1: Present facilities at Geodesy Village, National Centre for Geodesy, IIT Kanpur

National Network Programme on “Assessment of Regional Hydrological Systems using Space Borne Gravity Observations”: This National Network Programme has been developed involving three concerned Ministries and several partnering knowledge institutions. The Programme represents a novel opportunity to explore the feasibility of **monitoring total water storage variations using space borne gravity observations**. The Gravity Recovery and Climate Experiment (GRACE) satellite provides a new method for terrestrial hydrology research and enables researchers to monitor the fluxes of water mass changes and exchange of water masses between the ocean and land ice masses. The details of the various activities during the last year under this programme are as follows:

- A virtual Brainstorming Session on “**Satellite Observations and Modelling of GRACE Data for Terrestrial Applications**” has been organized with the participation of more than 64 national & international experts.
- CSIR-National Geophysical Research Institute (CSIR-NGRI) has coordinated and created a **central facility including a web portal (Capacity building, Knowledge Hub & Data Generation for Societal use)** for this network project. A Center of Excellence (CoE) has been established as a virtual laboratory in order to act as a knowledge partner (on Capacity building, Knowledge Hub; and Data Generation aspects) to provide remote support to all the members of the Network Programme to augment data and deliver data products from various sources.
- **Establishment of GPS & Soil Moisture Network:** This multidimensional project has a component “to study the effect of hydrological loading on crustal deformation using GRACE and GPS observations” over the Ganga Basin. The project aims at recording highly accurate position time series data to estimate annual, inter-annual and seasonal components of deformation due to hydrological load. The Network is expected to help understand tectonic deformation (plate velocity) and co- and po-seismic effects due to large Himalayan Earthquakes. So far, nine (9) GPS CORS stations including six (6) Soil Moisture Digital Probes [Jhansi (Uttar Pradesh), Roorkee (Uttarakhand), Gorakhpur (Uttar Pradesh), Sirsa (Haryana), Aurangabad (Bihar), Sitamarhi (Bihar)] have been installed during the year (**Figures 2 & 3**).

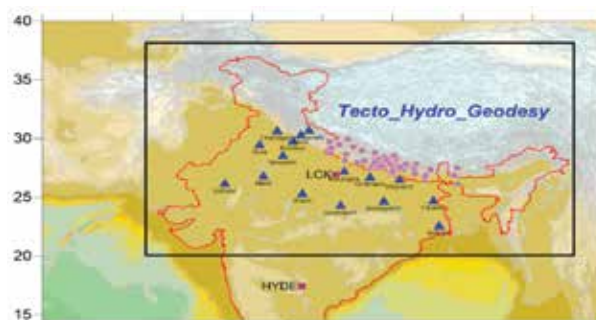


Figure 2. Location of 15 continuous permanent GPS stations (Blue triangles) including Six Hydra Probe Soil Moisture Measurement Systems

Geospatial Solutions Addressing National Priorities and Sustainable Development Goals

Geospatial Solutions for Urban Governance: R&D projects are supported in the areas of city governance applications as well as in the core R&D areas focusing on emerging technologies related to city development using Geo-ICT. Six new projects have been supported during 2021-22 focusing on IOT Enabled Smart Cities, Pollution; Health; City GML based 3D models using LiDAR point cloud; Indoor Location Based Services; Spatial Data Infrastructure for Indoor Navigation in Multi-storey Edifices; and City Governance etc.

Geospatial Location Estimation and Navigation in Autonomous Sensor Networks / smart city (IIT, Patna): Indoor localization has witnessed an increase in interest recently, due to the potential wide range of using in different applications, such as Internet of Things (IoT). This is also providing a solution for the absence/ poor performance of Global Positioning System (GPS) signals inside buildings.



Figure 3. GPS-Soil Moisture Observatory at JNV, Aurangabad, Bihar (Left). Three Digital Hydra Probe soil sensors installed at three distinct soil horizons (Right).

This project emphasizes on Smart Parking System and Smart IoT Cleaning Management System under heterogeneous sensor networks.

Smart Parking System provides real-time parking availability status and navigation for the user using Wi-Fi Received Signal Strength and Geo-magnetic field strength (**Figure 4a & 4b**).

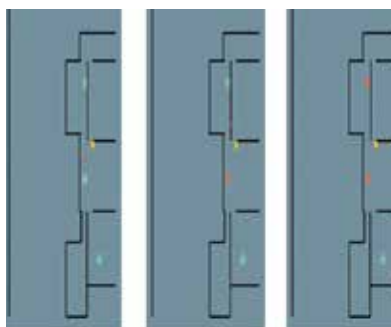


Fig 4: (a) Application dashboard showing user navigation to the nearest parking slot;

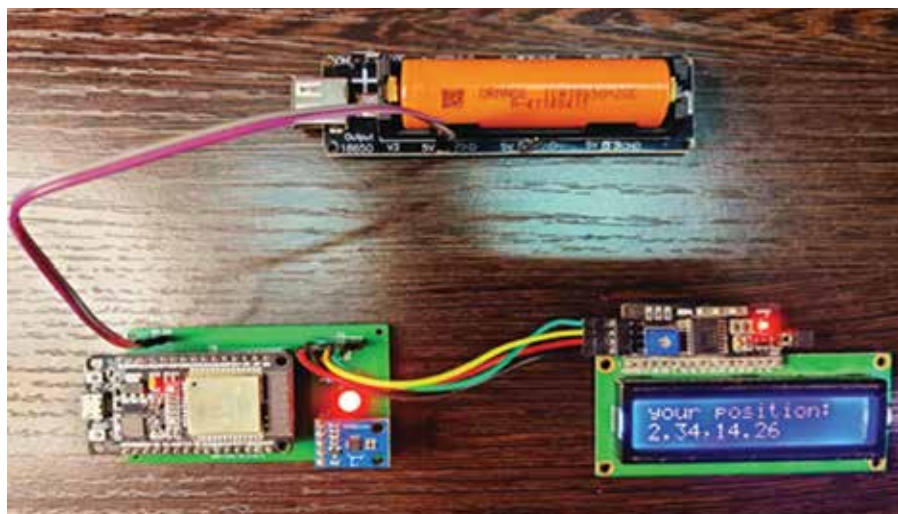


Fig 4: (b) Hardware localization unit showing live location of user

A dedicated mobile application guiding users to navigate to the nearest available parking slot has been developed. Accuracy below 3 meters has been achieved in large indoor areas in the presence of obstacles resulting in fading conditions. **For Smart Cleaning Solutions**, a dedicated mobile application along with a real time monitoring dash board has been developed. In this hardware prototype development, the real time monitoring of dust bin box status like weight of garbage in it, level up to which it is filled and moisture percentage in the garbage is continually monitored from the mobile application.

Spatio Temporal Air Quality Data Monitoring and Prediction Using Moving Vehicles (IIIT Delhi): A low cost and effective solution for achieving high resolution and dense air quality data for Indian cities has been prepared and demonstrated. Putting thousands of static sensors is not only impractical but also costly. **On the other hand, this solution only requires 10% of total static sensors needed and is much easier to scale and maintain than the current frameworks.** For demonstration of the above, public transit in Delhi and built special air quality monitors suitable for moving vehicles have been chosen. In the next version, use of solar panels to power these monitors is being planned in order to bring down the cost of intermittent charging of these monitors.

Geospatial Solutions for addressing SDGs

Guidebook on S&T Interventions for Pond Rejuvenation: A Networking Project on Revival of Village Ponds through Scientific Interventions has been supported to assess and document indigenous knowledge of construction, management, use of village ponds and demonstrate scientific interventions on a pilot scale towards developing a guidebook for ready reference of the field practitioners. The Guidebook being prepared by National Institute of Hydrology, Roorkee is expected to be of use to policy-makers, decision-makers, NGOs, state-run entities in decision- making, formulating plans, and executing tasks.

National Programme on Spatial Disaster Risk Reduction (SDRR)

The following are the details of the sub-programmes supported under the Programme:

Landslide Hazard Mitigation (LHM).

A set of **7 R&D projects** has been supported for the development of an early warning system covering areas (States) like Sikkim, Nilgiris (Tamil Nadu), Manikaran, Kotropi, Mandi and Darmashala (Himachal Pradesh), and Uttarakhand.

Landslide hazard mitigation for North-Eastern Region (NER), Landslide Investigations, Control Measures and Capacity Building in North Eastern States, India. The North Eastern Region of the country has been facing landslide problems almost every year. In view of these, a Coordinated Programme on landslide studies to fulfil the expectations and requirement of the North-Eastern Region has been supported. Geoscientific Studies – Geodetic, Geological, Geomorphological and Geotechnical Investigations have been carried out on individual landslide. **A compendium on the outcome of all the North East networking projects** has been prepared by Manipur University, Imphal.

Coastal Hazard, Risk Assessment and Reduction (CHRA)

CHRA has been initiated to cover the coastal areas of India with the aim to develop S&T enabled techniques for coastal disaster management encompassing disaster genetics, propagation, disaster vulnerability mapping, detection of causative factors, mitigation measures etc. In view of changing requirements, the name of the sub-programme has been modified to CHRAR from CHRA. Out of **13 R&D projects** supported, 05 has been initiated this year in the areas of Coastal Erosion and Risk assessment; Coastal Water Quality Information System (CWIS); Identification of Tsunami Vulnerable Zone; Land Subsidence and Sea level rise, etc. Few highlights of the work supported are as follows:

- Vulnerability Analysis and Risk Assessment of Coastal Erosion along the Odisha Coast (Institute of Green Energy & Geospatial Technology, Jagatsinghpur, Odisha):** Coastal Hazard Wheel (CHW) framework to evaluate the presence, spatial extent and intensity of coastal erosion along Odisha coast has been developed. The study depicts the vulnerability profile of coastal erosion and its presence along the Odisha coast. A total of 21% of the Odisha's coastline has been at a 'very high risk' category, 29 % at 'high risk', 5% at 'moderate' and 45% at 'low risk' of coastal erosion categories (**Figure 5**).



Figure 5. Representation of Odisha's coastline in terms of degree of Vulnerability to Coastal Erosion

Capacity Building Sub-programme

Summer/ Winter Schools in Geospatial Science and Technology: The capacity building sub-program has been substantially strengthened over the last ten years for conducting a set of 166 programs of three weeks' duration each while incorporating classroom, lab and field sessions with a mini project conducted across the length and breadth of the country over the last eight years benefitting over 5000 participants from Academia, Government and Research Institutes. In the year 2020-21 apart from the Level 1 (basic) three week and Level 2 (advanced) Summer/ Winter Schools, **a new sub-program aimed at harnessing young minds and developing a bank of innovative ideas that NGP could use further to develop future research themes has been introduced.** During the year, a set of 43 capacity building workshops have been supported. Of these, there have been totals of 25 Level 1, 10 theme specific Level 2 and 8 theme specific Geo-innovation workshops are being conducted in different parts of the country.

New Initiatives:

- **From the current year, all Level 2 workshops have been aligned to the respective SDG goals** and oriented towards focussing on those national indicators where geospatial tools are made use of. The 2021-23 capacity building cycle has been initiated with a workshop to re-orient the activities to the objectives of the program as well as to implement each event as a pre-cursor to the upcoming United National World Geospatial Information Congress (UNWGIC) to be held in India during October 2022.
- For the first time, a set of three 21- days Summer/ Winter School (level-2) on “Geospatial Science and Technology” have been **conducted in online/ hybrid mode including hands on practice** coordinated by Department of Remote Sensing & GIS, University of Jammu, Jammu and Kashmir, Delhi Technical University (DTU) and Gauhati University, Assam. These Summer/ Winter Schools will also include hands-on sessions for developing and suggesting innovative ways/ ideas to help achieve the SDGs in the Indian context by utilizing Geospatial Technologies.

Geospatial Chair Professorship: Under the Geospatial Chair Professorship Initiative, currently a set of 05 Chair Professorships have been supported with the objective of promoting Geo-spatial Education and related S&T at the National and Sub-National levels in the ever-changing geospatial ecosystem in the country. Details of various activities carried out under this Initiative are as follows:

Geospatial Information System for Modeling of 3D Buildings with high degree of details using a GEOBIM Approach (IIIT Hyderabad): A framework has been designed for the automatic generation of building heights using normalized digital surface models (NDSM = DST-DTM) from high resolution stereo pair data sets prepared using advanced photogrammetric procedures and tools. The average building heights are estimated using

mean values (**Figure 6a**). Ventilation Analysis using ventilation calculation tool sets, solar power potential calculation of each building using area solar radiation tool and delineation of suitable roof tops for installing the solar panels for the optimum utilization of the power have been carried out. (**Figure 6b**).

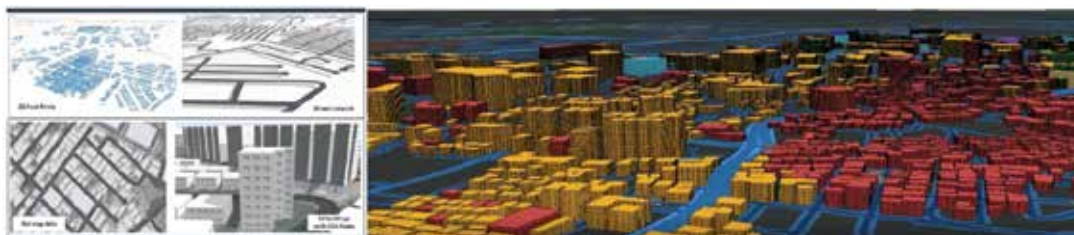


Figure 6(a): 3D Modeling of LOD 2 buildings extracted from generated building height Models



Figure 6(b): Geo BIM Model and Roof Top Suitability analysis for installing Solar panels

Geospatial Activities (DTU, Delhi): A Multi-disciplinary Centre for Geo-informatics (MCG) has been established at Delhi Technological University and PhD programs and AICTE approved M.Tech (Geo-informatics) courses have been commenced. With the involvement of MCG and all the concerned stakeholders, approval of AICTE has been obtained for the inclusion of Geospatial Technology (Geo-Informatics) as a subject in the GATE and NET Examinations.

Atulya Ganga Project: MCG is supporting the efforts of the Army veterans who have walked for more than 5000 Kms on foot from Gomukh (Uttarakhand) to Ganga Sagar (West Bengal) and back to create awareness amongst the populace for keeping the river Ganges clean.

Marine Geospatial Technology for Ocean monitoring (IIT Madras):

A Novel Algorithm/ method developed for denoising VIIRS Day/ Night Band (DNB) image

Data: The VIIRS Day/Night Band (DNB) images have been useful in nocturnal monitoring of global oceans, lands, and atmospheric activities at a reasonably high spatial resolution of 742 m. However, the quality of VIIRS night band images is seriously affected with periodic horizontal stripe noises. To address the issue, a novel method to reduce the noise effects while maintaining the radiometric integrity and quality of observed data has been developed.

Satellite monitoring and assessment of Tauktae and its impact: Tauktae, a category-4 pre-monsoon tropical cyclone, originated over the Arabian Sea (AS), had a landfall in Gujarat on 17 May 2021, and caused loss of livelihoods and property and affected the economy in the region. In this study, in-situ buoy and satellite observations have been explored to analyse the conducive ocean condition before the formation of the cyclone primarily from the air–sea interaction perspective.

In-situ measurements: Two field data collection campaigns have been conducted in Muthupettai Lagoon and near the coastal region of Adhirampattinam. All essential radiometric (above water, surface measurements) and photometrics (FLNTU) measurements have been performed along with laboratory analysis and determinations of the water constituents such as suspended sediments, chlorophyll, coloured dissolved organic matter (**Figure 7**).



Figure 7: In-situ measurement locations in Muthupettai Lagoon water. Radiometric and photometric measurements, and surface water biogeochemical properties data have been collected

COVID-19 Research Initiatives by Department of Computer Science and Engineering Indian Institute of Technology (IIT) Kharagpur.

COVID-19 Data Analytics and Visualization Framework- A portal has been launched (on NSDI-SOI Geospatial Cloud) to demonstrate the efficacy of the framework. A study (in the Indian context) to predict the effective reproduction number over time and the number of new cases has been attempted.

Mobile GIS for Health domain- The major research focus is to develop a framework for loHT (Internet of Health Things). The loHT involves collection, exchange and processing the data to monitor health condition of individuals. The basic health data (heart-rate, temperature, oxygen saturation level etc.) are collected using body sensors or BAN (body area network) and send to the user's mobile device (**Figure 8**).

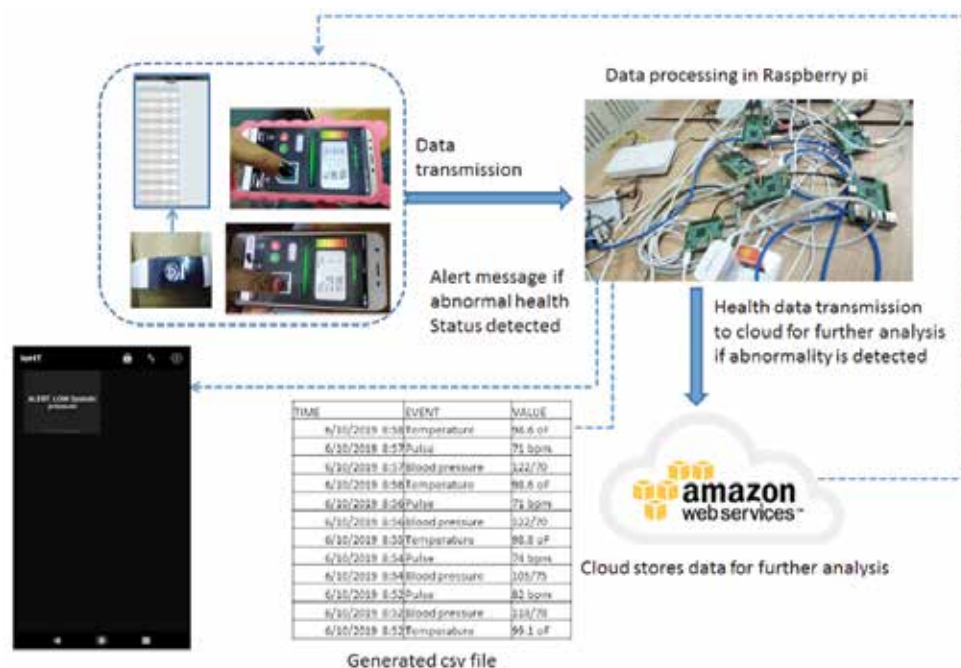


Figure 8: Location-aware loHT (Internet of Health Things) framework

International Collaboration

Activities under this Initiative aim at developing the national capacity for Geospatial Technology development, acquisition and transfer through international partnerships/ collaborations involving bodies/ agencies like the United Nations Global Geospatial Information Management (UNGGIM), Open Geospatial Consortium (OGC), Brazil Russia India China South Africa (BRICS) Cooperation, Indo-Africa collaborations etc. The following activities through **UNGGIM collaborations** have been carried out during the year:

- The members of the Indian Delegation attended the virtual Executive Board meeting of UN-Global Geospatial Information Management-Asia Pacific (UNGGIM-AP) on 20th May, 2021. The meeting aimed to discuss the work plan for 2021, funding opportunities and draft framework of the Asia Pacific Information Platform and the service center to the Member Countries.
- **India has been entrusted with the responsibility to host the Second United National World Geospatial Information Congress (UNWGIC) in India in the year 2022 at**

Hyderabad from 10-14 October 2021. Several preparatory meetings with UNGGIM Secretariat have been held for successful hosting of the Congress.

- In order to sensitize the Global Geo-spatial Community about the Congress and obtaining the views from the Scientific Groups, Academia, Industry, Civil Society and various other stakeholders on the event, **a side event as a curtain raiser has been organized virtually on 16 August, 2021 to the 11th Session of the UNGGIM held on 23, 24 and 27 August, 2021.**

New Initiatives and Major Achievements:

- A **call for proposal** for Geospatial start-ups and knowledge Institutions of the Country on **‘Geospatial Analytics for Revival and Restoring the Economic Growth in Post COVID-19 Scenario’** has been issued. Out of a total 140 R&D proposals received, eleven proposals have been supported in topics like Unmanned Aerial Vehicle in Covid-prone high-density areas; Pattern and Impact of COVID-19 Pandemic by Semantics; Geospatial Analytics for Rural Livelihoods in Post-Pandemic Era; Inter-dependency modelling of healthcare; Socio-economic Impact of Migration during COVID-19 Crisis; Social Vulnerability Mapping Impact Assessment; and Modelling geographically varying relationships of COVID-19 outcomes with socioeconomic and environmental factors etc.
- Call for proposal (**CFP**) in the area of **Geospatial Technology Development** focusing in the sectors of Geospatial Data Capture Technologies / gathering, Data Management, and Data Processing using Geospatial Technologies has been issued.
- **Geomatics Engineering (GE) Subject included in GATE-2022 and Geospatial Subject Approved by AICTE for GATE and NET Examination:** As per one of the major outputs of the Geospatial Chair Professor (GCP) Scheme, Geomatics Engineering – which involves the collection, measuring, monitoring, and archiving geospatial data - has been included as one of the subjects in the GATE examination for the Year 2022.
- India has been **entrusted with the responsibility of hosting the Second United Nations World Geospatial Information Congress (UNWGIC)** at the Hyderabad International Convention Centre in Hyderabad, India, from **10-14 October 2022** **Core theme of the Second UNWGIC has been decided as “Geo-enabling the Global Village”** which is in line with the Hon’ble PM’s vision ‘Sabka Sath Sabka Vikas’.

3.4 National Science & Technology Entrepreneurship Development Board (NSTEDB)

NSTEDB, through its strong network of incubators is leveraging the technological strength of the higher learning institutes for nurturing the national innovation and entrepreneurship ecosystem. NSTEDB has adopted a multipronged approach in its mission to foster innovation

& technology-based entrepreneurs. The key activities & outcomes of F.Y. 2021-22 are given below:

3.4.1 National Initiative for Developing and Harnessing Innovations (NIDHI)

The umbrella program of the National Initiative for Developing and Harnessing Innovations (NIDHI) aims to nurture start-ups through scouting, supporting, and scaling of innovations. Following are the key components of NIDHI umbrella programme:

NIDHI: CoE (Center of Excellence)

NIDHI-CoE strengthens existing capacities of Technology Business Incubators (TBIs) and supports potential start-ups with different support programs for translating technological innovations into marketable products and high-growth ventures. DST has supported seven CoE at different institutions. These NIDHI-CoE (Centre of Excellence) are at SINE IIT-Bombay; CIIE-IIM-Ahmedabad; PSG-Science & Technology Entrepreneurial Park (PSG-STEP) Coimbatore; TBI-Veltech University, Chennai; KIIT -TBI, Bhubaneshwar; and EDC NCL-Pune. In 2021-22, two new Centre of Excellences to support startups with incubation and funding are been supported at FITT, IIT Delhi (Domain: Electronics and Communication, Advanced materials and Assistive technology) and T-Hub, Hyderabad (Domain: AI, ML, and DeepTech).

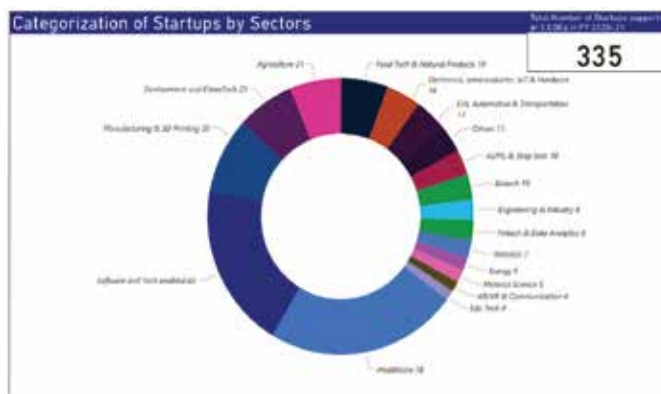


Fig 1. Sector wise categorization of startups incubated at NIDHI CoE

Some of the promising products from startups incubated at NIDHI CoE are

Jai Kisan: Rural Focused Neo Bank

Incubated at: CoE at CIIE, IIM Ahmedabad

Jai Kisan is a rural focused Neo Bank, whose mobile application - “Bharat Khata ” provides a one stop solution for rural businesses and individual’s financial needs with best suited credit products. It partners with equipment dealers, agriculture retailers, collection centers

and market linkage platforms, to directly provide credit to farmers, working in the domain of agriculture, poultry and dairy value chain.

- Raised ~**INR 217 crores (\$30M)**
- Jai Kisan had been disbursing close to INR 8 -12 crore in credit on a monthly basis, with average ticket sizes ranging from INR 50,000 to 1 lakh.
- The Bharat Khata service, which was launched in April 2020, captured more than \$380Mn of annualized GTV run-rate across over 25,000 storefronts in FY21.

MyLab Discovery Solutions Pvt. Ltd

Incubated at: CoE at NCL Venture Centre, Pune

India's first CDSCO approved indigenous RT-PCR & antigen tests for COVID-19. Developed India's first self-test diagnostic kit CoviSelf. The startup was provided incubation support by CoE at NCL Venture Centre, Pune and further supported by Technology Development Board, Office of the Principal Scientific Adviser and CSR funds through CoE.

- Test kits and machines used in more than 290 countries including the SAARC nations, European Union, and North America.
- ICMR-approved and NABL certified mobile testing labs powered by fully automated extraction + PCR-ready system, Compact XL which can conduct more than 1000 tests / day.

PadCare Labs Pvt. Ltd.

Incubated at: CoE at NCL Venture Centre, Pune

PadCare is a smart hygiene management solution that completes the loop of the menstrual hygiene economy starting from the accessibility of Menstrual products to generating recyclable output out of soiled pads.



Fig 2. PadCare van recycling unit



Fig 3. PadCare's sanitary pad

- 10000+ pads being recycled every month
- Uplifted washroom hygiene for 4000+ female beneficiaries and safeguarding them from UTIs.
- 5000 kgs+ Carbon emissions reduced
- Adopted by global corporations like P&G, Mahindra Group, Raymond, JSW, and Cummins.
- Pioneering 5D recycling technology has been acknowledged with Indian Patent as well as MPCB certification
- Seed Investee company of Venture Center, BIRAC-SOCH & Cummins & PubMatic CSR grantee.

ImmunoAdaptive Cell Therapy Pvt Ltd.

Incubated at: CoE at SINE, IIT Bombay

Immunoadaptive Cell Therapy Private Limited (Immune ACT) is a pioneer in the field of cell and gene therapy and aims at revolutionizing cancer treatment in India. Recently, they have developed an indigenous, novel, and efficacious living drug called the Chimeric Antigen Receptor T cell (CAR T) therapy against B cell leukemia expressing CD19 antigen. The company has started the Clinical trials for blood cancer treatment along with Tata Memorial Centre. The company has raised Rs. 55.75 crores of funding.

Go Floaters (SMBSure Business Solutions Pvt Ltd)

Incubated at: CoE at VelTech, Chennai

Go Floaters is pioneering a new paradigm of “on-demand workspaces” and it’s Work from Anywhere Platform. Go Floaters is building a fundamentally new way of working for mid-sized companies, startups, independent professionals and for remote workers. Go floaters provide on-demand, affordable, flexible, and hassle-free work and meeting spaces that can be booked when one wants, where one wants and for the time one wants.

- Received support of Rs. 10 Lakhs from DST. StartupTN Open Innovation Challenge Winner/Global Top 100 startups at XPitch.
- Have clients such as: Notion Press, Think Music, Cisco, Charge bee, Decathlon, Home Lane

NIDHI TBI (Technology Business Incubator)

Support for establishment of Technology Business Incubators primarily in and around Higher

Education Institutions (primarily technical) for nurturing startups is the flagship activity of the division. Technology Business Incubators support and nurture knowledge driven innovative start-ups into successful enterprises. During the year 2021-22, new TBIs under NIDHI program are being established at Indira Gandhi Delhi Technological University for Women, Delhi, Lovely Professional University, Phagwara; Bharat University, Chennai; Punjab Agricultural University, Ludhiana.

Some of the promising products from startups incubated at NIDHI TBI:

Satin Healthtech

Incubated at: DERBI Foundation, Dayananda Sagar University, Bangalore

Satin Healthtech product Cervisense is an inexpensive, portable way to bring cervical cancer screening to rural communities. It is a non-invasive, point-of-care imaging device for quick, enhanced and automated Cervical Health Examination and Cancer Screening. Cervisense comprises a digital imaging device, an android-tablet application and a web application.

- The imaging device uses advanced optical techniques to capture high-quality magnified images of the cervix for better visualization and enhanced diagnosis.
- The system generates an automated visual report for patient counselling, case-referrals and treatment-follow-ups.
- The startup has a recipient of Nidhi Prayas Prototyping Grant – Rs. 10,00,000/-



Fig 4. *Cervisense: portable, non-invasive point-of-care imaging device*

VDT Pipeline Integrity Solutions

Incubated at: Enterprise Incubation Center, IIM Lucknow

VDT is an indigenous R & D Company providing Pipeline Integrity tools having two patents in the same field. VDT is determined to give fantastic products and services that combine up with esteem valuing, while at the same time building up an effective, sound & long-term association with customers, clients and suppliers.

- Key clients & strategic partners of the startup include GAIL ONGC, Oil India, BPCL, HPCL, IOCL, Assam gas, Reliance, Adani etc.
- The startup has raised funding of Rs. 6.24 Cr [From GAIL and ONGC].



Fig 5. VDT pipeline integrity tools

Health Sensei

Incubated at: COEP's Bhau Institute of Innovation Entrepreneurship & Leadership, Pune.

Health Sensei provides continuous CCU Monitoring of patient care data from any ICU monitor, direct to mobile, saving up to 5h/ ICU/ day through automated vitals charting and providing better care with automated early alerts.

- The startup has completed 35 integrations with medical devices and completed 14 pilot implementations
- Won Stanford seed spark out of 86 Startups (2nd place winner)

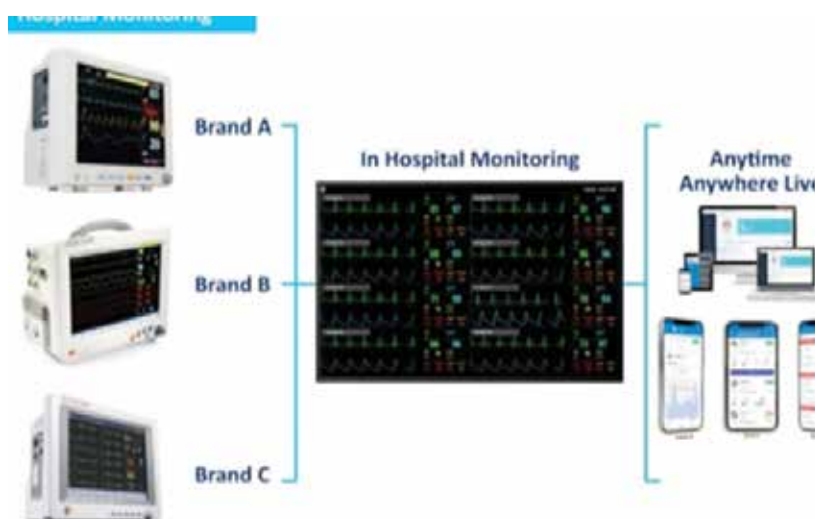


Fig 6. Health Sensei monitoring unit

NIDHI- PRomoting and Accelerating Young and ASpiring technology entrepreneurs (PRAYAS)

DST, NSTEDB continued to support NIDHI PRomoting and Accelerating Young and ASpiring technology entrepreneurs (PRAYAS) with the objective to support young innovators turn their ideas into Proof of Concept (PoC)/Prototype without fear of failure, and allowing them to reach a stage where they have a ready product and progress towards commercialization.

The program is being implemented by 43 PRAYAS Centres across the country, including 13 new PRAYAS centres established in the F.Y. 2021-22. The program has generated a considerable impact as given below:-

- total of 700+ innovators supported across the country
- Around 350+ prototypes successfully developed
- 300+ patents filed by the innovators
- Cumulative funding raised of more than 200 crores
- Revenue generated more than 60 crores

Fig 7. PRAYASEEs Project Details supported in the year 2019-2020

Details of figures

PRAYAS Centre name - Technology Business Incubator @ Kongu Engineering College (TBI@KEC)

Project Details -OxyHeal is a portable device that provides Localized Hyperbaric Oxygen Therapy (HBOT) to help facilitate the healing of chronic wounds.

PRAYAS Centre name—IIT Mandi Catalyst

Project Details - Geothermal renewable energy utilization to generate round the clock clean electricity and green hydrogen

Product image



PRAYAS Centre name – Technology Incubation and Entrepreneurship Development Society (TIEDS), IIT Roorkee

Project Details- Seismic Risk Investigations. Developing Solution for earthquake data recording and real time warning issuance systems. The innovator is the winner - Selected for India-Israel Industrial R&D and Technology Innovation Fund



PRAYAS Centre name – IIIT Hyderabad

Project Details- Developing wearable robotic exo-suit that can be strapped onto the knee portion of the user, with a control and power unit placed at the back of the wearer. Wearing this device, a disabled user can stand on his own time and will. The company Raised INR 75 lakhs from Angel investor



NIDHI-EIR Program

DST, NSTEDB continued to support Entrepreneurs-in- Residence (EIR) Programme under National Initiative for Developing and Harnessing Innovations (NIDHI) with the basic objective to inspire and motivate graduating to take entrepreneurship by providing support as fellowship, attachment to good incubator mentoring by incubation manager opportunity to do primary market research enabling to build the confidence to start own company.

The program is being implemented through 32 TBI's, including 12 TBI's which were equipped with EIR in FY 2021-22

Following is the impact of the NIDHI EIR :-

- 32 PEPs funded across 15 states and 25 cities
- 410 EIRs supported
- 217 IPs created 106 Patents, 86 trademark and 25 copyrights
- 880 + New jobs created
- ~5X of DST's disbursal(42.69 Cr) raised as follow-on funding by EIRs
- 156 EIRs (69%) formed a private limited company or an LLP

NIDHI – Accelerator

DST, NSTEDB continued to support NIDHI- Accelerator Program with the objective to provide startups to introduce to entrepreneurial development for identifying business opportunities (real problems that require real solutions), validate product ideas, engage with potential customers, build a scalable business model, build a product demonstration, manage team dynamics and pitch to investors.

During 2021-22, nine NIDHI Accelerator program were organised in the areas of, Agri tech, Fine tech, Social ventures, Women led ventures, Digital Healthcare, strategic sector for Atmanirbhar Bharat, manufacturing, life science, applications of AI and MI across the sectors, medical device, Ed tech, clean tech, electronics, waste & water management, with the total cohort size of 135 startups (15 each).

NIDHI- SEED SUPPORT PROGRAM (SSP)

The key objective of the NIDHI- Seed Support Program (SSP) is to ensure timely availability of the seed support to the deserving incubatee startups within an incubator, thereby enabling them to take their venture to the next level and facilitate their success in the marketplace.

During this financial year 2021-22, a total of about 65 startups have been supported so far. A total of 43 Technology Business incubators have been equipped so far with the NIDHI Seed Support including 8 new TBIs which were extended support in FY 2021-22. Two notable success stories of the Seed Support Program for this year are mentioned below:

Sustainable Reference Analytics

Incubated at: Society for Innovation and Entrepreneurship, IIT Bombay

A consumer IoT company which is into electricity smart-metering and big-data analytics. The product is positioned as FitBit for homes. The product has been launched in nearly 70 cities and has already been integrated with 3 global metering brands (Schneider Electric, Tata Power, elMeasure). The startup has raised funding of Rs. 2.25 crores along with being selected for Google Launchpad (2020), CISCO-CIIE IoT accelerator (2019), Oracle Global Startup accelerator (2018), and Mission Innovation 4 by the EU in top 100 (2018).



Fig 8. Electricity Smart Meter

Indi Energy

Incubated at: TIDES Business Incubator, IIT Roorkee

Indi Energy is an energy storage startup currently working in development and commercialization of Sodium ion batteries and its components (like Hard Carbon) etc.

- The startup is now also setting up India's first Hard carbon manufacturing plant in Roorkee, Uttarakhand made from bio-waste/agri-waste like Rice straw.
- Indi Energy's Hard carbon has already achieved one of the world's highest performance in Sodium ion batteries.
- They have already received commercial orders and interests for its Hard carbon from companies in countries like Sweden, France, Japan, China etc.



Fig 9. Sodium ion Pouch cell

3.4.2 Other Innovation & Entrepreneurship Initiatives

New Generation Innovation and Entrepreneurship Development Centre (New Gen IEDCs)

DST, NEB continued to support 25 New Gen IEDC established at various academic institutions with the objective to inculcate the spirit of innovation and entrepreneurship amongst the young S&T students, encourage & support start-up creation through guidance, mentorship & support and encouraged to take up innovative projects with possibility of commercialization.

Following are the highlights under the project supported by 25 New Gen IEDC during the

FY 2021-22

Total number of Student Projects supported:	493
No. of Patents filed by students:	72
No. of Patents Granted:	01

No. of companies Set up by Students: 45

No. of companies / Starts commercialized: 12

Innovation-based Science and Technology for Entrepreneurship Development (i-STED)

The i-STED (Innovation-based Science and Technology for Entrepreneurship Development) program addresses problems and challenges associated with region/industry/cluster in various locations of the country. The focus area includes energy, sanitation, housing, healthcare, water management etc. the implementing agency tries to introduce proven R&D technologies/ innovative solutions. A total of 11 projects have been supported. Outcome of the some of the projects is portrayed below :

- **I-STED project at Gujarat Incubator for Social Enterprises and Entrepreneurs Development (ISEED) at Institute of Rural Management Anand (IRMA), Gujarat:** The project nurtures early-stage rural, social, and collective enterprises with focus on technology and innovation. The project has created 16 enterprises and trained 270 persons.



Figure 10. Various Technologies developed & enterprises created at IRMA, Gujarat

- **I-STED project implemented through TANSTIA-FNF Services Center (TFSC), Chennai.** TFSC i-STED has supported 81 entrepreneurs in the area of Water Filter – 74, Briquetting – 04, Organic Manure – 03 and provided 84 direct employment. i-STED of TFSC has also won an Award from Tamil Nadu Agricultural University for propagating technology of briquetting among Briquetting Industry in Tamil Nadu.
- **I-STED project implemented by College of Food and Dairy Technology, TANUVAS, Chennai, Tamilnadu**

Under the project 8 number of capacity building programs (technology transfer) have been

conducted. A total of 156 beneficiaries & 67 women beneficiaries were trained on technologies of fabrication of milk protein, fibre noodles, millet ice cream, fruit yoghurt and designer chocolate. 20 number of the Startups created on the technologies for developing sustainable enterprises. The project has also led to filing of the Patents for three products (milk protein enriched noodles, millet ice cream, and designer chocolate) and they are in the final stage of granting.

Innovation and entrepreneurship Training Programmes

NSTEDB conducted following modules of I&E training programme i.e. Faculty Development Programme (FDP), Women's Entrepreneurship Development Programme (WEDP) and Technology Based Entrepreneurship Development Programme (TEDP). During 2021-22, FDP (100), WEDP (143) & TEDP (145) programmes were organized & 10425 beneficiaries were sensitized/trained under the programme.

Conference/ workshop supported: NSTEDB in collaboration with the ASSOCHAM promoted use of Smart technologies in various verticals like healthcare, Agriculture, Transportation, Education, Energy, Smart cities, Enterprise AI and automation, Industry 4.0, etc, by organizing **2nd SmartecIndia 2021 during 3rd- 15th December'2021**.

NSTEDB supported TiE Delhi NCR's annual event "**Online Resurgence TiEcon-Delhi NCR 2020 Conference during 27th to 30th January, 2021**."

NSTEDB also facilitated leadership series, in partnership with Indian STEP and Business Incubator Association (ISBA), where eminent speakers from incubation and entrepreneurial ecosystems were invited. The themes for this series included a) Managing Uncertainty- Challenges and Opportunities in Business Incubation Arena, b) Leadership Challenges - in Turbulent Times, Wisdom for Startup from Grown-ups, and Open Innovation : Corporate-Startups engagement dynamics.



Fig 11. Leadership series by Mr Kris Gopalakrishnan, Chairman, Axilor Ventures, Chairman, CII Centre of Excellence for Innovation Entrepreneurship and Startups & Co-Founder, Infosys

This year NSTEDB also facilitated Master classes on Seed Fund Management and Venture Debt Finance for the Incubators fraternity. Over 200 incubator managers benefited through the sessions.

Research Park

DST has supported establishment of Research Park at Indian Institute of Technology, Gandhinagar. The construction of the IIT Gandhinagar Research Park completed in November 2021. The state-of-the-art research Park building comprises approximately 18000 sq mt space with around 1.2 Lakh as fully furnished plug and play office/ lab space and around 7000 sq mt. warm shell structure. One of the Research Park company, InfyU Labs was among the top 4 teams of UNDP Youth Co:lab programme 2020. The company is trying to help farmers and warehouses to get their fruits and vegetables tested for the internal quality without cutting the fruits and vegetables. InfyU Labs has also received seed investment of Rs. 1.8 crores from angel investors.

3.4.3 Special Initiatives to Combat Covid

CAWACH

To support startup solutions to address challenges faced by the country during COVID 19 Health crises, DST launched a new initiative- CAWACH (Centre for Augmenting WAR with COVID-19 Health Crisis) program. The aim was to nationally scout and support the innovations and startups in the areas of Diagnostics & Drugs, Disinfectants & Sanitizers, Ventilators & Medical Equipment, PPEs and Informatics to address/ mitigate COVID-19 challenges. 51 startups have been supported under the initiative. The program is implemented by 8 CAWACH Satellite Centres (CSC) across the country.

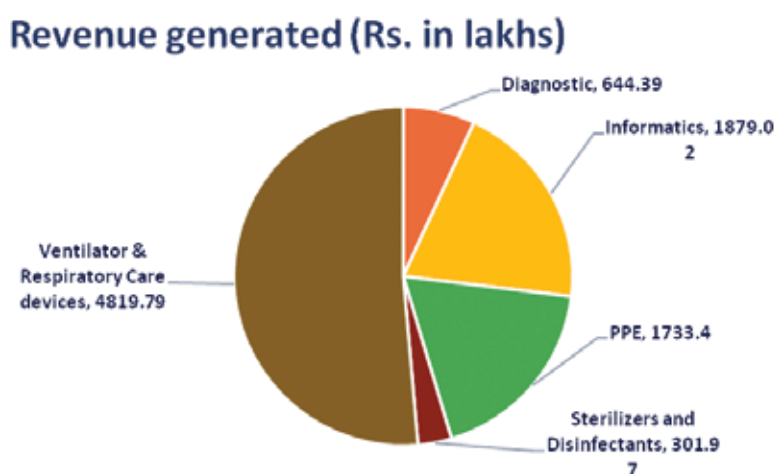


Fig 12. Sector wise revenue generation CAWACH supported startups

Few of the success stories from CAWACH supported startups are:

- **Turtle Shell Technologies Pvt Ltd** supported through the CAWACH satellite centre at IKP (Hyderabad) has launched Contactless patient monitoring & Early Warning System for Step down ICU & HDU units. This system named as Dozee is helpful in saving nursing hours and improving patient outcomes.



Fig 22. Turtle Shell's Contactless patient monitoring & Early Warning System

- **Haystack Analytics Pvt. Ltd.** supported through the CAWACH satellite centre at SINE, IIT Bombay is working in the field of Genome Sequencing and Informatics for TB, COVID19 variants etc. The company was onboarded by Brihanmumbai Municipal Corporation (BMC's) Kasturba Molecular Diagnostic lab to conduct in-house genome sequencing of COVID-19. Haystack has raised investment of around Rs. 7 crores from multiple investors. The company partnered with Metropolis Healthcare to offer TB diagnostic tests in Sri Lanka, Mauritius, the UAE, Kenya, Zambia, Ghana, Tanzania as well as three other African countries to help their fight against tuberculosis.

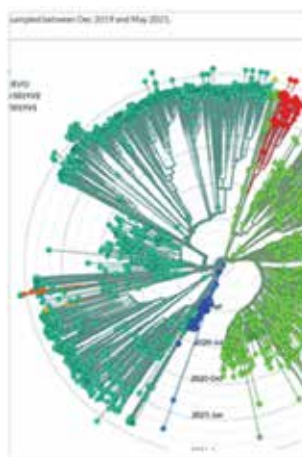


Fig 23. Genome Sequencing Informatics Snapshot by Haystack Analytics

NIDHI4COVID 2.0 Initiative

During this year, amid the current COVID-19 pandemic, NSTEDB has rolled out a specially devised initiative, NIDHI4COVID 2.0 to support startup led covid solutions relevant in the second wave of Covid. NIDHI4COVID 2.0 initiative of DST is being implemented by KIIT- TBI, a Centre of Excellence supported by the DST. 390 applications were received for this effort in five categories: diagnostics and medical accessories, oxygen innovation, portable solutions, informatics, and others. Finally, a total of 35 start-ups were recommended for funding support of up to 50 lakhs under the NIDHI4COVID2.0 initiative. The selected startups are expected to play a significant role in bringing innovative technology and goods to market, making our country stronger on multiple fronts in the ongoing fight against COVID.

3.5 National Council for Science & Technology Communication (NCSTC)

The programme spearheads the Indian science communication programme with two broad objectives, public awareness of science as well as promotion of scientific temper amongst masses. Highlights of various activities and achievements are summarized here under different areas

3.5.1 CONTENT DEVELOPMENT

Science Channel:

The Science TV Channel started with two innovative platforms, DD Science – a one-hour slot on DD National, in collaboration with Doordarshan, and India Science – a 24x7 OTT channel, which were launched on January 15, 2019 by Dr Harsh Vardhan, Hon'ble Minister (S&T, and ES). DD-Science was continued till 31 March 2020. The project is now focusing on India Science platform. During 15 January 2019 to 30 November 2021, a total of 3417 programmes were produced and streamed through India Science, 712 programmes (365 hrs) were Telecast through DD Science. Presently the reach of India Science channel is around 200 million across all platforms and various platforms.

Several research institutes/organizations/universities including My Gov have been associated with the channel as a knowledge partner. Some programmes of India Science are recognized at national and international level. COVID Warrior -a programme under series 'Life in Science with Pallav Bagala' received a prestigious Red Ink Award- 2021 under the category science and innovation - Television, Documentary- Secrets of Super Foods Makhana and Sabudana received first prize in International Science Festival of India 2021, Documentary -Indian Heritage in Digital Space has been nominated for Golden Tree Festival 2021, Germany and 12th educational film festival 2021, Poland, Documentary- Nutraceuticals New Age Avatar of Herbal remedies shortlisted for The Paus Premieres 2021 festival, France. India Science is accessible on the notable platforms -India Science App: Android / iOS App (download from Google play store /Apple store), YouTube: www.youtube.com/c/indiascience, India Science

Website www.indiascience.in, Facebook: <https://www.facebook.com/indiasciencetv>, Twitter: @indiascience, India Science Instagram: indiasciencetv, LinkedIn: India Science, India Science Pinterest, Jio TV, Jio STB, JioTV+, JioChat.

Development of S&T Content on Wikipedia in Indian Languages:

Development of S&T Content on Wikipedia in Indian Languages has been initiated. Formal discussions of group of experts have been conducted and an official expert committee has been constituted based on their commendations drawing diverse expertise including science and technology, encyclopedia, quality control, education, data science, media, and intellectual property rights, etc. Under the guidance of expert committee, proposals from IIIT Hyderabad, IIT Kanpur and CDAC- Noida have been recommended in-principle for DST support.

3.5.2 PROFESSIONAL DEVELOPMENT

Augmenting Writing Skills for Articulating Research (AWSAR):

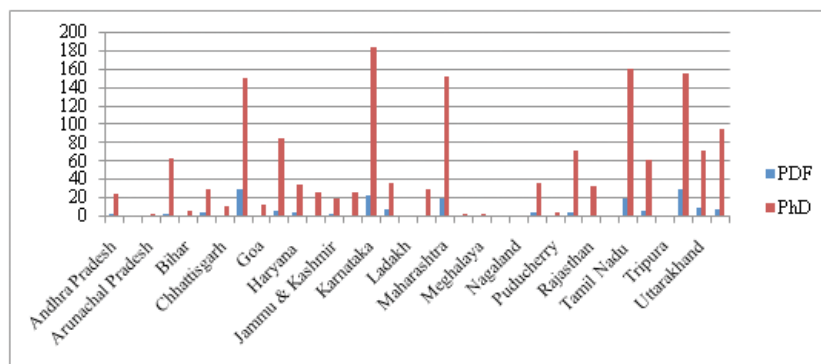
Augmenting Writing Skills for Articulating Research (AWSAR) program of DST is motivating young research scholars (PhD & Post-Doc Fellows) through an annual competition to write popular science articles about their own research. The scholars are oriented towards popular science writing, its methodology, formats, does' & don'ts, etc., through workshops organized across the country. On National Science Day (NSD), 28th Feb 2021, three PhD Scholars and one Post-Doc fellow were felicitated with AWSAR Award for Outstanding Story (Rs. 1,00,000) in PDF Category. First Prize (Rs.1,00,000), second prize (Rs.50,000) and third prize (Rs.25,000) under PhD Category were given. In addition, to the mentioned Awards, top 128 popular stories out of 2063 stories were selected for a cash prize of Rs 10,000 each. This year under AWSAR program, 3413 Scholars were guided on "Popular Science Writing" through 5 webinars. A total of 1779 stories including 22 stories in Hindi were received under AWSAR 2021.



Felicitations of AWSAR Award 2020



Popular Science Writing Workshop conducted virtually



AWSAR: State-wise Distribution of Stories Received in 2021

Training & Research in Science Communication and Science Media

The following notable initiatives have been supported to promote research and capacity building in science communication & science media:

- Innovativeness and Science Literacy among Secondary and Post-Secondary Students - Development and standardization of psychometric scales
- Virtual AR/VR Museum for Science and Technology Literacy
- Need Assessment for Scientific Communication and Strategic Intervention for Effective Scientific Communication among Tribal, Women, and Workers
- Pattern Analysis and Impact Assessment of NCSTC funded projects through Statistical, Text-based, Scientometric and Altmetric approaches
- Application of Blended Digital Learning Based on Science Communication for Field Capacity Development For Climate Resilient Livelihood

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 being given on National Science Day, Feb 28, 2022 as follows:

- National Award for Outstanding Efforts in Science & Technology Communication in General
- National Award for Outstanding Efforts in Science & Technology Communication through Print Media including Books and Magazines
- National Award for Outstanding Efforts in Science & Technology Popularization among Children

- 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
- National Award for Outstanding Efforts in Science & Technology Communication through Innovative and Traditional Methods
- National Award for Outstanding Efforts in Science & Technology Communication in the Electronic Media

3.5.3 *HANDS -ON SCIENCE PROGRAMME*

National Children Science Congress 2021:

Started in 1993 by National Council of Science and Technology Communication (NCSTC), NCSC encourages a child scientist of the age group of 10-17 years to identify some societal problems and motivate to arrive at a possible solution through his research-based solutions. It covers almost all the districts of the country with a participation of over 200,000 students. Emphasis is on hands-on science and presentation of the results and its analysis. Some teams also presented working prototype and models. 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 for Sustainable Living".

Initiative in Research & Innovation in STEM (IRIS):

The 'Initiative for Research & Innovation in STEM (IRIS)' is a research-based science initiative for students, with an objective to inspire promising young scientists in India. It is a public – private partnership of Department of Science & Technology (DST), and Broadcom for empowering the next generation of innovators. Winners of the Initiative for Research and Innovation in Science -IRIS National Fair, who represented 'Team India 2021' have competed with 1833 budding scientists from 64 countries, regions and territories across the globe and won 9 Grand Awards and 8 Special Awards at Regeneron International Science and Engineering Fair (ISEF), the largest pre-collegiate science & engineering fair in world.

Low Cost Teaching Aids for Innovative Hands-on Science Learning:

Training of teachers in innovative methods of science teaching by low cost teaching aids aims to develop the problem-solving capacity, reasoning power and creativity of the students. Training workshops were supported for teachers training in different states with low cost teaching aids to help the teachers in making teaching interesting with an aim to motivate science teachers to perform hands on activities that would enable them to grasp the basic principles of science easily. The participating teachers encourage students and promote the concept of learning science by fun.

Training workshops of 5 days on demonstration of low-cost teaching aids were organized in 9 districts of Uttar Pradesh. Some of the notable science experiments of the workshop include earth science experiments, experiments on magnetism, pressure, Bernoulli theorem, etc. The workshops are directly benefitting around 500 science teachers and more than 1,00,000 urban and rural students from across the state of Uttar Pradesh are helped indirectly.



Workshops on Low Cost Teaching Aids for Innovative Hands-on Science Learning

3.5.4 PROMOTION OF SCIENTIFIC LITERACY

Celebration of the National Science Day (NSD) and National Mathematics Day (NMD) are organized nationwide through State S&T Councils. The National Science Day programme was supported all over the country through State S&T Councils. Celebration of National Science Day began or culminated on 28 February. Similarly, the National Mathematics Day programme was supported all over the country through State S&T Councils involving colleges and schools' students. Celebrations or culminated on 22 December to commemorate the birthday of Srinivasa Ramanujan, the great mathematician with a focus on popularizing Mathematics.



Activity on National Mathematics Day



An Activity Corner, National Science Day

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. These events including mobile science exhibitions, serve to utilize the expertise of resource persons trained/being trained by NCSTC in various aspects of the concerned activities. More than 200 static and mobile exhibitions were organized in different parts of the country.

Science Exhibitions on Wheels:

Through ‘Mobile Science Exhibition’ students, especially having no or very little access to lab facilities, get an opportunity right at their school premises for hands-on engagement in science activities which will help them in understanding difficult curriculum-based concepts with fun and ease. The target group for these activities includes general public, school & college students, youths, women, teachers, gram panchayat members, voluntary organizations and policy makers, etc. Several such Mobile Science Exhibitions run in different states. The Mobile Science Lab (MSL) is a unique lab-on-wheels, which aims to take the laboratory experience to underprivileged children right at their school premises. NCSTC has been catalyzing and supporting several such Mobile Science Labs, which are run by its partners in different states.

The Mobile Lab run in Gujarat by implementing agency, Vikram A Sarabhai Community Science Centre, is taken to schools having no or very little access to laboratory facilities. This includes schools from aspirational districts. The Lab carries the necessary equipment, kits, consumables and other material required to perform curriculum-based science and mathematics sessions. The methodology used includes hands-on sessions like model-

making, experiments, interactive exhibits, as well as panel exhibition, and demonstrations. All students are involved in the hands-on sessions. Demonstration sessions are conducted for curriculum-based topics and also include scientific understanding of COVID-19, Science behind Miracles, Swachhh Bharat mission. Each participating school is given a set of Science and Mathematics resource material for carrying out the activities later on. In Gujarat, around 50000 students, 1800 teachers and 220 schools have benefited from this initiative over its two phases.



Mobile Science Lab and Off-board Activity (Gujarat)

Mobile Science Laboratory from Karnal district in Haryana was launched in April 2016. The laboratory is equipped with all types of basic scientific equipment's of physics, chemistry, biology, electrical, electronics and mathematics in general and relates daily life activities through scientific experiments justifying – ***“Parmanu se Brahmmand, Ek Hi Vigyan - From Atom to the Universe, Science is One”***



Mobile Science Lab (Haryana)

This Mobile Science Laboratory has visited over **506** Government Senior Secondary, Government High and Government Middle Schools of districts Karnal, Kurukshetra,

Yamunanagar and Nuh (aspirational district). More than 83,000 **students and many teachers** have performed hands-on experiments through mobile science laboratory.

The unique feature of this laboratory is that every child is engaged in performing at least one hands-on experiment fulfilling one of our ideologies - ***“Har Bachcha Ek Vaigyanik Hota Hai – Every Child is a Born Scientist”***. Students are provided with variety of kits to work on optics, magnetism, electricity, electronics, human physiology, microscopes, telescopes, sundials, pinhole cameras, lens cameras, different types of chemicals & glassware and many other apparatus to inculcate the scientific interest in students. Further, biographies of the eminent Indian scientists are screened through projector which develops in students the spirit of ***“Hum Bhi Kar Sakte Hain – Even we can do this”***. Another popular activity under the Mobile Science Laboratory is ***“Sitaron Se Mulaqat – Meet with the Stars & Planets”*** which involves the use of telescopes for watching planets, stars and constellations in night-sky. From April, 2021 onwards, the science laboratory has visited 53 Government schools in districts Yamunanagar and Nuh (Mewat) and interacted with more than 7569 students.





Science Exhibition & Mobile Science Laboratory at International Gita Mahotsav – 2021

STEMM Bike: The motivation behind STEM BIKE (Create Science Awareness through Demonstrations among the rural people) program is to promote Science, Technology Engineering, Math education through development of logic, systematic observation and hands-on experiments to make learning science an enjoyable experience. Seven science communicators travel on Bikes along with one programme coordinator and one co-coordinator to visit different villages in the districts to demonstrate various activities for awareness in remote areas in three Districts of Haryana State namely Panipat, Ambala and Kaithal in Schools & Villages. Programme inaugurated and Flag off in Kurukshetra and Yamunanagar districts by the Deputy Commissioner of respective districts. The activities relate to Physics through Bicycle, Mathematics, Electrical Energy, Day Time Astronomy, Low-cost Teaching Aids, Puppetry, Water Rocketry, Food Adulteration, etc. The campaign has covered 14860 students from 20 schools in Panipat District, 4200 students from 20 schools in Ambala District and 4270 students from 20 schools in Kaithal District.

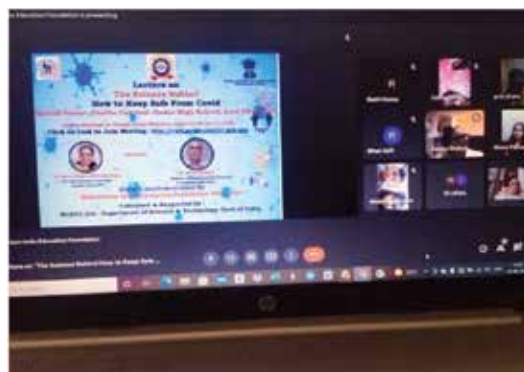


STEM Bike and Science Demonstrations

Online lectures on How to Stay Safe from COVID 19 in schools:

More than 200 schools were covered in Distt of GB Nagar and Ghaziabad under this program.

More than 10000 school children, teachers and parents attended these online lectures during last 6-7 months. The lectures were also streamed live on YouTube channel and more than 87000 viewership was recorded during the month of December 2021 itself. Children's illustrated story Book on corona titled as Shallya discovers Corona Virus was published in Hindi and English and distributed free to schools through Dept of education. The book has also been translated in to 17 Indian languages.



Online lectures on How to Stay Safe from COVID 19 in schools

Science Communication through Folk Media: Training workshops & awareness programmes were supported to promote S&T awareness in local language in different states and to develop resource persons as science communicators through folk media. Cultural Science Pandal Mahotsav was organized in 10 divisions of Chhattisgarh, Madhya Pradesh, Uttar Pradesh and Uttarakhand for imparting knowledge and spread awareness about preventive measures against communicable viral disease and to guide people to practice hygiene and sanitation in their daily lives for improving overall health hygiene status among masses. Cultural Science Pandal Mahotsavas for 5 days were conducted as a unique way for demonstrating Exhibitions, posters, short films, digital plays, etc. It has benefitted more than 2 lakh 50 thousand people directly and more than 10 lakh people indirectly.



Cultural Science Pandal Mahotsav to promote S&T awareness in local language

3.5.5 RISK COMMUNICATION PROGRAMME

National Programme on Risk & Health Science Communication

A full-fledged programme was evolved with emphasis on content creation, content reinforcement and its zonal utilization, along with assessments of outcomes and recycling the lessons learned. Over 100 projects are being implemented across the country in 20 States/UTs. The messages are going far and wide in preparing the nation in fight against COVID 19. Content reinforcement has been provided with COVID Katha, Vaigyanik Drishtikon (150+ stories), and India Science Channel (Doctor's Interviews, 424 Documentaries).

3.5.6 COOPERATION IN SCIENCE COMMUNICATION

UNESCO Kalinga Award 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. It was created in 1951, following a donation from Shri Biju Patnaik, then Chief Minister of Odisha and Founder President of the Kalinga Foundation Trust. Now 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.

French astrophysicist, cosmologist and author Dr Jean-Pierre Luminet is the winner of UNESCO Kalinga Award for Science Popularization for 2021. He shall be bestowed with the Kalinga Chair by Department of Science & Technology, Government of India.

BRICS Science Popularizer's Forum:

NCSTC participated with presentations by its Scientists on different themes and achievements pertaining to science popularization under corresponding technical sessions at **BRICS Science Popularizer's Forum** Oct 6-8, 2021.

3.6 Science for Equity for Empowerment and Development (SEED) Division

Science for Equity Empowerment and Development (SEED) Division of DST provides opportunities to motivated scientists & technologists from national Research and Development (R&D) labs, Academic Institutions and S&T-driven Non-Governmental Organizations (NGOs) to take up action-oriented and location-specific projects aiming at Socio-economic development of disadvantaged sections of the society through appropriate Science, Technology and Innovation (STI) interventions leading to improved quality of life and livelihood. Through its diverse schemes and programs, efforts are being made to empower the community by developing, adopting and disseminating technologies to address local needs and priorities considering available resources and moral prosperity of society for sustainable development. The schemes and programs of the division are also being converged with line function ministries/departments for the last-mile delivery and national development programs to achieve Sustainable Development Goals (SDGs).

Specific initiative under SEED division during the year 2021-22 are as under:

3.6.1 Technological Advancement for Rural Area (TARA) program

Under TARA program, Long Term Core Support was provided to 26 S&T based NGOs to evolve and deliver scalable technological solutions to address location specific challenges at the grassroots to empower local community in utilizing field-tested technologies and packages (Web Link: www.dsttara.in). Several adaptive technologies developed & disseminated under TARA program to benefit rural community and for strengthening rural innovation & social entrepreneurship ecosystem are as follows: -

- **Social Work and Research Centre (Barefoot College), Tilonia, Rajasthan**

Barefoot College designed a low-cost water vending machine capable of dispensing 0.1 to 100 liters of water quantity with user defined controls using keypad/single button, RFID-based recharge and vending processes to repair, maintain and modify. Piloted water vending machine in the campus of Barefoot College is dispensing safe and clean drinking water to 100 people. An IOT based solar charge controller for community that could be used through laptop or mobile phone (wired and wireless). The device monitors and maintains the health of solar systems with 15 kW installed capacity.

- **Gorakhpur Environmental Action Group (GEAG), Gorakhpur**

GEAG has developed technologies and techniques of farming & tools related to crop protection, compost processing, post harvesting and waste water management in flood prone areas to enhance productivity and income of small and marginal farmers. Recently, Shri Meghnath from GEAG was awarded the Water Positive Award by The Hon'ble Chief Minister, Uttar Pradesh, Shri Yogi Adityanathji for this innovative initiative to convert waste water into irrigation water. A retention tank was constructed to store and treat waste water 54,000 L/day. The treated water is being supplied to 80 households in one of the hamlets of jangle Kaudia Block. The base of the tanks has a slope of 0.5 degree and Typha (herbaceous perennial plants) as filtering materials at the base. A Compost Filtering Machine to filter 5 quintals of manure in an hour has saved labor cost. Several women self-help groups have adopted this tool and set up bio compost filter and packaging units.



Compost Filtering Machine



Sri Meghnath, receiving Water positive award from CM, Uttar Pradesh

Himalayan Environmental Studies and Conservation Organization (HESCO), Dehradun

HESCO has addressed connectivity problems in mountain areas of four districts (Almora, Haridwar, Dehradun & Tehri Garhwal) of Uttarakhand during monsoon by developing location specific need based low cost bridges made of Bamboo, Wooden and Steel. The intervention has reduced drudgery of locals from 10 villages by reducing risk to their life by crossing high current streams. A watermill skill up-gradation station has been established in Shuklapur, Dehradun, where 90 water millers have been trained on turbine design, field testing and installation.



Watermill for multiple use



Steel bridge

Foundation for Environment and Economic Development Services (FEEDS), Manipur

FEEDS, Manipur has developed a fortified food (Ethnic Hot n Sour Soup as immunity booster) prepared from local herbs viz., *Rhuschinensis*, *Allium hookeri* & *Allium odorum* having medicinal properties like anti-hypertensive, carminative, digestive problems. The soup contains no added preservatives and Mono Sodium Glutamate. It contains natural vitamins C, A, E & K and minerals. The organization is commissioning 52 kW Integrated Solar (40kW) Micro hydel (12 kW) pumped up storage power plant. A total of 2378 solar indoor home lighting systems were installed by the trainees at ST/SC households across un-electrified villages in hilly regions of Manipur.

- **Himalayan Research Group (HRG), Shimla**



Designing of Mountain Biogas Digester

Clean energy initiatives for household energy need in cooking, water and space heating were continued with biogas digester development for mountains. Three biogas design of 1 m³ of plastic tank and metal sheet hood were developed and installed for testing in the selected households for real time testing.

- ***Madhya Pradesh Vigyan Sabha (MPVS), Bhopal***

Development of local strain of *Azotobacter* (Bio-fertilizer) has increased average yield of Kondo and Kutki (minor millets) to 22.8% and 21.3% respectively. Experiments were carried out in the fields of 20 farmers of Harsdiwari, Gaidubba, Rated, Chintipur, Gudichhatri, Ghatlinga, Talabdhana, Kaream villages of Tamia & Chhindwada districts. The technology has been transferred to CATRD and FPOs are involved in it's marketing. Organization has developed a Rural Power Bank (Hybrid model of Solar and Biogas) to ensure at least 6 hrs lighting facility at 150 HHs with reduction of about 18 Ton CO₂ emission.



Large scale production of native
Azotobacter bacteria



Azotobacter (Bio-fertilizer)

Sardar Patel Renewable Energy Research Institute (SPRERI), Gujarat



Fluidized bed gasifier at New Raj Food Industry, Dahod

A pilot-scale fluidized bed gasifier (FBG), was designed using loose or powdered biomass and solid waste for production of thermal energy. Cyclone separators were designed and developed to reduce the Suspended Particulate Matter (SPM) content in the producer gas. The system has been installed at the premises of industry in *Dahod* for the performance monitoring. SPRERI-TECH forced-draft *dhabha* sized improved biomass cook stoves were installed at 5 different locations. The stove was socially accepted by these groups as it reduces wood & LPG consumption, CO₂ emission, cooking time and increases annual income.

- ***Society for Technology & Development (STD), Mandi***

Organization is propagating & supplying quality planting material of Lavender (*Lavendula officinalis*) & Rosemary (*Rosmarinus officinalis*) and raised about 12000 rooted plants of Rosemary and Lavender in fabricated 5 poly-tunnels (100 sqm. each) in farmers' fields. STD supported 25 farmers in cultivating wild marigold (*Tagetes minuta*) on 36 bighas (3.0 hectare) of land in Aspirational *Chamba Distt.* An Emulsion Making Unit (EMU) of 25 Kg capacity (SS 304) with variable duties has been designed and fabricated for making moisturizers at GAK equipment's and Technologies, Mohali, Punjab.

- ***Vivekananda Institute of Biotechnology (VIB), Nimpith***

VIB has developed an Integrated Nutrient Management (INM) Package with Endophytic Diazotropic Bacteria along with other biofertilizers for Paddy cultivation in Coastal Saline, Red & Laterite and Vindhyan Alluvial Zones of West Bengal. Potash Solubilizing Bacteria was included in INM package for vegetable cultivation in Sundarbans area. It reduced use of chemical fertilizer by 25% based on soil analysis determined recommended dose. The organization has brought in 14426 farmers, under the umbrella of Good Agricultural Practices (GAP) –resulting in average increase of Rs 34470/ha, in their annual farm income (58%) and up to 21% increase in farm productivity.

- ***Vigyan Ashram (VA), Pune***

VA developed a Low cost ultra-violet light based water filter for potable water, Cost effective fertigation of hydroponics vegetable cultivation and COVID-19 response technologies for frontline workers including face-shield (7000+), Sanitizer dispensers (500+), UV cabinets (5) etc. An oxygen concentrator technology 'Oxykit' has been adopted, lab tested and training on repair & maintenance has been provided in collaboration with Makers Asylum #M-19 initiative. The organization has demonstrated agro-waste composting to 72 farmers in district Pune.



EDP goat farming



Oxykit repair cafe



Solar UV filtre technology

- ***VilKSAT Nehru Foundation for Development, Ahmedabad***

System of Wheat Intensification (SWI) and System of Maize Intensification (SMI) technologies were evolved and propagated to small land holding areas of 27 and 11 villages respectively to enhance the livelihood of Tribals in Aravalli & Sabarkantha districts of Gujarat through integrated farming system in agriculture, horticulture, livestock, fodder and Business model (Vermicomposting, Turmeric Value addition, Biopesticide). SWI & SMI technologies have increased 28.86% yield over farmers practice from 0.1ha area in Rabi seasons and 16-18% yield over farmers practice from 0.4ha area in all (winter, summer & kharif) seasons respectively.

World Wide Fund for Nature – India (WWF-India)

Management of water resources by WWF has enabled Fluvial geo-morphology studies to assess the impact of sedimentation and siltation in the rivers of the *Terai* region on local communities and wildlife. Several fodder species were introduced with 100 farmers covering 35 acres in 10 villages of Uttarakhand. Mushroom cultivation has been adopted by farmers in 12 villages of Pilibhit and Dudhwa Tiger Reserves to generate alternative income. After getting training from WWF, women weavers have received dozens of recognitions and awards from the state and central government and today, more than 200 women are working in the *Tharu* cluster of Dudhwa, Uttar Pradesh.



Women from indigenous Tharu tribe residing in Terai East Forest Division, Uttarakhand weaving daily use products of contemporary designs using traditional technology.

3.6.2 S&T FOR WOMEN Scheme

- **Rural Women Technology Park in Parappa block, Kasaragod district, Kerala.**

A rural women technology park was established at Malabar Social Service Society, Kasargod, Kerala in Kannur to provide technologies for sustainable utilization of natural resources-for livelihood generation. Under this initiative 25 SHGs were formed and 61 Skill development training programs were conducted in association with CPCRI Kasaragod, KVK Kasaragod, Agriculture College Padannakkad, Coir Board, Alappuzha, Department of Microbiology, Pious X College, Kasaragod and Bamboo Development Board, Kerala, benefiting 700 local women. These groups have started 29 enterprising units Micro hatchery, Coconut drying, Arecanut De-husking, Coir-pith compost production, Herbal medicinal oil production, virgin coconut oil production, Pearl culture, bamboo craft, etc.

- **Eco-friendly Silk Dyeing Technology**

Kumaraguru College of Technology, Coimbatore is implementing a project on Eco-friendly silk dyeing technology for rural women of *Sirumugai* weaving cluster with the aim of their economic upliftment and improved process of silk dyeing for Sericin recovery. For effluent treatment process, locally available agricultural waste has been selected as source for preparation of adsorbents to reduce the cost of the process. Prototype development of dyeing machine has been designed with the Collaboration with Trytex Machines and Co.

- **Preventive Women's Safety Device**

Aarupadai Veedu Institute of Technology, Tamil Nadu designed a prototype app especially for women safety and security. The developed system will send an emergency alert encompassing location, date and time of the incidence to the list of people enrolled during user registration process. The message will also notify the nearest police station available in the locality. The app will tested with the women in and around Paiyanoor, Kanchipuram.



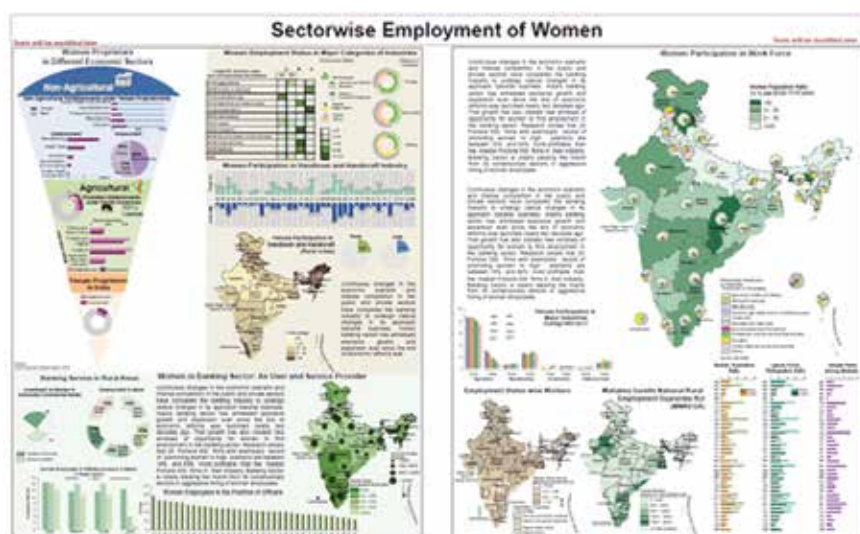
Device with MINI NODENCU



User Application

- Women Empowerment Atlas of India: Science & Technology Perspective**

A National Atlas on Women Empowerment with science & technology perspective is being prepared by the National Atlas & Thematic Mapping Organization, Kolkata and Department of Geography, Kirorimal College, University of Delhi, with focus on visualizing the present status of women empowered by Science and Technology; identification of the gender gaps and locate areas of opportunities for women in Science and Technology; and envision priority areas for improving livelihood status of women and empower them. Till now, 422 variable data sets have been collected broadly along selected themes and different weightages prescribed with the help of experts using Delphi method for calculating a holistic Women Empowerment Index.

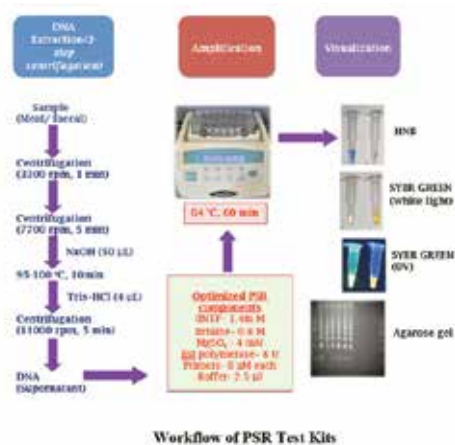


3.6.3 Scheme for Young Scientist and Technologists (SYST)

Scheme for Young Scientists and Technologists (SYST) was initiated in the year 1991 to harness the potential of young scientists and technologists towards socio-economic development of the country by providing technology based/led solutions for societal challenges. The scheme has been revamped in 2019 to use knowledge and fresh perspective of young researchers in new and upcoming technological areas such as Artificial Intelligence and IoT for Societal Application, Scientific Validation and Upscaling of Traditional Knowledge Systems, Effective Indigenous Methods of Disease Identifications and Monitoring etc. A total of 52 new projects were supported in the year and some of the noteworthy achievements are as follows:

- Point-of-care, cost effective, easy-to-perform and equipment-free diagnostic toolkits to detect *Salmonella*, *Staphylococcus aureus*, *Clostridium perfringens*, *Campylobacter jejuni* and *Campylobacter coli* contamination of food at source using polymerase spiral reaction (PSR) for rapid detection of foodborne pathogens in contaminated animal-based food products were developed. The developed assays were found to be 10x

sensitive than RT-PCR and 100x sensitive than conventional PCR. The technology is currently ready for transfer and could be useful for food regulatory agencies, small-scale food processing industries and other stakeholders in the food chain at national and local levels.



- Apen drive size android app enabled user friendly DNA sensor was developed in collaboration with industrial partner Class One Systems Pvt. Ltd. India (dealing with Palmsens) for onsite detection of scrub typhus, a disease highly endemic in rural areas of hilly areas of Himachal Pradesh and Uttarakhand. The developed system could detect 0.02 ng of bacterial genomic DNA at room temperature within 60 sec. The developed sensor has been validated with patient's samples and comparative studies were performed with standard methods of diagnosis like ELISA and PCR.



- A bouquet of coloured artificial diets for rearing silkworm was developed that produces naturally coloured cocoon thus limit the use of synthetic dyes for dying purpose leading to environment protection. The technology also encourages landless farmers to take up sericulture by providing them a source of revenue generation.

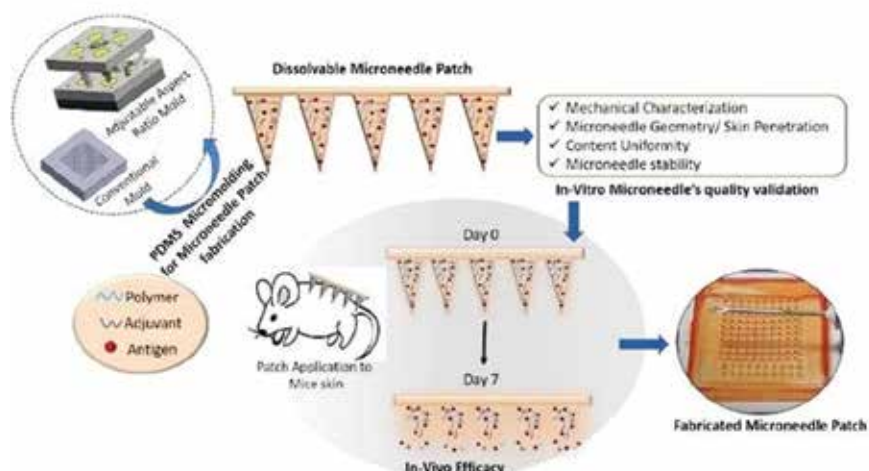
4. Field trials to determine effect of artificial diet on cocoon quality and quantity



5. Demonstration of the usage of artificial diet to Sericulture farmers in Chickballapura and Kolar district villages



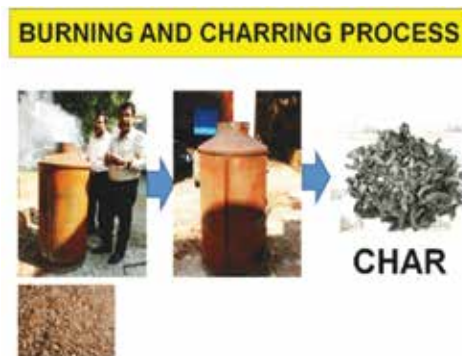
- Dissolvable microneedle patches to get an adequate immune response through sustained release of vaccines was developed. Technology is currently at TRL-3 (*Proof of Concept demonstrated*) for the 'Adjustable Aspect Ratio Moulding Platform'. This technology can be further adapted to develop new and improved microneedle patches, which will be smaller, cheaper, easy to carry, pain-free and attaining better therapeutic activity of a drug.



3.6.4 Technology Intervention for Addressing Societal Needs (TIASN) programme

The TIASN program involves technology development and adaptive R&D for the benefit of society in Agriculture, Health, Nutrition and activities related to Non-Farm sector. During current financial year, DST supported 4 projects. Significant achievements of the projects funded under TIASN:

- A technology for preparing bio-coal (briquetted char) from waste green coconut shell was developed. The biocoal has calorific value of 6500 kcal/kg, 20% more than coal. The use of this technology would enhance the income of a family having 10 coconut trees to about Rs. 3000/month by selling tender coconuts as soft drink and preparing biocoal from the used tender coconuts for fulfilling the domestic cooking fuel requirements for 2.5 months for a family of 5 members.



- *Pt. Deen Dayal Upadhyay Vigyan Gram Sankul Pariyojana* was supported for effective utilization of natural resources and promotion of traditional knowledge in four districts of Uttarakhand i.e. Bazira (Rudraprayag), Bhigun (Tehri), Kausani (Bageshwar) and Gairidkhata (Haridwar). Modern Nursery units including one mist chamber, four polyhouse and two net-house and fifteen mushroom units (with 100-150 bags each) were established in three hill clusters to promote the allied agriculture practices. *Pleurotus ostreatus* (Oyster) and *Agaricus bisporus* (Button) mushroom units were introduced as per environmental condition and market demand. Apiculture units (50-100 boxes) with latest equipment's and scientific tools were setup in all the four clusters with *A. indica* and *A. mellifera* species. The villagers were trained to extract honey without destroying the bee colonies and would generate income of 5 lakhs per year from apiculture. Medicinal plants cultivation (Satawar, Tulsi, Ashwagandha, Sarpagandha, Lemon grass etc.), spices cultivation (large Cardamom, Turmeric, Black Turmeric and Ginger) and local fruit cultivation (Citrus fruits, Kiwi, Aonla, Apple, Kagzi Lemon) was promoted in all the clusters by providing high quality seeds and plant saplings as per environmental conditions and soil type. For value addition of horticulture crops juicing, pulping, pulverizing and packaging were installed. Several capacity building workshops were conducted to promote traditional handicraft using "Ringal" a dwarf bamboo species of Uttarakhand.

3.6.5 Technology Interventions for Disabled and Elderly (TIDE) programme

TIDE program aims at developing accessible and affordable tools, techniques and technologies for providing inclusiveness and improving the quality of life of *Divyangjan* and Elderly in different built environments, mobility, information and communication systems. Total 20 new projects were supported for development of various assistive tools and technologies focusing on various disabilities and total 25 projects were successfully completed, and the technologies developed are at various stages of field trials, validation, scale up and commercialization etc. These projects will help in development of assistive technologies related to various issues pertaining to communication, education, mobility, accessibility, skill development, capacity building, employment, rehabilitation etc of *Divyangjan* and Elderly. More than 50 research

papers were published out of the completed and ongoing projects. Approximately, 100 students were trained in research and development activities pertaining to development of various assistive technologies. The projects yielded 5 patents which were published. The details of few significant prototype devices ready for deployment and commercialization are given below: -

- **Assistive device to impart perceptual ability to visually-impaired using intelligent scene captioning**

- The developed prototype “Blind Assistive Device”, is fully automatic assistive system based on artificial intelligence used to recognize different objects where auditory inputs are provided to the user in real-time for better understanding of



Prototype of Blind Assistive Device

their surroundings. It is a sensor and camera-based, multi-mode device with deep learning model (artificial intelligence algorithm) trained on various images of objects which are highly relevant to blind people. The visual information is analysed to generate the audio prompt with the name of the detected object for making a user aware of the surrounding environment with different object detection and classification techniques. The device, works in three different modes: indoor (it works inside the building), outdoor mode (road and public places), and a text reader mode (for restaurant menu/other text stuff, and could read multiple languages like Hindi, English, Bengali, Tamil, etc.).

- **Artificial Intelligence Based Non-Invasive System for the Identification and Assessment of Children with Autism Spectrum Disorders (ASD)**

Conventional methods of detecting Autism are primarily focused on observational techniques and cognitive assessment and objective methods of assessment are not available to detect or assess the level of ASD till now. This research developed by Vellore Institute of Technology, Chennai paved a way to objectively detect ASD with a prominent biomarker from EEG signal. Current advancements in signal, image processing, machine learning, and deep learning techniques were applied for detecting ASD. The technology has potential to (i) Early diagnosis and identify the of the level of ASD, (ii) level of impact of training given by the therapist and (iii) customize the teaching learning process for the individual child. The study can be extended to understand the root level of cause of many brain disorders if data sets of different origin, ethnic group, regional groups and cultural groups are available. The prototype software can be accessed at <https://drive.google.com/drive/folders/1uxfkFaTJxslgg1NdBrIkJRMa2IRLY3xJ?usp=sharing>.

- **Speech- Input Speech–Output Communication Aid (SISOCA)**

An Augmentative and Alternative Speech Communication (AASC) for speakers with

Cerebral Palsy was developed to address problems pertaining to unintelligible speech and communication problems of cerebral palsy speakers. It has a Raspberry Pi, Microphone, and a portable speaker. A two-level data augmentation approach was used to augment the collected dysarthric speech data. The augmented dysarthric speech data is trained using a transfer learning (TL) approach. The sentence of cerebral palsy speakers using after processing is synthesized into intelligible speech and is heard through a speaker. This device uses dysarthric speech itself as input, unlike the previous technologies that rely on switches or touching icons to frame a message to communicate with others. Further, the system recognizes sentences up to 6 words, whereas the speech recognition systems available in the market today recognize mostly isolated words of dysarthric speech. The device was developed for Tamil language and could be extended to any Indian language and other speaker types based on their needs and requirements.



Prototype Model of SBOCA

- **Prototype of Cognition based Intelligent Mobility Device (Wheel Chair)**

The wheelchairs available in the markets for Physically Challenged and Elderly People do not have provisions for enabling the user to reach objects located at different heights (Z Plane) and to navigate in multiple directions, i.e., in X, Y & Z planes. The developed mobile app controlled multi directional Wheel Chair for with height adjustment mechanism enables the users to navigate the wheelchair in multiple directions at different speed levels. In addition to these movements, this wheel chair enables the user to reach objects positioned at different heights in racks, shelves etc., through its uniquely developed height adjustment mechanism. Electro-Mechanical Actuator was used as the lifting device for lifting & lowering the height of the wheel chair and scissor mechanism was used for lifting the height thereby making it compact & light in weight.



Prototype Height

- **Apex Locating, Anti-microbial and Adaptive Gutta Percha (GP) Points for Root Canal Applications**

SRM Dental College, Chennai has developed the project for Geriatric patients who are unable to sit for long dental treatment. The novel technique attempted reduce

radiation exposure and provide a better antimicrobial obturating material that will in turn reduce the time taken for the whole procedure and enhance the healing of the periapical tissues. Gutta Percha (GP) points were coated with bioactive AgFPG granules in optimal concentration and layers, so as to develop an apex locating, antimicrobial GP that is adapting to the root canal walls. This will eliminate the step of master cone radiograph, enhance healing of the periapical pathology and lead to a better life for the patient. The developed Gutta Glass Percha (GGP) enables sealing of the interface between the root canal wall and the obturating material, thereby

eliminating the need for the use of a sealer. The apex locating ability of the GGP will enable proper apical extent and seal of the obturation, eliminating the need to verify the working length before obturation. Animal trials are underway. **“Scientific Utilization Through Research Augmentation – Prime Products/Panchagavya from Indigenous Cows” (SUTRA-PIC)** an inter-ministerial funding program is being implemented by DST in collaboration with Department of Biotechnology (DBT), Department of Scientific and Industrial Research (DSIR)-Council of Scientific & Industrial Research (CSIR); Ministry of Ayush, Ministry of New and Renewable Energy (MNRE), Indian Council of Agricultural Research (ICAR) and Indian Council of Medical Research (ICMR).



GP coated with AFPG glass granules & with Ag Nanoparticles

The main objective of the program is to carryout evidence based Scientific research on prime products from indigenous cows including translation of R&D to develop appropriate products for their application in sectors like energy, agriculture, health care, food and nutrition etc. This knowledge to products transformation will help in scientific utilization of the huge livestock resources for socio-economic development.

36 R&D proposals were recommended for financial support under this initiative by various departments. DST had already released grants (Rs. 2.97 Crore) to 9 projects for Scientific Research on Prime-products from Indigenous Cows based Utility Items. These projects focus on characterization of indigenous cow's dung and urine to convert paddy straw into complete fodder, block conversion of dairy waste cum derived fatty acid methyl ester into potential biofuel (biodiesel), cow dung as hybrid adsorbent for heavy metal removal and its subsequent utilization as cheaper electrodes for energy storage devices, development of corrosion inhibitors from cow manure and their performance evaluation for combating corrosion of reinforced steel, development of an innovative dermal trace metal delivery system with multifunctional facets from cow dung, exploring anti-infective potential of *Panchagavya* metabolomics and proteomics and arsenic removal from contaminated water and soil matrices using cow dung derived biochar.

3.7 Special Component Plan for Schedule Castes (SCSP) & Tribal Area Plan (TSP)

The broad mandate of the Scheduled Caste Sub Plan (SCSP) and Tribal Sub Plan (TSP) schemes of Science for Equity Empowerment and Development (SEED) Division of the Department of Science and Technology (DST) is to empower the Scheduled Caste (SC) and Scheduled Tribe (ST) Communities through promotion of research, development and adoption, transfer and dissemination of proven technologies (including delivery of science led solutions) to solve their problems, especially in rural areas through application of Science and Technology.

76 new projects (including STI Hubs and SC/ST Cells) were supported during FY 2020-21 in diverse sectors 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 enterprises, sustainable agricultural practices etc. which will directly benefit more than 50,000 people belonging to SC&ST Community. 50 ongoing projects are benefitting approximately 25000 people by creating sustainable livelihoods through various Science and Technology (S&T) interventions and S&T Capacity Building. Glimpses of achievements and details of projects supported during 2021-2022 under SCSP and TSP schemes are given below

Individual Projects under SCSP and TSP.

- 2000 SC farmers in four districts of Uttar Pradesh benefitted from standardization of large-scale microbial technology of agro waste using microbiological and composting techniques under the project ***Scale-up, fortification and dissemination of microbial agro-waste bioconversion technology for empowering rural weaker sections*** implemented by ICAR- NBAIM, Mau. The farmers were trained on rapid Composting of Agro waste and making of value-added fortified compost using microbial inoculants. The beneficiary farmers at present are using the compost produced by them in their own field (in field size ranging from 0.4 to 2 acre) and have reduced chemical fertilizer inputs gaining economic benefit ranging from Rs 1000 – Rs 8000/- per application.



Fig 1. Demonstration on Rapid Composing Technology

- A prototype model of an Internet of Things (IoT) based smart underground Drainage Water Monitoring and Cleaning Systems has been devised based using various sensors like flow sensor, gas sensor, water level sensors. The water blockage between two manholes and the geo location of the blockage inside the underground drainage water pipe can be identified and the Robot arm is used to remove the blockages. The prototype developed is under field trails in real conditions. The proposed device is highly useful in removal of manual scavenging of drainage systems.



Fig 2. IoT based Drainage Cleaning System

- The existing tool (sakta) for cutting dried betel nut requires more time and the output is very low, hence the efficiency is very poor. Finger cut and musculoskeletal pain due to poor ergonomics is very common among SC and ST women associated with supari business in different parts of Assam. Rural Technology Action Group – North East (RuTAG – NE) at Indian Institute of Technology Guwahati has developed a novel Betel Nut Cutting tool which reduces drudgery and increase the work efficient (output). Field trials has revealed that the improvised tool has helped in cutting 12 bags of betel nut per day instead of 4 bags using the traditional sakta thereby giving an additional income of Rs. 9,600/- per month for one woman. Fifty women SHGs were trained and provided with the improvised tools in Kamrup, district, Assam.



Fig 3. Traditional betel nut cutting (left) and improved machine

- A project on **Socio-economic development through technology intervention for sustainable muga culture among Tribal Communities in Nagaland** is being implemented at Ungma, Kobulong and Aosenden villages of Mokokchung district in Nagaland. Muga cluster groups have been formed where the S&T capabilities of the ST farmers are being improved in the aspects of scientific rearing of muga silk worms, eco-restoration by raising food plantation in waste/degraded land, augmenting the resources for rural development and providing raw material for cottage and textile industry. The project has also addressed several cross cutting issues like climate proofing (establishment of wild silk moth farm with different host plants to initiate ecological restoration in waste land, degraded forest land and Jhum fallow areas), gender equality (creating sustainable livelihood and employment generation to women through diversification of on farm and off farm economic activities) and knowledge creation (educate the local people about the importance of rearing and conservation of the species). During the project period three rearing were conducted during which 8200 dfls and 264000 Cocoons were harvested which has provided financial benefit to rearers.



Fig 4. Cocoon Rearing & Harvesting in Green House

- The project on **nutritional value, toxicity, phyto-chemical analysis, conservation, sustainable utilization and value addition to common edible food Tashe (*Wallichia oblongifolia*)** was implemented in Palin block of Kurung Kumey district covering 120 beneficiaries. The nutritional analysis, antioxidant assays and HPLC analysis shows “Tashe” -as a promising anti-diabetic agent. In vitro assay, Molecular docking and QSAR studies were also done. The results of Quantitative HPLC analysis of “Tashe” sample collected from Koloriang and Seppa of Arunachal Pradesh are given below.

Name of component	Interaction energies (Kcal/mol)	pIC ₅₀
Chlorogenic Acid	-21.0889	5.87645
Ferullic Acid	-19.8222	5.87895
Epicatechin	-24.9282	5.72232
Acarbose	-26.7226	6.03058

The studies established *Tasche* as a prominent product which can be used as a potential staple food. Several value-added products were prepared and the activities were converted into a social enterprise activity. Initial studies revealed that the income of ST people into the value addition and post harvest processing of *Tasche* has been doubled.

- The highlands of cold arid regions of Ladakh have sandy soils with low organic matter and poor soil quality leading to low crop productivity. 1350 tribal farmer were selected under a project **“Innovative technological interventions to address basic needs of the tribal farming people of Ladakh region”** for addressing the issues of soil fertility and augmenting their income with alternate livelihoods. A biocontrol agent *Trichoderma harzanium* was isolated and released by Krishi Vigyan Kendra, Leh under the project to promote organic farming in the region. A new structure of vermicompost pit was designed which will maintain the temperature during winter resulting in faster vermicompost production and survival of worms in winter months. Farmers were trained on these aspects as well as in designing low cost structures for cultivation of mushroom which can maintain ambient temperature and humidity for mushroom production using zero energy. The project is being implemented in Sumoor and Chamshen from Nubra valley, Basgo and Skurbuchan from lower agricultural zone, Shara from Changthang and Chiktan and Bodh-kharbu from Kargil district.



Fig 6. Button & Pink Mushroom produced under controlled environment

- Intercropping based Broom Grass Cultivation with Microbial Inoculants has been introduced to improve the livelihoods of ST population belonging to 20 tribal hamlets in Paderu Division of Visakhapatnam District, Andhra Pradesh. The project while addressing their livelihood problems (shifting cultivation and collection of Non-Wood Forest Products) also attempted to solve the problems of land and conversion of degraded lands into fertile land. Intercropping based Broom Grass Cultivation with Microbial Inoculants has been introduced in these degraded forest lands. Inter-cropping with pulses and millets has led to enhanced income for tribal and is also providing nutritional security. Arbuscular Mycorrhizal (AM) fungi used as Microbial Inoculants has enhanced plant growth through supply of diffusion-limited nutrients like P, Zn, Cu, etc., water uptake, production of plant growth promoting substances, thereby helping in survival and establishment of plants in degraded forests. Similarly, several Plant Growth promoting Rhizobacteria (PGPR) have

been screened for selecting the best for inoculating broom grass. 30 acres of degraded forest lands covering sixty farmers were restored and experiments were conducted with 40 farmers on intercropping with Rajama, cow pea, Niger and Broom grass.



Fig 7. Degraded Land before and after interventions

Science Technology and Innovation (STI) Hubs:

This programme has been initiated for holistic development of SC and ST Communities in the Country through systemic interventions in different regions of the country with the following objectives: -

- (i) To address the weakest linkages in the predominant livelihood systems through Science & Technology (S&T) interventions.
- (ii) Creation of social enterprises based on the strengths in livelihood systems.
- (iii) To improve the Indigenous Knowledge Systems (IKS) through inputs of S&T

Seven (07) STI Hubs for SC population and Five (05) STI Hubs for ST population have been established in the states of Uttar Pradesh, West Bengal, Andhra Pradesh, Madhya Pradesh, Tamil Nadu, Telangana, Punjab, Odisha, Meghalaya and Jharkhand. Significant activities under STI Hubs are given below.

- ***The Science Technology and Innovation Hub for development of Scheduled Tribe in Medchal-Malkajgiri district of Telangana state*** is operating in Yellampet, Pudur, Ravalkole, Kistapur and Rajbollaram villages of Medchal Mandal of Medchal-Malkajgiri district of Telangana State covering a total of 854 households. The STI Hub is providing technical services that include continuous R&D activities, Product development, Re-engineering, testing facilities, Quality assurance and Market Research, Workshops and Capacity Building programmes for ST Communities related to the project as well as any other problems that arise and need to be solved through technological interventions. The hub is also facilitating grants and capital, networking and other technical resources to incubate some of the viable technologies. It is providing agricultural extension services (market linkages, weather advisory services, organic certification system etc)

and capacity building of drop-out youth. Some of the location specific technologies developed and deployed are Dual mode groundnut pod stripper, smart fencing system to protect agriculture, invasive plant cutter, smart crop and 2 water management and smart agro sprayer. These technologies have resulted in drudgery reduction, solving human-wildlife conflict and better management of resources. 213 ST persons has been trained so far under the project. Five Common Facility Centres were created under the program are being used by 650 direct beneficiaries and 3408 indirect beneficiaries. Increase in agricultural productivity in the range of 20-25% with increase in household income to the range of 15-20% is envisaged due to interventions proposed under the programme.



Fig 8. Smart Agro Sprayer & Dual Mode Groundnut Pod Stripper developed

- The STI Hub at Ladakh established by CSIR-Institute of Microbial Technology** is integrating Information Technology (IT) and Health Diagnostics and developing the skills of ST population in IT domains. The center is providing local people with digital health access, IoT based PoCD (Point of Care Devices) /e-diagnostics and innovation hub to develop PoC devices prototypes from their own ideas. Further, the STI Hub is working for developing smart diagnostic technologies for transmitting real-time observations to medical experts or also the patient can approach local healthcare facility. The teachers, lecturers, academicians and officials in various departments of Ladakh Government are benefitted through training of trainers' initiative of the program. They are being imparted trainings in Data Analytics, Office Automation, System Administration etc.
- The STI Hub for SC population established in Dundigal in Medchal-Malkajgiri district in Telangana** is directly benefitting 763 SC households belonging to Nuthankal, Bandamadharam, Goudavalle, Dundigal, Railapur, Srirangavaram and Jawaharnagar villages. The Hub is intervening in areas of agriculture and food security, rural enterprises & habitat and environment. Several, location specific need-based technologies were developed viz (i) multifunctional automated solar hybrid mini power tiller, (ii) semi-automated solar based robotic equipment called 'AGROBOT' for farmers, (iii) low cost compact cold pressing machine for extracting oil from Groundnut, Sunflower seeds and Rice Husk and (iv) low cost and energy efficient portable solar sugar cane machine.

The SC youth have been trained in fabrication and troubleshooting of these machines. Nearly 1000 people were trained in different technologies with a view to establish social enterprises and creation of equipment banks to cater to the need of the people.



Fig 9. Multifunctional automated hybrid mini power tiller (left) and AGROBOT (right)



Fig 10. Training of beneficiaries on AGROBOT & Multifunctional Power Tiller

- A STI Hub has been established in Srivilliputhur block of Virudhunagar district of Tamil Nadu** is benefitting more than 2000 SC population. The proposed interventions look at integration of farming and non-farming technologies for doubling the farmer's income and improving the socioeconomic conditions (improvement in quality of life and health status) of nearly SC beneficiaries. The interventions along with the S&T capacity building programmes related to Geopolymer Technology, Agricultural Technology (Use of Microbial wood ash as a fertilizer), Textile Technology (production of fibers & yarn from bamboo) and Composite Technology (blending of bamboo fibre with Bio-resins and fabrication of composite products like Helmets, Switchboards and Retrofitting

materials) are improving the capabilities, competence and capacities in such a way that the beneficiaries are producing innovative high quality value added products in cost effective manner.

The 12 STI Hubs will collectively benefit more than 15000 SC/ST Households directly and will develop human resources (approximately 60 personnel) for finding solutions to specific livelihood problems face by the SC/ST Communities. More than 150 Training and Capacity Building Workshops will be conducted to improve the STI capacities and capabilities of SC/ST communities for resilient and sustainable livelihoods.

Scheduled Caste/Scheduled Tribe Cells in State Science and Technology Councils:

The Department had initiated a programme for *systemic mapping of livelihood assets including village wise infrastructure gaps, identification & categorization of S&T needs of SC/ST community (technology gaps), identification of gaps in existing Government/ Non-Government schemes, spatial representation of livelihood assets at the state and below level etc* through establishment of SC/ST cells in State S&T Councils. The Councils will follow a bottom up approach for gathering information on livelihood system consisting of human, natural, social, physical and financial capitals, local and indigenous knowledge systems to help in development of specific strategies, plan and programmes for development of target beneficiaries and define policies for implementation. Seven SC/ST Cells have been established during 2020-21 in the states of Arunachal Pradesh, Kerala, Mizoram, Punjab, Sikkim, Tamil Nadu and Tripura. The cells would help in integration of SC/ST S&T empowerment in the planning process, development of SC/ST required S&T at state level, dissemination and last mile delivery of interventions.

3.8 National Good Laboratory Practice (GLP)

Good Laboratory Practice (GLP) 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 38 member-countries of the OECD and other countries, thus removing the technical barriers to trade.

As on date, there are **49 GLP certified test facilities** in the country.

Some of the major achievements of the Indian GLP programme during the financial year 2021-22 are given below:

- **Interactions with OECD Working Group on GLP:**
 - Representative of NGCMA, India attended the 35th meeting of OECD's Working Party on GLP held virtually during April 7-9, 2021 and the Optional Session held on April 6, 2021.
 - The On-Site Evaluation of Indian GLP Programme was due in 2020. However, due to COVID-19 pandemic, the same is now re-scheduled for July/ August, 2022. NGCMA is in process of preparing for the same.
- Grant of GLP re-certification and Extension in scope of GLP certification & periodic surveillance(s) of certified test facilities were done as per the laid down procedures of NGCMA.
- **Study Audits on request of Foreign Regulatory Authorities:** Study audits for specific studies conducted at GLP certified Test Facilities in India were conducted at the request of the following Regulatory Authorities:
- **United States Food and Drug Administration (USFDA):** Study audits conducted at:
 - Vanta Biosciences, Gummidipundi (Tamil Nadu)
 - Shriram Institute of Industrial Research, Delhi
- **European Chemicals Agency (ECHA):** Study audits conducted at:
 - Bionneeds India Private Limited, Bengaluru
 - Vanta Biosciences, Gummidipundi (Tamil Nadu)
- **Training Courses/ Capacity Building Programmes:** The following capacity building programmes were conducted by NGCMA:
 - One Day Sensitization Workshop on GLP
 - One Day Interactive Meet with Test Facility Managements of GLP Test Facilities
 - One Day Webinar on Good Laboratory Practice for NIPER Kolkata and NIPER Hajipur
 - Three Day Training Course for Study Directors of GLP Test Facilities
 - Two Day Training Course for Test Item Control Officers of GLP Test Facilities
 - Two Day Refresher Training Course for GLP Inspectors

- o Two Day Training Course for Archivists of GLP Test Facilities
- o Two 1-Day Sensitization Workshops on GLP for Students and Researchers

3.9 Technical Research Centres

This programme 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.

The TRC programme is translating scientific discoveries and technological inventions into products and services of societal and industrial relevance. TRCs have been instrumental in building R&D translation ecosystem by supporting advancements in technology readiness levels of background R&D capabilities and intellectual properties, streamlining multi-stakeholder involvement (including industry-academia partnerships), technology out-licensing, setting-up platforms for start-ups, and strengthening state-of-the-art R&D infrastructure.

The significant achievements made under these TRCs during the year of report are given below:

Technical Research Centre @ IACS-Kolkata

The Technical Research Centre (TRC) at IACS has successfully made inroads into translational innovations involving high end science for collaborations with industries in the interdisciplinary areas, foraying into new vistas of translational research.

Significant Achievements:

- Technology has been developed to modify sunscreen with novel antibacterial and photocatalytic properties with ZnO-9-aminoacridine hydrochloride hydrate drug nanoconjugates. This project has been funded by Unilever Industries Private Limited, Mumbai.
- TATA Steel Ltd., Jamshedpur has funded two projects entitled “HO· radical treatment for removal of the colorants in the effluent-water of coke plant of TATA Steel and diagnosis” and “Assessment of the level of HO· radical, the atmosphere's detergent, in the ground level air of Jamshedpur and suggestive remedies”.

- Technology for the selective sensing of female sex pheromone of certain agricultural pests like *Helicoverpa armigera* and *Bactrocera oleae* for the early detection of pest infestation has been developed and is in the near transfer stage. The companies like GK Machineries & Robotics Pvt. Ltd., Bengaluru and Monsanto, Bengaluru an agrochemical and agricultural biotechnology corporation, have signed Non-Disclosure Agreement (NDA) and trial IP license.
- Incoming and outgoing Material Transfer Agreement (MTA) has also been signed with Rajasthan Agricultural Research Institute (RARI), Jaipur, Rajasthan for the remediation of white grubs by pheromone nanogels.
- Oligo-Guanidines composed of heterocyclic rings with hydrophobic/ lipophilic group at the N-terminal based cellular transporter has been developed for effective delivery of nonpenetrable cargos *in vitro* and *in vivo*.

Technical Research Centre @JNCASR- Bengaluru

The TRC at JNCASR has been instrumental in building R&D translation ecosystem by supporting advancements in technology readiness levels of background R&D capabilities and intellectual properties, streamlining multi-stakeholder involvement (including industry-academia partnerships), technology out-licensing, setting-up platforms for start-ups, and strengthening and sharing state-of-the-art R&D infrastructure.

Significant achievements:

- JNCASR has been invited to be a part of Indian SARS-CoV-2 Genomic Consortia (INSACOG), an initiative of Department of Biotechnology & Ministry of Health & Family Welfare.
- On the occasion of National Technology Day on May 11, 2021, JNCASR Start-up Company Breathe Applied Sciences Pvt. Ltd, Bengaluru won National Award for Technology Start-Ups from Technology Development Board, Department of Science & Technology. The novel CO₂ reduction technology developed by the company has the capacity of converting 300 kg of CO₂ per day into methanol & other useful chemicals.
- A team of researchers from JNCASR in collaboration with the University of Alberta and Eiwave Digitech designed a robust mobile group oxygen concentrator named “**OxyJani**”, which can be used in rural settings and also be rapidly deployed in emergencies at any location.
- TRC facilitated Technology License Agreement between Jawaharlal Nehru Centre for Advanced Scientific Research, The Indian Council of Agricultural Research- National Bureau of Agricultural Insect Resources (ICAR-NBAIR) and ATGC Biotech Pvt. Ltd, Hyderabad for the development of “Controlled release dispenser for delivery of rice

stem borer, Scirpophagaintertulas, citrus leaf miner, Phyllocnistiscitrella, diamond back moth, Plutellaxylostella, Fall armyworm, Spodopterafrugiperda and tomato pinworm, Tutaabsoluta pheromone”.

Technical Research Centre @ SCTIMST-Thiruvananthapuram

The Technical Research Centre for Biomedical Devices continued to focus on the development of cardiovascular, neuro-prosthetic, hard tissue (dental, craniofacial and orthopaedic), *in vitro* diagnostic, biological and combinational devices. The TRC program continued to have good progress and Industrial partners were identified for following three projects and technology transfer agreements signed.

Significant achievements:

No	Product / Process	Name of Industry	Current Status (Transferred / Commercialised)
1.	Atrial Septal defect (ASD) Occluder	M/s. Biorad Medisys Pvt. Ltd., Pune	Transferred
2.	Intracranial flow diverter stent	M/s. Biorad Medisys Pvt. Ltd., Pune	Transferred
3.	Chitra Multiplex RT-PCR Kit for Covid -19	M/s. Meril Diagnostics Pvt Ltd., Vapi	Transferred
4.	Chitra Multiplex RT-PCR Kit for Covid -19	M/s. Huwel Life Sciences Pvt. Ltd., Hyderabad	Commercialised



(The technology transfer agreement for the atrial septal defect occluder and the intracranial flow diverter stent were signed between SCTIMST and M/s. Biorad Medisys Pvt Ltd, Pune. These devices were jointly developed by SCTIMST and CSIR NAL, Bangalore)



(Intracranial aneurysm is a condition in which weakness in the wall of a cerebral artery cause a localized dilation or ballooning of the blood vessel. Chitra Flow Diverter Stent is a device used for managing intracranial aneurysm by implanting in the parent blood vessel to divert blood flow away from the aneurysm.)



(ASD Closure device used for treatment of a birth defect of the heart in which there is a hole in the wall (septum) that divides the upper chambers (atria) of the heart. Both devices are made of NiTiNOL alloy and can be delivered to the site using a catheters.)

- The technology transfer process is in final stages for another two products, namely, endovascular stent graft and radiopaque polymeric microspheres for embolization therapy.

Technical Research Centre @ SNBNCBS-Kolkata

The aim of the above TRC was to establish a research centre and create an eco-system by harnessing science and technology platforms and leveraging on the existing core strength in materials science and spectroscopic techniques in the Centre. The Centre has so far transferred seven technologies to industries, generated several IPs (six patents granted) and trained manpower to cater the future need of the country. The major target areas of ongoing TRC are given below:

- Development of Low-cost Non-Invasive Medical Diagnostics for Capacity Building for maternal/child health care.
- Development of Low-cost Sensors to provide food security to households.
- Development of low-cost instrumentation for the industries and to enhance employment opportunity.
- High-end computation for the development of technologically Important Indigenous Materials of national need.

Significant achievements:

Technology Transfer	Industry Partner
Non-invasive detection of ulcer causing <i>Helicobacter pylori</i> infection in human stomach using exhaled breath analysis (Breathe Analyser)	M/s. HPA Instruments, Hyderabad



(Breathe-Analyzer)

Technical Research Centre @ ARCI- Hyderabad

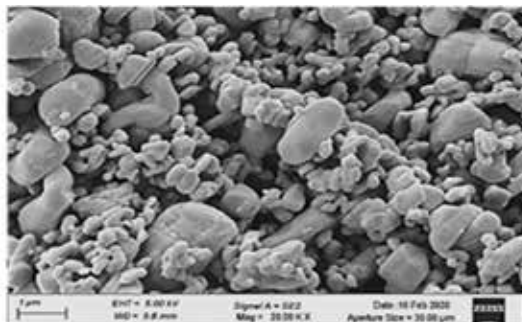
The overall objective of TRC is to build-up technology strengths in the field of Alternative Energy Materials & Systems to reach a maturity level that is necessary for prototype development and demonstration and facilitate subsequent technology assimilation by the automotive and energy related industries. The TRC comprises of sub-programs in the broad areas:

- Energy storage (batteries & supercapacitors);
- Energy conversion (fuel cells);
- Energy efficiency (Magnets for motors, waste heat recovery);
- Renewable energy generation & efficiency improvement (Solar CSP, PV).

Significant achievements:

- Indigenously developed Lithium iron phosphate (LiFePO_4 or LFP) cathode material for Lithium-ion battery was prepared at large scale level (15 kg/batch) by high energy attrition milling
- Development and optimization of process parameters for obtaining high coercive

anisotropic Sr-ferrite particles with suitable size distribution for bonded magnet applications.



High coercive anisotropic Sr-ferrite powders with bimodal distribution developed indigenously suitable for bonded magnet application

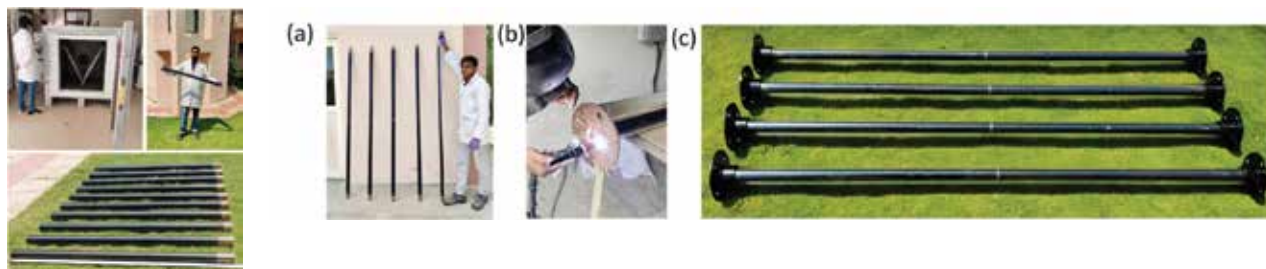
- Effective Thermal Management of Fuel Cell Stacks in closed loop cooling systems for prolonged operations.
- Successful deployment, demonstration and training for operation of 1kW Polymer Electrolyte Membrane Fuel Cell (PEMFC) stack for stationary AC application at Bhabha Atomic Research Centre (BARC), Mumbai.
-



(Integrated 1kW Polymer Electrolyte Membrane Fuel Cell System with power conditioner for plugin type AC application)

- Large-scale development of medium and high-temperature stable spinel nanocomposite based (CuNiMnOx/SiO_2) absorber tubes (10 x1m) with high targeted optical properties ($\alpha=0.95$ & $\epsilon=0.14$) and high thermal stability ($<500^\circ\text{C}$) withstand open atmospheric

condition for 2m Prototype receiver assembly. Field performance of receiver tubes with the commercial receivers' tubes is in progress.



(Large scale development of receiver tubes and assembling of 2m Prototype Receiver tubes for field validation)

- Developed large scale Broad-band AR coating sols (100 litres) and supplied for coating demonstration at industrial roll to roll process and observed $>2\%$ T enhancement from 380-1100nm at single side.
- Lab-scale (size: 15mm x 15mm) perovskite solar cells with power conversion efficiency of $\sim 19\%$ under standard test condition successfully demonstrated by spin coating process.
- Fabricated Supercapacitor device (1200 F, 2.7V, 1.2 Wh) with the capacity of about 1000 F using activated carbon derived from petcoke derived carbon, assembled a Supercap module (75 F, 43V, 19.2 Wh) and designed Capacitor Management System in collaboration with industry and successfully demonstrated E-bicycle powered by supercap packs made from indigenous supercap devices for the driving range of 2km.



(Design, development and assembly of supercapacitor module for demonstration of E-Bike)

- Technology Transfer agreements made with Industry partners:

S. No.	Name of Technology / Agreement	Industry Partner	Nature of Agreement
1	Establishing Lithium-ion battery Pilot Plant Facility (1 MWh), Process demonstration and Manpower training	Nsure Reliable Power Solutions Pvt. Ltd., Bengaluru	Technical know-how transfer agreement
2	Production of Carbon coated Lithium Iron Phosphate Powder Material	Allox Minerals Pvt Ltd., Hyderabad	Tenchnology know-how agreement
3	Fuel Cell Electrocatalysts	LAS Engineering, Pvt Ltd, Navi Mumbai	Technology transfer
4	Technology demonstration to industries and field validation of coating	Marichin Technologies LLP, Mumbai	T e c h n o l o g y agreement signed
5	Easy-to-clean coating sol composition and coating technique for Solar Photovoltaic (PV) applications	& Allox Resources LLP, Hyderabad	Transferred Know-how document



(Technology demonstration at rooftop PV plant, Mumbai and to commercial products on Easy to clean coating technology)

3.10 Exhibitions and Fairs

The Exhibition Cell is concerned with the work relating to organizing exhibitions and participation in science exhibitions at national and international level. In addition, it has also been assigned responsibility of coordinating the work of participation of Department of Science & Technology along with its organisations in science exhibitions. The aim of organising exhibitions is 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 2021-2022 were as under: -

- Organised India International Science Festival (IISF) – 2021 in association with Ministry of Earth Sciences, Departments of Bio-Technology and Scientific & Industrial Research along with Vijnana Bharati (VIBHA – an NGO) during 10-13 December 2021 at Panaji, Goa.

- Participated in *Make in Uttarakhand – 2021* (Ram Nagar), 24th National Science Exhibition (Kolkata) and *Rise in Uttar Pradesh 2021* (Ghaziabad)
- Participated in *Mega Goa EV International World Expo 2021* (Panaji), during 2-4 December 2021 and received “Best of India Biz Award” for special display and presentation.
- The Cell also coordinated with subordinate offices and autonomous institutions working under the Department for participation in a number of activities.
- As part of the Republic Day Celebrations 2022, Exhibition Cell is coordinating a Drone Show during Beating Retreat Ceremony on 29.1.2022



Fig. Dr. Harsh Vardhan, Hon'ble Minister Health & FW, Earth Sciences and Science & Technology, Shri Sanjay Dhotre, Union Minister of State for Communications, Education and Electronics & IT, Shri Ashutosh Sharma, Secretary (DST) & Shri Dushyant Mudgal, Director, Postal Services releasing Special Cover in connection with Golden Jubilee Commemoration of DST 182053/2020/Exhibition 12



Fig. Dr. Harsh Vardhan, Hon'ble Minister Health & FW, Earth Sciences and Science & Technology & Shri Prahlad Singh Patel, Hon'ble Minister of State (Independent Charge) for Culture are inaugurating 360° video immersive experience in a circular dome at Gandhi Darshan, New Delhi on 2nd November, 2020 182053/2020/Exhibition 13

3.11 National Spatial Data Infrastructure (NSDI)

National Spatial Data Infrastructure (NSDI)'s vision has been to ensure that "current, accurate and organized geospatial data sets are readily and continuously available and accessible on a national, state, district and village level basis to contribute to economic, environmental and social growth of the country". Five strategic goals set for NSDI include establishing required governance structure, ensuring capture, preservation, and maintenance of both fundamental and non-fundamental data sets; ensuring that the governmental geospatial data sets are readily discovered, appraised, and accessed; ensuring that the geospatial data sets, services, and systems owned by different government agencies are interoperable, and can be combined and reused for multiple times; and providing a coordinating framework for the delivery of the desired product space for its multiple stakeholders.

Towards the above goals, during 2021-22, focus of the NSDI has been on strengthening and using the National Data Registry (NDR) Geo-portal and the individual organisational Data Nodes; provisioning a proof-of-concept Geospatial Cloud based Infrastructure (NSDI Geo-platform) services for hosting geospatial data/ applications; maintaining the NSDI Clearing house Node as a single window gateway for access to digital geospatial data; maintaining the on-going and establishing new State Geoportals in various States; coordinating the development of National and State Level Geospatial Foundation Data and applications; framing and using geospatial data and process standards with the involvement of the Bureau of Standards (BIS); and the revision of the draft National Geospatial Policy.

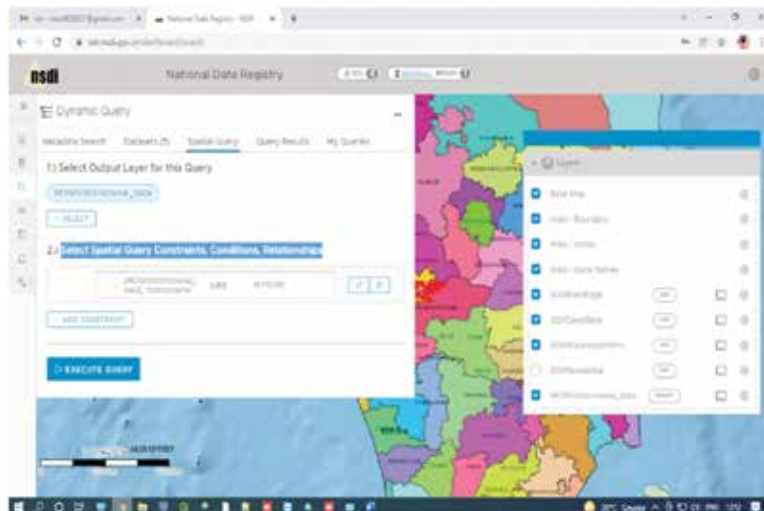
National Data Registry (NDR): Under the National Data Registry (NDR) Initiative, a set of on-line registers has been developed to facilitate search, discovery, and utilisation of on-line geospatial data sets and services for interoperable access from 5 Central



(Figure 1: National Data Registry's Harvest Functionality to automatically harvest metadata from Partnering Agency Data Nodes in a decentralised mode)

Partnering Agency and 1 State Agency Data Nodes. The registers provide an array of meta-level information for each feature data item covering its uniquely assigned identification code, concept or meaning of each theme or feature; geometric and attribute details (standards-based schemas); and possible values (domain values or code lists) for the attributes. NDR is expected to facilitate registering of data sets and provision of data services of various agencies thereby creating a framework for minimising duplication in data acquisition and

maximising utilisation of already acquired data sets in various organisations. During the year, the NDR Geo-portal has been further strengthened with registration of additional definitions of features/ themes, application schemas, and code list values etc. Fresh data services from Central/ State/ UT Agencies like Ministry of Statistics & Programme Implementation (MoSPI), National Atlas & Thematic Mapping Organisation (NATMO), Punjab Remote Sensing Service Centre (PRSC), State Department of Science & Technology, Govt. of West



(Figure 2: Demonstration of interoperable integration of statistical data with geospatial data in the Global Statistical Geospatial Framework – GSGF)

Bengal; Nagaland Science & Technology Council, and J&K Remote Sensing Application Centre (J&KRSAC) etc. have been registered in the NDR along with metadata. The MoSPI Data Node has been used to demonstrate the principles of Global Statistical Geospatial Framework (GSGF). Based on the feedback on the security of the NDR Data Nodes including specific inputs from the concerned agencies in MHA/ State Government, fresh sets of credentials have been shared with the Partnering and User Agencies for access. Experiences of implementing the NDR have been useful in the drafting and finalising the National Standards to be published by the Bureau of Indian Standards (BIS).

Geospatial Cloud Platform

The proof-of-concept Geospatial Cloud-based Data Centre (NSDI Geo-platform) established in Survey of India (Hyderabad Campus) for demonstrating management of data life cycles has been upgraded during the year. Aimed at meeting the additional computing resource needs of NSDI and its Partnering Agencies, the up-gradation has provided deeper insights into issues and challenges in scaling up an existing Geo-platform for meeting higher order computing performance needs of geospatial data processing services.

Both the 2D and 3D data sets of Varanasi City, covering an area of approximately 146 square

To facilitate integration of larger scale drone-based surveys with the National Topographic Frame of Survey of India in 1:50,000 scale and digitally monitor the progress of data gathering at the local level, a framework of high-resolution grids as per the provisions of the National Map Policy has been designed, developed and made accessible from the India Geo-portal.

Partnering Agency Data Nodes

NSDI and State SDI Partnering Agency Data Nodes provide interoperable access to map (display/ visualisation) services. Metadata and Data Services of the geospatial Data Nodes of the NSDI and State SDI Partnering Agency Data Nodes have been maintained in collaboration with the respective Ministries/ Departments and the State Governments for sustained access to their data sets. Efforts have been made to host the *Surveykshan* Geoportal from the NSDI Geo-platform for providing the topographic map services of Survey of India. Bhoomi Geoportal of NBSS&LUP has been reoriented towards providing soil feature data services.

Data Nodes/ Geoportals for States/ Union Territories (UTs) like Karnataka, Kerala; West Bengal; Uttarakhand; Jharkhand; Haryana; Odisha; NCT of Delhi; Jammu & Kashmir (including Ladakh UT); Madhya Pradesh; Himachal Pradesh; Nagaland; and Punjab have been maintained/ developed for providing standards-based interoperable access to the geospatial data sets of the respective State/ UT Governments. During the year, steps have been taken to launch Geoportals for Arunachal Pradesh, Andhra Pradesh; Goa; and Sikkim.

The Partnering Agency Data Nodes have been accessible from the single window gateway of the India Geoportal (<https://nsdiclearinghouse.gov.in>) that is evolving as a Data Clearinghouse to support orchestration of Data Services and development of on-line GIS applications.

Application Services

State-wide consistent and seamless high-resolution foundation spatial data sets have been identified as the starting point for developing geospatial applications. Based on the recommendations of the State SDI workshops, State Geo-portals are being upgraded and re-oriented to capture and share high resolution foundation data sets over the web for the Line Departments to add their thematic details, attaching attributes; geo-registering their maps; and linking & orienting their results of applications to the local landscapes. It has thus been recommended by the NSDI Executive Committee to prepare and share through the State Geo-portals foundation data sets in 1:2000 (panchayat level, 2D) and 1:500 (ward level, 2D/3D) scales. Towards coverage of one block and one city/ town each in Arunachal Pradesh and Odisha under the application development initiative, System Integrators have been identified by each of the Partnering Agencies in the States.

The study areas dominated by scheduled tribe population have been surveyed during the year using airborne optical and LIDAR sensors for sharing the resulting high-resolution data sets as standards-based data services for the preparation of panchayat and ward level geospatial applications.

Developing and Utilising ISO/ OGC/ BIS Geospatial Standards

National standards on 'Rules for Application Schema', 'Conceptual Schema Language'; and 'Geography Mark-up Language (GML)' co-branded and published from the ISO/ OGC in the previous years have been utilised in strengthening the NDR and State Geo-portals. ISO 19135 standard specifications for the procedures for registering geospatial objects have been used by the Geological Survey of India (GSI) in registering its data services in the NDR. NSDI has participated in the 20th meeting of the eElectronics & Information Technology Division (LITD) Council of the Bureau of Indian Standards (BIS) for the review of the Council's activities on the development of the National Standards in the domain of Electronics & Information Technology. Intensive deliberations have been made in the 7th meeting of the LITD-22 Sectional Committee for firming up the Data Content Standards for 'Surface Geology', 'Soils'; 'Forestry'; 'Land Resource Management'; and Standards relating to 'LIDAR'. NSDI has participated in the meetings of the LITD-28 Sectional Committee on 'Smart Cities'.

GISE Hub at IIT Bombay

A Geo-Information Science & Engineering (GISE) Hub has been launched at the Department of Computer Science & Engineering (CSE), Indian Institute of Technology (IIT), Bombay to support the implementation of the NSDI and the State SDIs with the involvement of all the stakeholders of the geospatial ecosystem.

Training and Capacity Building

A 2-Day Training Workshop on "Geodetic Network Adjustment for High Resolution 2D/ 3D Surveys for NSDI Application Development" has been organised by the National Centre of Geodesy (NCG), Indian Institute of Technology, Kanpur for the NSDI and the State SDI Nodal Officers on 26-27 August 2021 in Virtual Mode. Two course modules, one-week duration each, has been drawn up for regular training programmes on 'Geospatial Standards' and 'NDR and Geo-platform' by the National Institute for Geo-Informatics Science & Technology (NIGST), Survey of India, Hyderabad. A set of 5 demonstration-cum-training workshops have been organised for exposing the representatives of the NSDI and the State SDI Partnering Agencies on 'Standards', 'NDR' and the 'Geo-platform'.

Interaction with OGC

A physical meeting of the Open Geo-spatial Consortium - India (OGC-India) Forum has taken place on 08 December 2021 with the stakeholders of open geo-spatial standards from the Government, Academia; and the Private Enterprises on the sidelines of the Geo-Smart India 2021 held at Hyderabad. Status of development and adoption of OGC standard specifications for interoperable sharing of geospatial data over the web have been discussed for working out the future strategies on Interoperability with the help of the OGC-India Forum.

R&D priorities

Based on the recommendations of the NSDI Expert Committees, R&D projects have been evaluated and supported in areas like 'Geospatial Data Quality Evaluation and Certification', 'Block Chain and Distributed Ledger Technologies'; 'Geo-Cloud/ Edge Computing'; 'Geo-data/ Spatio-temporal Data Analytics'; 'Geospatial Machine / Deep Learning Techniques in various Application Domains' etc.

Draft National Geospatial Policy

For further consultation with the NSDI stakeholders, the draft National Geospatial Policy has been revised to incorporate mandatory registration of all the data sets in the NDR to help develop a centrally-coordinated geospatial catalogues to facilitate search, access, delivery and utilisation of standards-based geospatial data. For easy access to geospatial data/ products/ services and solutions by efficient processing on a scalable PoC-based Geo-platform, the revised Policy provides for establishing a suitable geospatial infrastructure with the help of a managing technical partner. Interactions have been made with the Potential Industry Partners for working out strategies for increased investment by Industry in the management of data sets on the National Foundation Spatial Data Themes and the Application Data Themes.

Future

In order to draw up a strategy for the implementation of NSDI, a study has been conducted by the International Institute of Information Technology Bengaluru (IIITB) for a Third-Party Review. Some of the major recommendations of the study include appointing NSDI as the spatial data regulator of the country, NSDI should persuade data creators both in government and in private to contribute to NDR while taking recourse to legal route to enforce this; NSDI should actively catalyse and support hubs which will work with a network of spokes in creating and disseminating tools, applications and methods built upon open source technologies. Hub should be located in academic institutions of national eminence and spokes could be in other academic institutions, government departments, NGOs, private enterprises and start-ups with each hub focussing on one vertical e.g. Agriculture, Health, School Education and for hosting data created by citizen groups, private companies and smaller government departments. Each of these hubs could be a section 8 company. NSDI should become an autonomous agency governed by an independent board with a complement of full-time staff.

Designed to be mounted on the NDR and a fully functional Geo-platform, NSDI 2.0 should be made operational by leveraging the outputs of NSDI 1.0 including the distributed network of geo-portals from the Partnering Central and State Government organisations; a well-knit team of scientists and experts built over the past years; and an innovative group of Private Enterprises/ Start-Ups/ System Integrators. With the framing of the National Geospatial Policy, the start-ups should be supported with the help of a group of identified coordinating hubs for developing and providing geospatial application and solution services towards addressing the social, economic, and environmental challenges facing the country.

CHAPTER 4

NATIONAL MISSION ON INTERDISCIPLINARY CYBER PHYSICAL SYSTEMS (NM-ICPS)

Department of Science & Technology (DST) is implementing multi-stakeholder National Mission on Interdisciplinary Cyber Physical System (NM-ICPS). The Mission was approved by the Union Cabinet in 2018 at a total outlay of Rs.3660 Crores for a period of five years.

4.1 Mission Technologies

The Mission to create a platform for academia, industry and government to collaborate for development of advanced technologies, translation, start-ups and commercialization. The advanced technologies that Mission focuses are Artificial Intelligence and Machine Learning; Technologies for Internet of Things & Internet of Everything; Data Banks & Data Services, Data Analysis; Robotics & Autonomous Systems; Cyber Security and Cyber Security for Physical Infrastructure; Computer Vision, Augmented and virtual reality; Device Technology and Materials; Speech, Video & Text Analytics; Sensors, Networking, Actuator & controls; Autonomous Navigation and Data Acquisition systems(UAV, RoVetc); Data Analytics & Predictive Technologies; Technologies for Under water exploration; Human Computer Interaction; Cobotics; Technologies for Agriculture & Water; Technologies for Mining; Intelligent Collaborative Systems; Advanced Communication System; Bio-CPS; Data Science, Big Data Analytics and Data Curation etc; System Simulation, Modelling & Visualization; Cognitive Computing & Social Censing; Quantum Technologies; Positioning and Precision Technologies, Technologies for financial sector (Fintech).

4.2 Mission Implementation Strategy

The NM-ICPS is a comprehensive Mission aimed at complete convergence with all stakeholders by establishing strong linkages between academia, industry, Government and International Organizations. The Mission is implemented through 25 number of Technology Innovation Hubs (TIHs) established in the top academic Institutes. Each TIH will have four major activities i.e., 1. Technology Development, 2. Human Resource & Skill Development (including development of CPS technology application tools for education at elementary and high school level), 3. Innovation, Entrepreneurship & Start-Up Ecosystem and 4. International Collaborations.

4.3 Mission Implementation Model

Hubs are at the core of the implementation of the NM-ICPS as all major activities will be carried out through these Hubs. Hubs to build linkages and collaborations with network of research institutes and labs across India and abroad. Hubs to work in close collaboration with Industry to create symbiotic relationship and world class products development. Hubs to emphasize on development of infrastructure tools for direct application of basic and applied research leading to Technology Development, including development of new areas of CPS applications/ platforms. Hubs to provide the ecosystem for application based technology development and deployment. Hubs also be responsible for delivering commercial technology, and taking ideas / concepts or prototypes and turning them into marketable products by way of proactive coordination, communication and interfacing for technology transfer to the industry. These would work closely with Startup ecosystem, Corporate, Governments and regulatory bodies as well. These would include webinars, events, workshops, grand challenges, hackathons and also online courses with live projects. Each Hub will specialize in a thematic domain and will connect with all institutes/ groups/ individuals who have expertise in that domain. It will coordinate across the country and will act as single point of contact for that particular domain. Hubs to collaborate with industry for fabrication/ services, work with nano-fabrication, material centers, other Centers and Technology Business Incubators (TBIs). International network – TIHs would connect to a global network of leading labs and institutes and researchers that can enable close research collaborations. Under the Mission, each Hub to follow a technology life cycle approach, addressing all stages viz. Knowledge-Development-Translation-Commercialization. As Hubs are part of the technology life-cycle continuum in the Mission, these hubs will not have sharp boundaries of functions; overlapping of their operations will be encouraged to address the complete technology lifecycle, if the delivery and commercialization of technology is promising. With this design, each such hub will, on one hand have forward and/or backward linkage with each other; on the other hand, they will work in tandem with experts/ institutions outside or with other initiatives of government and international institutions. In the highly networked mode as each Hub would be, they will be equipped sufficiently to function independently as stand-alone entity, however, they would leverage each other's strengths and the power of collaboration to produce synergistic outcomes. This would ensure that there is a dynamic functional model where technologies being focused are driven by market demands.

4.4 Technology Innovation Hubs

All Technology Innovation Hubs (TIHs) are established as Section 8 Companies registered in India according to the Companies Act, 2013 by the Host Institute. All Hubs to follow standard practices of Corporate Governance. The Hub Governing Body (HGB) serves as the apex administrative unit advising the Board of Directors (BOD) of the Company and set its overall direction in consultation with the Mission Governing Board (MGB). The Company led by a Chief Executive Officer (CEO) and all the activities and operations of the hub are supervised

by the Project Director who is an academic member of the host institute.

The Mission is in its 2nd year and already 25 Innovation Hubs are established. The following figure depicts the geographical distribution of Hub in the country:



Map courtesy: Survey of India, GOI

☐ **Brief on each Technology Innovation Hubs (TIHs):**

1. AI4ICPS I-Hub Foundation (TIH) at IIT Kharagpur, Technology Vertical: Artificial Intelligence and Machine Learning

AI4ICPS aims to create a multidimensional ecosystem to foster innovations of Artificial Intelligence (AI) and Machine Learning (ML) interventions to ICPS spanning across several sectors. This would address the grand problem of incorporating Fairness, Accountability, Transparency and Explainability (FATE) into AI and ML developed for translation to ICPS. Novelty of innovation shall include methods of black box testing, unboxing and clearboxing of complex models like deep neural networks, induction based causal reasoning leading to discovery of underlying physics of complex physical systems, space-compute-energy complexity analysis for algorithm optimization. The major application areas include industry sectors of (i) healthcare, and (ii) energy infrastructure. The interventions would also be extended to (iii) precision agriculture and nutritional security, (iv) manufacturing, (v) transportation, (vi)

environment and pollution, (vii) education, (viii) judiciary and legal, and (ix) communication.

2. TIH Foundation for IoT and IoE at IIT Bombay, Technology Vertical: Technologies for Internet of Things & Internet of Everything

TIH Foundation for IoT and IoE aims to develop an eco-system for channelizing commercialization and to develop novel technologies for stationary and self-driven IoT and IoE spanning the cyber and physical systems. It will develop technologies for devices ranging from ultra-low power to high power, various communication ranges and target various climatic conditions depending on the industry requirements and government needs of national importance. The TIH-IoT would act as a premier hub for disruptive yet practical ideas on IoT for system-level implementation, prototype development, tested and handed over to capable partners for commercialization and deployment in various industries. A typical portfolio of these industries would include agriculture, aquatic, automobiles, defense, healthcare, nuclear, process, smart cities, smart energy, space, structures and telecommunication applications.

3. IIIT-H Data I-Hub Foundation at IIIT Hyderabad, Technology Vertical: Data Banks & Data Services, Data Analysis

IIIT-H Data I-Hub Foundation has been established to coordinate, integrate and amplify the research in the larger areas of Data Banks, Data Services and Data Analytics. Its mandate to prepare a critical resource for the future use by researchers, startups, and industry. Collecting, collating and distributing useful data from multiple domains for use by the national and global community will be a significant effort at TIH-Data. The Data Foundation of the TIH-Data will coordinate the data collection, storage, distribution, processing, etc.

4. I-HUB for Robotics and Autonomous Systems Innovation Foundation at IISc Bangalore, Technology Vertical: Robotics & Autonomous Systems

The primary goal of this TIH will be to provide a platform to translate innovative technology research into POC (Proof of Concept), Productization and finally Commercial Application. The hub will also build an ecosystem of venture studios, Venture Funds and other capital providers so that these technologies can be spun off as companies after achieving TRL 5-6 stage. Some potential grand challenge problems in Avatar Robotics, Drone Skyways and some Strategic applications will be explored. Major applications areas for seen are Mobility, Drones, Urban Transportation, Agricultural, Healthcare, Education, Water Sufficiency, Energy Footprint, Supply Chain Optimization, Smart Cities, Manufacturing, Governance etc.

Major Achievement: An AI-driven platform developed to help early intervention through rapid screening of COVID 19 with the help of Chest X-ray interpretation over WhatsApp for doctors who have access to X-ray machines. The solution called XraySetu can work with low-resolution images sent via mobiles, is quick and easy to use, and can facilitate detection in rural areas.

5. IHUB NTIHAC Foundation at IIT Kanpur, Technology Vertical: Cyber Security and Cyber Security for Physical Infrastructure

The IHUB aims to address the issue of cyber security of cyber physical systems in its entirety. From analysing security vulnerabilities and developing tools to address them at various levels of system architecture, to translating these tools to deployment-ready software, to nucleating start-ups developing these tools at scale, to partnering with industries in this domain and co-development and transfer of these technologies, to training the next generation of cyber security researchers and professionals. The Hub plans to carry out research in cyber security and cyber defense of three domain verticals – namely critical infrastructure cyber physical Systems (CI-CPS), Automotive Control (A-CPS), and Unmanned Aerial Vehicles Control (U-CPS).

6. IHUB Drishti Foundation at IIT Jodhpur, Technology Vertical: Computer Vision, Augmented and virtual reality

IHub Drishti, will: (i) focus on advancing the research outcomes in core problems related to CV and, ARVR, (ii) augment imaging with additional (multimodal) sources of input such as haptics, language, and IoT to advance state-of-the-art in the domain areas, (iii) create technology solutions for socially relevant and industry-facing problems, (iv) support and nurture start-up ecosystems, (v) stimulate skilling and reskilling educational programs, and (v) to advise governments for appropriate policy-related matters in the domain of CV and ARVR.

7. Divyasampark IHUB Roorkee for Devices Materials and Technology Foundation at IIT Roorkee, Technology Vertical: Device Technology and Materials

This TIH aims to enable innovative ecosystem in cyber- physical systems (CPS) and becoming the source for the next generation of digital technologies, products and services by promoting translational research, enhancing core competencies, capacity building, and training to provide solutions for national strategic sectors and becoming a key contributor to Digital India. The hub will foster research innovation towards product/technology development and commercialization in CPS with relevant and next-generation Devices and Materials in the areas of (a) Healthcare 4.0 (b) Industry 4.0 (c) Smart Cities. Further the hub envisions that the smart devices and materials are the key enablers for CPS which includes sensors, actuators, computing, communication and control devices built on the smart engineering of the existing and novel materials intelligently coupled with frontier trends like artificial intelligence, machine learning, augmented/virtual reality etc.

8. IIT Patna Vishlesan I-hub Foundation at IIT Patna, Technology Vertical: Speech, Video & Text Analytics

Vishlesan I-Hub aims to create a strong and seamless ecosystem for leveraging the potential

and exponential growth of Interdisciplinary Cyber Physical Systems (ICPS). The HUB will mark an impact, both at the national and international level, by carrying out fundamental and translation research in the broad areas of speech, video and text analytics. Some of the distinguishing aspects of our TIH activities include: foundational research on speech video and text analytics, especially efficient multimodal (text, video and/or speech) Presentation, multilingual and multi-dimensional embedding. Multitasking models, Meta learning and few-shot learning, transfer learning, knowledge infused machine learning models, techniques to solve a variety of problems in low resource scenario.

9. IIT Madras Pravartak Technologies Foundation at IIT Madras, Technology Vertical: Sensors, Networking, Actuator & controls

The TIH is assigned the technology vertical of Sensors, Networking, Actuators and Control Systems (SNACS). This involves multidisciplinary interventions starting from sensor manufacturing, sensor testing and characterization, sensor interfacing with control systems, establishing command and control through actuators, networking the sensor to aggregators and secure data transmission to the cloud and decision support systems at the cloud level. SNACS can be viewed as the basic building block of IOT/IOE, which as defined by the International Telecommunication Union is a global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies (ICT).

Major Achievement: I-STAC.DB - Indian Space Technologies and Applications Consortium Design Bureau, is a consortium launched by IITM Pravartak Technologies Foundation and five other entrepreneurial start-up companies in deep tech and engineering domain. The consortium will focus on building an end-to-end Atmanirbhar ecosystem for space technologies from on-demand access to space including rapid launch capability, satellites, sensors, future generation communication such as 6G, satellite data and its applications.

10. NMICPS Technology Innovation Hub on Autonomous Navigation Foundation (TiHAN) at IIT Hyderabad, Technology Vertical: Autonomous Navigation and Data Acquisition systems(UAV, RoVetc)

This TIH focuses on the development of novel and cutting-edge next generation autonomous navigation and data acquisition technologies with applications primarily in the following verticals: Intelligent and Autonomous Transportation Systems, and Agriculture. A first of its kind state-of-the-art Testbed for Autonomous Navigation (Aerial/Terrestrial) is being developed at TiHAN IIT Hyderabad. The Facilities includes Proving Grounds, Test tracks, Mechanical integration facilities like Hangers, Ground control stations, Anti drone detection systems, State of the art Simulation tools (SIL, MIL, HIL, VIL), Test tracks/circuits, Road Infra – Smart Poles, Intersections, Environment Emulators like Rainfall Simulators, V2X Communications, Drone Runways & Landing area, Control Test centers.

11. I-DAPT-HUB Foundation at IIT BHU, Technology Vertical: Data Analytics & Predictive Technologies

TIH, I-DAPT is an emerging approach which is implemented by using fusion of various technologies from various disciplines. Some of them are matured and some under development. Technology choices are wide and based on application domain; a set of technologies will be converged to deliver a DAPT. The implications of DAPT for these five domains of the economy namely (a) Telecommunications (b) Power(c) Defence Research and Development(d) Road Transport and Highways(e) Health and Family Welfare.

12. IIT Guwahati Technology Innovation and Development Foundation at IIT Guwahati, Technology Vertical: Technologies for Under water exploration

The TIH is setup to conduct interdisciplinary research and development in the broad area of underwater exploration. Therefore, a grand problem has been formulated, whose aim is to design and develop Mechanical Structures, Prime Movers, Sensors, Controllers, Software, and Communication systems, of national and international importance for underwater applications. The Hub shall focus on Research and Development (R&D) in two primary areas, namely (i) Underwater Systems Development and (ii) Underwater Vision, Monitoring, Surveillance, Intelligence and Tracking.

13. IIT Mandi IHub and HCI Foundation at IIT Mandi, Technology Vertical: Human Computer Interaction

The IIT Mandi IHub would be developing and testing technology/computer systems that make them usable by human beings. A sub-goal of the TIH would be studying how people use technology/computer systems in different domains (environment, healthcare, information technology, and Defence & security) and making this interaction simpler and efficient. The iHub also intends to address HCI issues and design effective interfaces to solve the Grand problems in the following application domains: a) Multi-sensory AR/VR - perception b) Brain-Computer Interfaces (BCI) and their applications.

14. I-Hub Foundation for Cobotics (IHFC) at IIT Delhi, Technology Vertical: Cobotics

IHFC is focused towards a particular theme of the National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS), i.e., Cobotics or Collaborative Robotics for Human-Robot Collaboration (HRC). The hub aims at making humans and robotic systems must work together towards common goals. Further competency in Cobotics or Collaborative Robotic Cyber-Physical Systems is crucial especially for our country such so that robotic systems enhance the capabilities of our workforce rather than trigger replacement.

15. IIT Ropar Technology and Innovation Foundation at IIT Ropar, Technology Vertical: Technologies for Agriculture & Water

Primary focus of this TIH is to develop CPS (Cyber-Physical Systems) and IoT based collaborative robots to address issues related to agriculture & water in line with the developed countries. The technology advancements achieved at TIH - AWaDH, which include hardware and software, will be deployed in the following major application areas, 1. Environment, Forest and Climate Change, 2. Fisheries, 3. Food Processing Industries, 4. Rural Development, 5. Land Resources, 6. Skill Development and Entrepreneurship, 7. Textiles, 8. Electronics and Information Technology, 9. Fertilizers, 10. Food and Public Distribution, 11. Atomic Energy, 12. NITI Aayog, and, 13. Earth Sciences.

16. Technology Innovation in Exploration & Mining Foundation at IIT (ISM) Dhanbad, Technology Vertical: Technologies for Mining

This TIH is dedicated in the Mining vertical for the development and implementation of CPS base technologies in the Exploration and Exploitation of natural resources with most of the world's surface mineral deposits already found, we need to be looking deeper to find the next generation of deposits. This hub is looking to develop CPS and IoT technologies towards making the Future of Mining more intelligent, faster, safer, and more data-driven than ever.

17. IIT Palakkad Technology Ihub Foundation, Technology Vertical: Intelligent Collaborative Systems

The technology vertical assigned to this TIH is Intelligent Collaborative Systems (ICS) which is an amalgamation of robotics, control, machine learning, networks, embedded systems, computer vision and fundamental theoretical models. This Hub will address problems in Agriculture, Healthcare, Transportation, Surveillance, Exploration and Communication systems with special focus on problems related to energy and safety.

18. IIITB Comet Foundation at IIIT Bangalore, Technology Vertical: Advanced Communication System

This TIH will be located at the heart of India's Silicon Valley (Bangalore). The hub will be surrounded by a vibrant R&D ecosystem including MSMEs/start-ups and will leverage the academic and industrial talent pool available locally and elsewhere in India. The hub has been assigned to mainly focus on Advanced Communication Systems, with respect to the present and future needs of our nation as well as international dynamics. The hub will focus on enabling the design and development of fundamental technology building blocks of 5G-advanced (5G+) & 6G systems and networks. The prime focus will be on indigenous research leading to intellectual property (IP) generation that includes product IP for commercial usage and development of patents (IPR) that will not only enable product-oriented innovation but also target adoption into the upcoming 5G-advanced and 6G standards. It will also focus on other advanced communication systems R&D which have commercial potential.

19. BITS BioCYTiH Foundation at BITS Pilani, Technology Vertical: Bio-CPS

This TIH is working in the field of Bio-Cyber Physical Systems (Bio-CPS), combining biological knowledge with the advances in computing and physical systems. Healthcare, agriculture, consumer products, environment, information and communication technologies (biocomputing) etc. are some of the areas in which Bio-CPS can make an impact.

20. IDEAS- Institute of Data Engineering, Analytics and Science Foundation at ISI Kolkata, Technology Vertical: Data Science, Big Data Analytics and Data curation etc.

In this era of modern and fast life, every genre of human life generates its own representation and gives birth to Big Data(BD) through CPS, video, IoT, Sensor data. This TIH will analyse these BDs with the help of Data Science. TIH will concentrate mainly in the following four challenges 1. Prediction of machine fault 2. Dynamic alerts for an anomalous sub-process 3. Video analysis for human security both in public and industrial areas 4. Climate monitoring and healthcare.

21. IITI Drishti CPS Foundation at IIT Indore, Technology Vertical: System Simulation, Modelling & Visualization

The name of this TIH, DRISHTI CPS that stands for **Driving Innovation through Simulation Hub for Technologies in Interdisciplinary Cyber Physical Systems**, the hub is invested in developing into a single stop facility for CPS design and modelling and its applications thereof. The TIH has identified two major thrust areas: i) Cyber Physical System Design and ii) Application specific development in CPS: Industrial and Social systems

22. IHUB Anubhuti-IIITD Foundation at IIIT Delhi, Technology Vertical: Cognitive Computing & Social Censing

This TIH focuses on Cognitive computing and social sensing (CC&SS), where intelligent machines simulate human brain capabilities to help solve society's most vexing problems. Cognitive computing overlaps with AI and involves many of the same underlying technologies to power cognitive applications, including Expert Systems, Neural Networks, Robotics, Augmented Reality (AR) and Virtual Reality. This hub will work on two grand problems along with the relevant theoretical and applied challenging applications in the broad area of Cognitive Computing and Social Sensing 1) AI driven Data Curation 2) Intellective Information Systems.

23. I-Hub Quantum Technology Foundation at IISER Pune, Technology Vertical: Quantum Technologies

This TIH will conduct focused research in experimental, commercialization as well as theoretical aspects in three themes of Quantum Technology: i) Quantum Information and Metrology ii) Quantum Communication and iii) Quantum Materials and Devices. In particular,

in the initial stages, the Hub is planning to deliver a 20-qubit fault tolerant quantum computer that can be deployed for small scale problems and more importantly it will serve as a stepping stone to begin work on creating bigger quantum computers in India. In addition to this hub aims to achieve quantum communications over optical fiber over 5 kms, quantum technology based sensitive and portable magnetometers for civil and defense applications, Gravimeter used in prospecting underground natural resources and mapping seismic zones and inertial sensors applications in defense and deep space navigation and in day-to-day consumer system.

24. IIT Tirupati Navavishkar I-Hub Foundation at IIT Tirupati, Technology Vertical: Positioning and Precision Technologies

The TIH technologies include remote sensing (non-invasive), Geographical Information Systems (GIS) and Global Positioning Systems (GPS). The Hub will primarily focus on Public Private Partnership (PPP) model to generate revenue through: (i) Research and development sponsorship from industries, government and start-ups in form of innovative products and services in PPT; (ii) linkage with industries, accelerators and Venture Capital to create funding ecosystem; (iii) training and consulting; (iv) standards development and policy creation for rapid adaptation of PPT across various stakeholders; and (iv) databank creation across strategic areas of PPT.

25. IIT Bhilai Innovation and Technology Foundation at IIT Bhilai, Technology Vertical: Technologies for financial sector (Fintech)

This Technology Innovation Hub (TIH) strives to provide the finest and the state-of-the-art research and engineering solutions for diverse FinTech products mainly in the following four verticals, e-Payment systems, Blockchain Technologies, Artificial Intelligence and IoT. In E-payments, projects aiming at development of products facilitating minimal physical human intervention, enhanced security, low cost, unification of different modes of transactions on a single device/platform, functional under low bandwidth or even intermittent Internet connectivity (i.e., for rural and remote areas). On the Blockchain angle, projects will focus towards applied research wherein techniques like Consensus algorithms, Powerful smart contracts, Permissioned and permission-less hybrid platforms, Integration of hardware modules in Blockchain architectures etc. Main application areas would be Micro-payments, energy trading, secure digital identity management etc. On the third vertical, that is Artificial Intelligence, the focus is on development of efficient models for FinTech applications; for example, evaluation models for predicting client risk in terms of mortgage, loan, health policy and investment; algorithmic trading models to provide stock market related suggestions like when to sell, hold, or buy stocks etc. The fourth vertical is based on IoT paradigm, where the focus would be on development of IoT enabled FinTech products like Smart ATMs, reliable authentication devices, wearable gadgets to collect client related information etc., enhancing the security environment for IoT devices, and testing of IoT based systems.

4.4 Current Status and achievement

(a)	Mission Parameters	Mission Targets	Achieved Targets
1.	Technology Development	6824	496
1.1	No of Technologies developed	763	46
1.2	Technology Products Developed	607	41
1.3	Publications, IPR and other Intellectual activities	2698	191
1.4	Increase in CPS Research Base	2756	218
2.	Entrepreneurship Development	256182	1073
2.1	Technology Business Incubator (TBI)	25	13
2.2	Start-ups & Spin-off companies	1170	54
2.3	GCC - Grand Challenges & Competitions	62	6
2.4	Promotion and Acceleration of Young and Aspiring technology entrepreneurs (PRAYAS)	54	24
2.5	CPS-Entrepreneur In Residence (EIR)	726	33
2.6	Dedicated Innovation Accelerator (DIAL)	28	7
2.7	CPS-Seed Support System (CPS- SSS)	37	7
2.8	Job Creation	254075	928
2.9	Social Entrepreneurship Program	5	1
3.	Human Resource Development	30694	2024
3.1	Graduate Fellowships awarded	7386	593
3.2	Post Graduate Fellowships awarded	1795	165
3.3	Doctoral Fellowships awarded	986	147
3.4	Faculty Fellowships awarded	182	12
3.5	Chair Professors	140	1
3.6	Skill Development programmes conducted	19618	1083
3.7	Postdoctoral Fellowships awarded	587	23
4.	International Collaborations started	101	32

4.5 Mission under consideration

National Mission on Quantum Technologies and Applications (NM-QTA)

Quantum Technology is based on the principles of quantum theory, which explains the nature of energy and matter on the atomic and subatomic level. It concerns the control and manipulation of quantum systems, with the goal of achieving information processing beyond the limits of the classical world. Quantum principles will be used for engineering

solutions to extremely complex problems in computing, communications, sensing, chemistry, cryptography, imaging and mechanics.

Government has announced a National Mission on Quantum Technology & Applications (NM-QTA) on 1st February 2020 in the budget speech of Finance Minister. To realise the budget announcement, Department of Science & Technology (DST) has prepared a Detailed Project Report (DPR) on NM-QTA. NM-QTA is a pan-India Mission implemented through academic, R&D institutes and in association with Industry.

Mission Objectives: Broad objectives is to develop Quantum Computers, highly secured Quantum Communication, Quantum Key Distribution (QKD), Quantum clocks quantum sensors, imaging devices, advanced quantum materials, Human Resource Development, international collaborative research and startups. The mission draws upon the existing deep strengths within academic institutes across India to support interdisciplinary research projects in key verticals involving quantum technology, while simultaneously developing key foundational strengths in important core areas.

Expected Deliverables: On successful implementation of the Mission, it is expected that a quantum computer with around 50 qubits, Quantum devices, Quantum communication – in particular QKD, free space and fibers are also expected as an outcome of the Mission. Other Quantum technology based field deployable products are also a planned deliverable for the Mission.

Current Status: Mission DPR was prepared and EFC under processing.

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:

5.1 Maharashtra Association for the Cultivation of Science (MACS)-Agharkar Research Institute (ARI), Pune.

The institute's research is focused on Biodiversity & Palaeobiology; Bioenergy; Bioprospecting; Developmental Biology; Genetics & Plant Breeding; Nano bioscience.

Major Accomplishments:

- ARI with collaborators developed a sustainable and non-polluting microbial process to produce hydrogen and methane from agricultural crop residues.
- Diversity and prevalence of methanotrophs associated with paddy fields in Western India was investigated using a specialized culturing method. A total of 31 methanotrophs belonging to nine genera were obtained and exploited to transform waste methane to valuable products like carotenoids, single cell proteins, etc.
- 162.5 and 225 quintals breeder seeds of high yielding, disease resistant, early maturing wheat and soybean varieties were supplied to the Seed multiplying agencies seed industries, farmers and producers' organizations. Cuttings and saplings of grape variety ARI 516 have been supplied to farmers.

Important Highlights of Major Programmes:

- A memorandum of agreement was signed between ARI, Pune and SKR Agrotech, Wardha, Maharashtra, for licensing of production and commercialization of three technologies, viz. i) Nano formulation preparation of essential oils, like citronella, garlic oil for foliar application as a deterrent against mealy bugs, ii) Copper nano formulation as an antimicrobial agent, iii) Zn-chitosan nanoparticles formulation (Zn-CNP) to be used as a foliar spray for delivery of essential micronutrient in crops.

- Grape variety ARI 516 was released and notified by the Central Varietal Release Committee for horticultural crops for cultivation in Maharashtra, Punjab, Telangana and Tamil Nadu. Three soybean varieties MACS 1407, MACS 1460 and MACS 1520 were released and notified for cultivation in different agro-climatic zones of India.
- A Kunitz trypsin inhibitor free soybean variety MACSNRC 1667 was developed and released for cultivation in Southern zone of India especially for soya food industry.
- ARI is also working on to determine the mechanism of autophagy-related gene-1 (Atg1) mediated regulation of mitochondrial dynamics during *Drosophila* oogenesis. Besides, work is continuing to explore the cell-cell interactions in the models zebrafish and hydra.
- *Srinivasaniasundarbanensis* gen. et. sp. nov., a new genus and species of an agglutinated benthic foraminifera from the Indian Sundarbans, Bay of Bengal, and a new benthic foraminifer *Ammonia arabica* sp. nov., endemic to coastal Maharashtra were discovered.

Important Output Indicators:

S.No.	Parameters	Output
1.	Papers in refereed journals	76
2.	Books	8
3.	Chapters in Books	9
4.	Papers in Conferences	2
5.	Number of Ph.Ds. produced	10
6.	Indian Patents filed	1
	Indian Patents granted	1
7.	Research Manpower trained (other than Ph.Ds)	2
8.	M.Tech/M.Sc./M.Phil projects guided	55

5.2 Aryabhata Research Institute of Observational Sciences (ARIES), Nainital

The Institute focuses 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. Research at ARIES is being carried out on a variety of astrophysical sources in Galactic and Extragalactic astronomy covering both observational and theoretical aspects. The research in solar physics concentrates on the observations and modelling of transient phenomena, space weather phenomena and magneto-hydrodynamic waves in the solar atmosphere. In Atmospheric Sciences, research is focused on the lower atmospheric processes that are governing the air pollution and climate changes. Modelling and satellite data analyses are also carried out to understand the chemical, physical and dynamical processes in the atmosphere.

Major Accomplishments:

- One of the strongest flares was reported by ARIES is from a feeding supermassive black hole or blazar called 'BL Lacertae' some 10 million light years away.
- Farthest Gamma-ray Emitting Narrow-Line Seyfert 1 Galaxy (NLS1) 'TXS 1206+549' was discovered at a distance of 31 billion light-years.
- ARIES scientists were part of a team that discovered a rare dozen quadruply imaged quasars, which are warped by a naturally occurring cosmic 'lens' and split into four similar images.
- Indian astronomers were part of team spotting first ever short duration gamma-ray burst 'GRB 200826A' from a stellar collapse.
- A rare supernova explosion was traced to one of the hottest kind of stars called Wolf-Rayet stars or WR stars.
- Possible origin of winds from black hole accretion discs was probed using numerical simulation techniques developed indigenously.
- The first theoretical model for the existence of the Near-Surface Shear Layer (NSSL) of the Sun was given.
- Nighttime cloud cover study revealed Trans-Himalayan region is becoming one of the promising astronomical sites globally.
- Chemical composition and source apportionment of total suspended particulate in the central Himalayan region was investigated.

Important Highlights of Major Programmes:

- 3.6m Devasthal Optical Telescope (DOT), India's largest, was fully operational during the year. A rare superluminous supernova (SLSNe) 'SN 2020ank' shining with borrowed energy source was spotted with the 3.6m DOT Facility. Devasthal Faint Object Spectrograph & Camera (ADFOSC), a low-cost optical spectrograph indigenously designed and developed by ARIES, is fully operational now, and open for astronomy across the globe. 206.5 MHz ST Radar (ASTRAD) is fully operational and highlighting the indigenously designed.
- Aditya-L1 Support Cell (AL1SC), a joint effort of ISRO and ARIES, is set up at ARIES. This center will jointly work to maximize utilization of science data from upcoming Aditya-L1 space mission.
- A novel technique to detect accelerated coronal mass ejections (CMEs) in the solar atmosphere was developed which will be quite useful for the future space missions.

- Accurate estimation of black carbon (BC), the second most important global warming pollutant after CO₂, will be possible in the Himalayan region due to estimation of mass absorption cross-section (MAC) specific to the Himalayan region.

Important Output Indicators:

S.No.	Parameters	Output
1.	Papers in refereed journals	119
2.	Papers in Conferences	2
3.	Number of Ph.Ds. (submitted)	5
4.	Research Manpower trained (other than Ph.Ds)	15
5.	Technical Manpower trained	22
6.	M.Tech/M.Sc./M.Phil projects guided	23
7.	Scientific outreach programmes organised	12

5.3 BirbalSahni Institute of Palaeosciences (BSIP), Lucknow

The institute carries out research on fundamental as well as applied aspects of Palaeosciences that includes Evolutionary history of biota, Paleoclimate, studies of past Civilization, Human history and contemporary climate change issues, following an integrated and multi-disciplinary approach. Key research activities are: Understanding origin and evolution of life through time and space; Understanding climate change in recent and deep geological times; Understanding past civilization and human history; Application of Palaeosciences in exploration of fossil fuel.

Major Accomplishments:

Some of the research output of BSIP are as follows:

- Conducted studies on Late Quaternary tectono-geomorphic forcing vis-a-vis topographic evolution of Indus catchment, Ladakh, India.
- Central Himalayan tree-ring isotopes reveal increasing regional heterogeneity and enhancement in ice mass loss since the 1960s.
- Studies on Late Cretaceous–Paleogene Indian monsoon climate vis-à-vis movement of the Indian plate, and the birth of the South Asian Monsoon was conducted.
- Sea surface temperatures in the Indian Sub-Antarctic Southern Ocean for the last four Interglacial periods.
- Precambrian crustal evolution in Northern Indian Block: Evidence from detrital zircon U-Pb ages and Hf-isotopes.
- Changing Indian monsoon rainfall patterns under the recent warming period 2001–2018.

- Long term natural and anthropogenic forcing on aquatic system - evidence based on biogeochemical and pollen proxies from lake sediments in Kashmir Himalaya, India.
- Apatite (U-Th)/He thermochronometric constraints on the northern extent of the Deccan large igneous province.
- Neogene calcareous nannofossil biostratigraphy of the northern Indian Ocean: Implications for palaeoceanography and palaeoecology.
- Petrographical-geochemical characteristics and floral-faunal compositions of the Valia lignite deposits from Cambay Basin (Gujarat), Western India.

Important Highlights of Major Programmes:

- In view of the worldwide COVID-19 Pandemic, the Institute extended its BSL-2A testing laboratory into the RT-PCR based testing facility.
- BSIP established wood isotope laboratory along with installation of ICP-OES instrument and fusion bead machine.

Important Output Indicators:

S.No.	Parameters	Output
1.	Papers in refereed journals	145
2.	Chapters in Books	4
3.	Papers in Conferences	34
4.	Number of Ph.Ds. produced	4
5.	Research Manpower trained (other than Ph.Ds)	8
6.	Technical Manpower trained	4
7.	M.Tech/M.Sc./M.Phil projects guided	8

5.4 Bose Institute (BI), Kolkata

The Bose Institute pursues research for augmentation of fundamental knowledge-base and developing solutions in the areas to understand infectious diseases through classical biology, structural biology as well as bioinformatics assisted approaches; understand and target chronic disease like cancer and neurodegenerative diseases using chemical, structural as well as cell biology approaches; understanding response of plants under biotic and abiotic stress; systems and synthetic biology; high energy and nuclear physics; sub-atomic particles; quantum information and communication; environmental microbiology and climate change; bioorganic chemistry for drug development & identification of drug target and validation of bioactive molecules for therapeutic intervention and dynamics of atmospheric pollutants especially in the Himalayan Region.

Major Accomplishments:

- Significant progress has been achieved towards uncovering key mechanisms of brain disorders towards possible identification of future therapeutic targets.
- Identification of potential drug targets against infectious diseases, such as tuberculosis.
- Development of inter-specific hybrid sesame, as well as transgenic rice with enhanced inorganic phosphorus and minerals.
- Exploration of the candidate gene(s) for molecular marker-assisted breeding through genomics/transgenics techniques.
- Computer based approach for identification of FDA approved drugs for possible re-purposing against COVID-19.
- Impact of air pollution on the low lying clouds over Eastern Himalaya.
- Characterization of quantum teleportation using two-qubit states.
- Identification of high lying resonances in $7\text{Be}(d,p)8\text{Be}^*$ reaction in the context of the widely known Cosmological Lithium Problem.

Important Highlights of Major Programmes:

- Identification of the structures and roles of critically important proteins in the pathogenesis of *Staphylococcus* and *Giardia lamblia*, understanding and identifying ubiquitin biochemistry, and evaluation antibiotic resistome in the Sundarban mangrove estuary.
- Understanding the allosteric inhibitors of important Kinase families, deciphering the role of parental non-coding RNAs in fertilization and early embryonic development and understanding the mechanism of antimicrobial resistance gene mutation patterns in MTB and in human lung microbiome using bioinformatics approach.
- Structural biology approaches in designing Inhibitors for Alzheimer Plaque Reduction, understand role of G-Quadruplex in regulating Cancer Stemness, identify effective scaffolds forage-related processes through understanding the enzyme-pathway structure-function relationships, understanding the Structure-Function Relationship of IKK1 in Regulating NF- κ B Activation and Beyond.
- Study Mycobacteriophage – mycobacteria interactions to unveil novel targets for developing anti- TB drugs, Understanding the biogeochemical significance of aerobic microbial life amidst anoxia, characterization of assimilation pathway of aromatic nitriles in *Burkholderia* sp. strain BC1.

- Investigate the Role of AtHMGB15 in pollen development, transcriptome analysis of inter-specific hybrid sesame for SNP-based marker discovery associated with oil quality and yield, biogenesis control mechanisms and function of stress responsive miRNAs in tomato, investigating the effector function of two extracellular ribonucleases of *Ustilagomaydis*.

Important Output Indicators:

S.No.	Parameters	Output
1.	Papers in refereed journals	244
2.	Chapters in Books	2
3.	Papers in Conferences	8
4.	Number of Ph.Ds. produced and/or thesis submitted	26
5.	Research Manpower trained (other than Ph.Ds)	163
6.	M.Tech/M.Sc./M.Phil projects guided	16

5.5 Centre for Nano and Soft Matter Sciences (CeNS), Bengaluru

The Centre focuses its R&D activities in the area of Nano science and nanotechnology; antimicrobial face masks; triboelectric face masks; liquid crystals; soft-nano composites; Coordination polymers; optical metamaterials; 1D and 3D soft photonic systems; liquid crystal Gels; triboelectric nano generators; metal-oxidenano structures; gassensors; transparent conduct ingelectrodes, smart particle filters; spent electrocatalysis, lead free nanocrystals for photovoltaics; printed electronics; electrochemical biosensors and energy storedevices.

Major Accomplishments:

- Influence of alkyl and alkoxy groups on photoresponsive behaviour of bent-core azo mesogens have been studied and an optical storage device is fabricated.
- A p-typeorganic field-effecttransistor that operates in accumulation mode and makes use of a synergistic heterostructure and detects H₂S gasselectively is fabricated.
- Switchable smart windows using a biopolymer network of cellulose nanocrystals imposedon a nematic liquid crystal.
- Photo-tunableepsilon-near-zero behavior in liquid crystal–nanoparticle hybrid material.
- Dielectric and viscoelastic investigations in a binary system of soft- and rigid-bent mesogens exhibiting the twist-bendnematic phase. Topological defects due to twist-bendnematic drops mimicking colloidal particles in anematic medium.

- Investigation of electro-optical and dielectric properties of nematic liquid crystal dispersed with bio waste based porous carbon nano particles: Higher birefringence for display applications.
- Octadecylamine-capped CdSe/ZnS quantum dot dispersed cholesteric liquid crystal for potential display application: Investigation on photoluminescence and UV absorbance.
- Self-cleaning structural colors by TiO_2 /Ti nanostructures.
- UV assisted room temperature oxygen sensors using titanium dioxide nanostructures.
- Morphology driven spatial dependence of wetting, evaporation, and unidirectional spreading of water on hexagonally patterned gold micro structure arrays.
- Degradation studies of $\text{Cs}_3\text{Sb}_2\text{I}_9$: A lead-free Perovskite.
- Scalable fabrication of scratch-proof transparent Al/SnO₂ hybrid electrodes with unusual thermal and environmental stability.
- FeOOH-based ternary composite as a high-performance anode for lithium-ion batteries.
- Spontaneous formation of gold nanoparticles on MoS_2 nanosheets and its impact on solution-processed optoelectronic devices.

Important Highlights of Major Programmes:

- Using two parallel pathways with independent origins, metal enhanced fluorescence in incorporating gold nanoparticles having an organic shell of pro-mesogenic cholesterol esters; and matching the photonic band gap due to the helical structure in a self-assembled chiral system with the excitation wave length intrinsic photoluminescence of an organic emitter dispersed in a liquid crystal medium is enhanced.
- Tunable Epsilon-Near-Zero (ENZ) behavior brought about by an optical field in a room temperature stable self-assembled liquid crystal - nanoparticle system has been achieved. The effective permittivity of the system obtained from ellipsometry indicates ENZ behavior in the visible spectrum with a band width of ~45 nm, which gets enhanced by a factor of 1.6 on shining with UV light.
- Growth and thermal stability of blue phase liquid crystals, the 3D soft photonic crystal which otherwise is difficult to achieve with conventional methods has been obtained using graphene substrates and using UV light, transition between one- and three-dimensional photonic structures has been achieved.
- Silver nanocubes (AgNCs) are demonstrated as an efficient substrate for the detection of a fungicide, Thiram at ultra-low concentrations using Surface Enhanced Raman Scattering technique.

- Metal mesh networks deposited on the PET substrates provides better electromagnetic shielding compared to conventional metal film where the transparency is compromised.

Important Output Indicators:

S. No.	Parameters	Output
1.	Papers in refereed journals	49
2.	Number of Ph.Ds. produced	3
3.	Research Manpower trained (other than Ph.Ds)	12
4.	Indian Patents filed	3
5.	Indian Patents granted	3
6.	Technical Manpower trained	16
7.	Papers in Conferences	3
8.	No. of Technologies/Designs/ products commercialized	1
9.	Outreach programmes conducted	9
10.	No. of Technology leads awaiting transfer	1

5.6 Indian Association for the Cultivation of Science (IACS), Kolkata

The IACS pursues research on the areas of Biological Sciences, Chemical Sciences, Materials Sciences, Mathematical and Computational Sciences, Applied and Interdisciplinary Sciences and Physical Sciences.

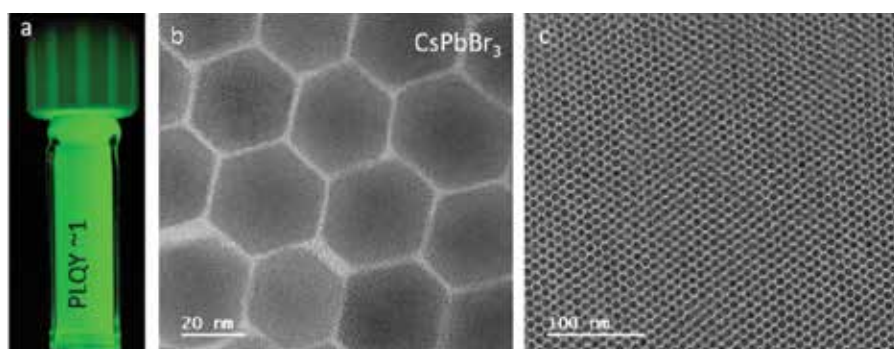
Major Accomplishment:

- Development of Graphene Oxide Doped Polyaniline Nanotubes.
- Synthesis of Fmoc protected morpholino monomers and their use in the synthesis of morpholino oligomer.
- Bicyclic compounds as topoisomerase I inhibitors.
- Development of a Laser Assisted Long-Path Liquid-Core Optical Guide (LLOG) for Ultra-Sensitive Absorbance Measurements.
- Fabrication of Orange Emitting Organic Nanoparticle Protamine Conjugate: Fluorimetric Sensor of Heparin.
- Development of Free-energy-based gene mutation detection using Locked Nucleic Acid probes.
- Using metal complexes of azo aromatic ligands towards memristive devices was developed with <10 at to joule switching energy.

- Polymeric nanoparticles and gold nanoparticles-based light harvesting system was designed.
- Functional integrated materials in the form of thin films were grown using pulsed laser deposition method.

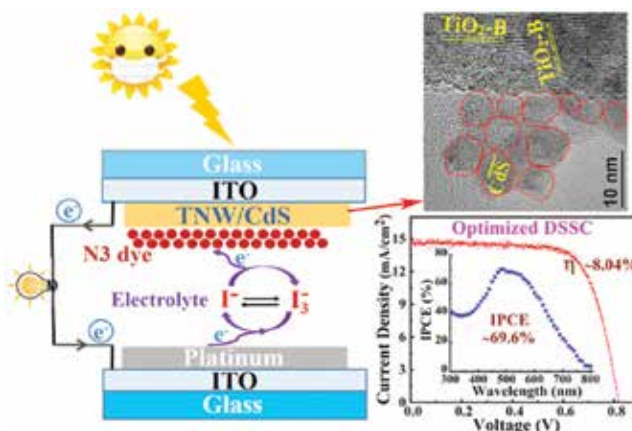
Important Highlights of Major Programmes:

- CsPbBr₃ dodecahedron shaped perovskite nanocrystals obtained with haloketone as brominating agent showed near unity photoluminescence quantum yield. Even with larger size (10-30 nm), these retain the brightness year under ambient exposure.



(a) Illuminated nanocrystals in solution, (b) transmission microscopic image and (c) image showing self-assembly.

- Sequential sensitization of TiO₂-B nanowire photoanodes via Cadmium Sulphide (CdS) Q-dots impregnation and further by N3 dye molecules adsorption improves the light harvesting, facilitates efficient photo-carrier generation, prevents interfacial charge recombination, and their cumulative electron injection has been assimilated in superior photovoltaic performance via novel 'CdS-Q-dots & N3-dye co-sensitization of TiO₂-B NWs' in 'Q-dot co-sensitized Dye Sensitized solar cells'.



CdS Quantum-dots impregnated TiO₂-B nanowire based photoanodes for photovoltaic conversion

- Nanocrystalline Diamond (NCD) Embedded Diamond-Like Carbon (DLC) Films are grown at $\sim 300^\circ\text{C}$ on glass substrates without any pre-treatment, using a specially-designed stainless-steel shadow-mask assembly creating diffuse secondary-plasma that shields the growth-zone from high energy ion-bombardment and nurtures the growth of NCDs embedded in the DLC network.

Important Output Indicators:

S.No	Parameters	Output
1.	Publications	270
2.	No. of Ph.D Produced	63
3.	Patents grants	5

5.7 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 scientists have developed a new method based on machine learning to identify the membership of stars in a cluster.
- By combining asteroseismic and lithium abundance data, novel observational evidence has been found with regard to the evolutionary status of lithium-rich giant stars.
- The surface abundances of 14 R Coronae Borealis stars (RCBs) have been revised based on their carbon abundances measured from the observed C2 bands instead of the earlier methods of using assumed carbon abundance (due to the well-known “carbon problem”).

Important Highlights of Major Programmes:

- IIA is actively engaged in several national and international programmes like the Thirty Meter Telescope (TMT), Aditya-L1, Maunakea Spectroscopic Explorer, National Large Solar Telescope (NLST), and a next generation Ultraviolet space mission.
- 1-metre class UV-Optical Indian Spectroscopic and Imaging Space Telescope (INSIST). Team is building a prototype spectrograph using digital micromirror device (DMD) to understand its operation and control. DMD will be used in the INSIST for a multi-object spectroscopic capability in space.
- IIA established the first-of-its-kind large optics facility {India TMT Optics Fabrication Facility (ITOFF)} and an Environmental Test Facility (ETF) at CREST campus, Hosakote.

ITOFF has several technical areas necessary to transform the TMT mirror blanks into high-quality surface hexagonal mirror segments, including two large areas equipped with railway cranes and dedicated to the preparation of the mirror surfaces, several isolation slabs for machinery and final metrology. This facility will be a value addition for India's pursuit to build a 10-m class segmented mirror telescope in future. With the ETF, IIA can now design, build, and qualify space payloads of smaller size up to its final level without any external help in the coming days.

- Several activities were carried out as part of the TMT mega-project this year. Handling and pre-production inspection of primary mirror segment blanks received from National Astronomical Observatory of Japan was done at the ITOFF in the CREST campus of IIA. The process of developing glass coupons to get required surface roughness is in progress at ITOFF. Activities related to the work package to develop a conceptual design for the coating of the secondary and tertiary mirrors of the TMT are in progress.

Important Output Indicators:

S.No.	Parameters	Output
1.	Papers in refereed journals	181
2.	Papers in Conferences	7
3.	Number of Ph.Ds. produced	12
4.	Research Manpower trained (other than Ph.Ds)	303
5.	Technical Manpower trained	10
6.	B.Tech/ UG projects guided	5
7.	M.Tech/M.Sc./M.Phil projects guided	20

5.8 Indian Institute of Geomagnetism (IIG), New Mumbai

The Institute focuses on Geomagnetism and Allied Fields.

Major Accomplishments:

- A new class of ion-acoustic solitons that can exist below the critical Mach number has been reported for the first time in a three-component plasma consisting of hot Maxwellian electrons, and two counter streaming ion beams. Adopting a Sagdeev pseudo-potential technique, it was shown that when the normalized streaming velocity is below or at a threshold value, only the regular solitons having Mach numbers greater than critical Mach number can exist. However, when the streaming velocity exceeds the threshold value (all modes are stable), both regular and the new class of ion-acoustic solitons can exist. The results could be useful in the interpretation of slow electrostatic solitary waves (ESWs) observed in the magnetosphere.

- Ionospheric observations made at low latitudes showed twin episodes of pre-reversal enhancement (PRE) in the dusk sector, which is attributed to under shielding and over shielding conditions respectively during an intense geomagnetic storm of December 19–20, 2015. The most striking feature was the enhancement in virtual height in the dawn sector and associated drifts during the recovery phase. Further analysis indicates varied impacts of interplanetary electric fields (IEFy) and the disturbance dynamo (DD) electric field on the electrodynamics of the ionosphere at low latitudes.
- Soft-sediment deformation structures were identified along Nandakini River valley near Chamoli village of Garhwal Lesser Himalaya. The deformation in each outcrop is restricted to a single stratigraphic layer bounded by un-deformed flat-lying layers, eliminating the influence of slope failure. The structures are multiple liquefaction features like sand dikes, flame structures, pear-drop disturbance and downward warping of beds. It is interpreted that the deformations resulted from earthquake-induced liquefaction and their existence adjacent to the Nandaprayag Fault can be related to episodic seismicity that occurred along this fault.
- The spatial variations in effective elastic thickness, isostasy and crustal structure of Greater Maldives Ridge (GMR) have been investigated in detail using high resolution satellite derived gravity, residual geoid and bathymetry data. Relation between excess crustal thickness and Curie isotherm along the GMR was carried out. It is found that there exists an inverse correlation between the two. Based on the studies, it is postulated that Curie depth in combination with excess crustal thickness may act as a proxy to provide information on the duration of interaction of mantle plume and ridges.

Important Highlights of Major Programmes:

- A resonant instability of kinetic Alfvén waves (KAWs) driven by ion beam was examined through a theoretical model encompassing Maxwellian background ions and beam ions and non-Maxwellian κ -electrons. The ion beam velocity alone as a source is able to excite the KAWs up to a significant growth. The present model can generate waves which are relevant to explaining the observed ultralow frequency waves at auroral ionospheric altitudes. Theoretical model predictions will also be applicable to other planetary environments where ion beams and non-Maxwellian κ -electrons are present.
- The knowledge about future solar activity is necessary to plan the space-based missions. As yet, several prediction models (statistics- or dynamo-based) have been developed to forecast the peak smoothed sunspot number (SSN) of the upcoming solar cycle. A new data-based model of peak sunspot number has been proposed, which is based on the updated Version-2 sunspot number data. This model provides the summation of peak smooth SSN of even-odd pair of solar cycles. Further, the model suggests that the Solar Cycles 26 and 27 would be similar or slightly stronger than Solar Cycles 24 and 25.

- Data were acquired across Aravalli and Tural hot springs (in Konkon region of Deccan volcanic province) by IIG to bring out the geoelectrical crustal structure beneath these geothermal zones. 2D inversion of data brings out different conductivity anomalies (a) shallow conductivity anomaly related to upward propagation of meteoric water through faults/fracture zones, (b) Major fracture/fault zones extending up to mid-crustal depths through which Deccan volcanism may have erupted and (c) the presence mid-crustal (12-15 km) and deep seated conductivity anomalies related to trapped carbonate fluids that is linked to basaltic magmatic intrusions at the base of the crust (Moho).

Important Output Indicators:

S.No.	Parameters	Output
1.	Papers in refereed journals	70
2.	Chapters in Books	3
3.	Papers in Conferences	4
4.	Number of Ph.Ds. produced	2
5.	Indian Patents filed	1
6.	Research Manpower trained (other than Ph.Ds)	6
7.	M.Tech/M.Sc./M.Phil projects guided	2
8.	Scientific Outreach Programmes organized	8
9.	Popular Science Articles published	23
10.	Scientific Lectures/Training Programmes organized	6

5.9 Institute of Advanced Study in Science and Technology (IASST), Guwahati

The institute focuses on five research programs viz., (i) Basic and Applied Plasma Physics, (ii) Advanced Material Sciences, (iii) Mathematical and Computational Sciences, (iv) Biodiversity and Ecosystem Restoration Programme and (v) Traditional and Modern drug discovery and diagnosis.

Major Accomplishments:

- Evaluated therapeutic effect of *Premnaherbacea* in diabetic rat and isoverbascoside against insulin resistance (IR) in L6 muscle cells through bioenergetics and stimulation of JNK and AKT/mTOR signaling cascade.
- A Soy yoghurt with improved shelf-life, enriched with functional metabolites and Cow milk curd with probiotics having anti-ageing property have been experimentally established and accordingly two patents have been filled from IASST for both Cow milk curd and Soy yogurt.
- Cold atmospheric pressure (CAP) plasma for nanomaterial synthesis with tunable optical and photocatalytic activity. Biomedical application of CAP plasma.

- Developed a Green synthesis of gold Nano bio-conjugate from onion peel extract and evaluated their antioxidant, anti-inflammatory, and cytotoxic properties.
- Synthesis of crystalline rubrene nanocomposite by one-step plasma process and fabrication of plasmon enhanced thin film transistor using the nanocomposite.
- Reversible hysteresis nature of human serum albumin (HSA) monolayer on water surface is confirmed and it is found that the tilting to untilting transition of HSA molecules under compression-decompression cycle is responsible for that. Interaction between globular proteins and titanium oxide nanoparticles (TiO₂ NPs) reveals that higher order complex formation and excited state quenching play the major role in modifying the optical responses of the system.
- A Linear Plasma Device is designed, fabricated and installed successfully for basic plasma physics research.

Important Highlights of Major Programs:

- Particle growth in gas phase plasma using organic precursor (C₂H₂) in a radio frequency discharge and complex dynamics of dust density waves have been investigated.
- CAP plasma reactors were developed for WO(3-x) nanoparticle synthesis with defect states leading to band gap reduction and enhanced photocatalytic activity. Demonstrated biomedical applications of CAP plasma (SARS COV-2 deactivation).
- Developed a fluorescent boron doped carbon quantum dot which can detect the presence of hydrogen peroxide in a cell.
- The quality and safety assessment of Indian and Sri Lankan antivenom has been assessed successfully by different analytical technique, standardized in the laboratory.
- Exploration of hydrocarbons degrading bacteria for the bioremediation of petroleum-oil contaminated hydrocarbons in soil and water.

Important Output Indicators:

S.No.	Parameters	Output
1.	Papers in refereed journals	102
2.	Books	4
3.	Chapter in Books	26
4.	Papers in Conferences	50
5.	Number of Ph.Ds. produced	10
6.	Indian Patents filed	1
	Indian Patents granted	3

S.No.	Parameters	Output
7.	Number of Technology leads awaiting transfer	6
8.	Research Manpower trained (other than Ph.Ds)	27
9.	Technical Manpower trained	7

5.10 Institute of Nano Science and Technology (INST), Mohali

Research activities at INST encompass physics, chemistry, biology, and interdisciplinary sciences addressing problems in the field of energy, environment, quantum materials, nano-devices, and chemical biology. Institute has set a unique mission to work at the forefront of fundamental science together with the development of technologies to address problems of national and global priorities.

Major Accomplishments:

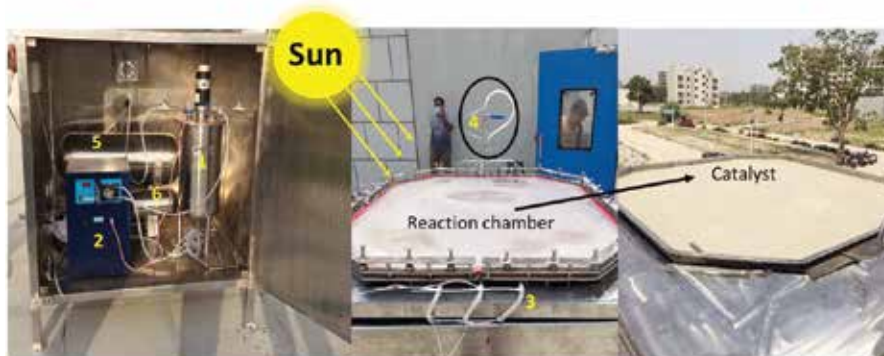
- Developed an oral nanomedicine based on surface modified solid lipid nanoparticles based combinational cargo system for combating visceral leishmaniasis when administered orally.
- Developed a non-toxic, highly stable security ink based on luminescent nanomaterials to combat the counterfeiting. Unique luminescent properties of these nanomaterials make the patterns show different colors under different excitation wavelengths of light. By making patterns/writing with this security ink makes the common man easy to identify the originality of the documents, currency, goods, and products.



Digital images of Digital India and Aadhaar logs printed with security ink on black paper under daylight(white), 254(red), 365(greenish yellow), and 394 nm(pink) UV light.

- Developed a composite paper made of carbon (graphene oxide) loaded with preservatives that can be used as a wrapper to extend shelf life of fruits benefiting farmers & food industry.
- Developed a reactor that produces a substantial amount of hydrogen using sustainable sources like sunlight and water, which is a cost-effective and sustainable process.

Prototype Photocatalytic Hydrogen Production Reactor : Closer view of components/ processes



Components/ Processes: 1) Solution chamber, 2) Peristaltic pump & overhead stirrer control unit, 3) Solution inlet, 4) H₂ sampling outlet, 5) H₂ storage tank and 6) Chemical collection unit.

Natural sunlight driven H₂ production using large-scale prototype reactor fabricated in INST Mohali.

- INST scientists have demonstrated a Tribo respiratory Face Mask, having combinations of textiles of different nature and of electro spun waste nylon materials (triboelectric filter). This unique design acts as a virus net filter having inbuilt circuit sandwiched between the layers. This proposed smart mask provides the wearer protection in terms of fighting with incoming and outgoing virus carrying particles.
- An injectable hydrogel has developed from kappa-carrageenan, a water-soluble polysaccharide found in edible red seaweeds and a pigmented protein called C-phycoerythrin found in spirulina shows regenerative wound dressing property to heal the wound rapidly and to monitor the progress in real-time. Its injectable property allowed its application in tough to reach internal injuries and holds promise to be utilized in high altitude frost injury application due to its self-healing properties.
- A broad range of impactful magnetic nano-systems have been generated and established for magnetic hyperthermia mediated cancer therapy at both in-vitro and in-vivo levels.
- A non-viral siRNA delivery system for epigenetic targeting of histone methyl lysine transferase (Ezh2) for superior anti-leukemic therapy has been developed.
- Researcher at INST observed an unprecedented enhancement in ferromagnetic properties upon X-annulation in Blatter di-radicals. This allows control over the modulation of magnetic properties in molecular systems.

Important Highlights of Major Programmes:

- INST offers PhD as a part of their mandate, through IISER, Mohali, Panjab University, Chandigarh & AcSIR, Ghaziabad. Currently, the number of students pursuing their Ph.D. at INST has reached 212, out of which 194, 13 and 4 number of students have registered for their Ph.D. at IISER-Mohali, Panjab University and AcSIR respectively.
- INST, Mohali conducted programme for highly motivated and bright Scheduled Tribe (ST) candidates for engagement of Research Internship in various research projects in the field of Nanoscience and Nanotechnology at Institute. A total of four students have been benefitted from this programme and pursuing their higher studies in Germany and Korea.

Important Output Indicators

S. No	Parameters	Output
1.	Papers in refereed journals	148
2.	Number of Ph.Ds. produced	17
3.	Indian Patents filed	10
	Indian Patents granted	1
4.	Number of Technology leads awaiting transfer	3
5.	Research Manpower trained (other than Ph.Ds)	38
6.	Technical Manpower trained	4
7.	B.Tech/ UG projects guided	30
8.	M.Tech/M.Sc./M.Phil projects guided	25

5.11 International Advanced Research Centre for Powder Metallurgy and New Materials (ARCI), Hyderabad

The Institute focuses its research on the areas of Automotive Energy Materials, Solar Energy Materials, Nanomaterials, Engineered Coatings, Ceramic Processing, Laser Processing of Materials, Fuel Cells, Carbon Materials.

Major Accomplishments:

- Transferred Know-how for Easy-to-clean coating (super-hydrophobic) sol composition and coating technique for Solar Photovoltaic (PV) applications to two companies: a) M/s. Marichin Technologies LLP, Mumbai that launched the product as “NOVUS Coat and b) Allox Resources LLP, Hyderabad launched the product as “Klincoat”
- Completed Know-how demonstration of Honeycomb inserts for anti-mine boot applications and provided training to Defence Materials Stores and Research & Development Establishment (DMSRDE), Kanpur (technology recipients)

- Completed virtual demonstration of 'Synthesis of electrocatalysts for use in fuel cells' to LAS Engineering and Consultants Pvt. Ltd., Mumbai.
- Produced Oxide dispersion strengthened (ODS) iron aluminide rods from ODS powders developed through gas-atomization, high-energy ball milling followed by hot extrusion process and generated a database for High temperature applications.
- Developed and supplied 500g of CuO-Ag nanopowders produced by flame spray pyrolysis to a company for production Self-disinfecting COVID-19 masks (10000 Nos). Masks exhibited 99.99% disinfection against bacteria and virus.
- Developed and supplied 5 Nos. of MgAl_2O_4 spinel windows (25 mm x 25 mm x 5 mm) coated with saline repellant sol-gel coatings conforming to MIL-C-675C and MIL-C-48497A standards for strategic applications to end user.
- Biofilm inhibiting sol-gel coatings on surgical sutures made of nylon, silk and polyglactin910 were tested and found to be non-cytotoxic
- Tungsten weight balancing components for aerodynamic controls for strategic application were produced and supplied to end user
- Developed a method of production of 2.5 nm^3 / hour hydrogen by electrochemical methanol reformer process
- Developed complex shaped integrated aeroengine valve blocks of Al alloy and Stainless Steel with 50% weight reduction, through Laser based Metal Additive Manufacturing

Important Highlights of Major Programmes:

- Developed a single-step process for production (1Kg/batch) of indigenous Lithium Iron Phosphate (LFP) and Lithium Titanate (LTO) electrode materials by Attritor Milling and developed a process for the fabrication of Lithium-ion cells (26650) using the LFP powders; Lithium-ion cells (NMC based) made at ARCI exhibited a discharge profile and cycle life at high rate (2C) similar to a freshly produced cell, even after 1 year of storage at 100% SOC (State of Charge), ascertaining good shelf life of cells.
- In-situ carbon coated $\text{Na}_3\text{V}_2(\text{PO}_4)_3$ powder production scaled up to 250 g/batch and 300 mAh sodium ion pouch cell fabricated;
- Developed a process for fabrication of supercapacitors (6080) of 1200F capacitance using indigenously developed porous carbon derived from petroleum coke and assembled a supercapacitor module(43V,75F,19.2Wh) having a charging time of 2 minutes and demonstrated it on a bicycle with a driving range of 2 km.
- Prototype alternators developed with indigenous Fe-P soft magnetic material in collaboration with Lucas-TVS showed 3-5% enhancement in performance.

- The facility for the production of low expansion glass ceramics the consortium project was demonstrated during the Factory Acceptance Test (FAT) to the consortium team deputed to vendor's facility.
- Partial graphitization of C-C composites for throats application for motors of crew escape modules of Gaganyaan vehicles was carried out by ARCI.
- Established the manufacturing process for the production of oxide dispersion strengthened (ODS) iron aluminides and developed ODS iron aluminides with a unique combination of strength (1100 MPa) and ductility (17%) at room temperature.
- Increased productivity and high quality Cr_3C_2 -NiCr coatings with enhanced high temperature erosion resistance developed using Activated Combustion High-velocity Air-Fuel (HVOF) spray system.

Important Output Indicators:

S.No.	Parameters	Output
1.	Papers in refereed publications	132
2.	Books & Chapters in Books	4
3.	Papers in Conferences (with or without proceeding)	68
4.	Number of Ph.Ds. produced (including employees and Fellows)	13
5.	Foreign Patents filed	2
	Foreign Patents granted	3
6.	Indian Patents filed	8
	Indian Patents granted	14
7.	Number of Technologies Transferred/applications developed/products supplied	28
8.	Number of Technology leads awaiting transfer	20
9.	Research Manpower trained (other than Ph.Ds)	11
10.	Technical Manpower trained	99
11.	B.Tech/ M.Sc projects guided	27
12.	M.Tech/ projects guided	47
13.	Number of Fellows Pursuing Ph.D	31
14.	Number of Project Scientists Pursuing Ph.D	8

5.12 Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bengaluru

The Centre focuses its research on Chemistry and Physics of Materials, Engineering Mechanics, Evolutionary and Integrative Biology, Geodynamics, Molecular Biology and Genetics, Neurosciences, Theoretical Sciences, and New Chemistry.

Major Accomplishments:

- As per the National Institute Ranking Framework (NIRF) 2021, JNCASR ranks 19th among research institutions in the country. According to the Institution Table 2021 released by Nature Index, JNCASR ranks 8th in India by Nature Index 2021. In the Nature Index 2021: JNCASR ranks 23rd among the top 50 rising institutions in the materials sciences globally. In Scimago Institutions Rankings 2021, JNCASR stands on 15th position across all sectors and 7th among universities in India.
- A research group in JNCASR developed novel self-forming artificial synaptic network that can emulate some complex human behaviours.
- In collaborative research, JNCASR scientists construct a micrometer-sized Stirling engine.
- Developed a set of novel small molecules, of which the small molecule TGR63 was shown to suppress amyloid beta toxicity, which is involved in pathogenesis of Alzheimer's disease (AD).
- A team of scientists from JNCASR and IISc, Bengaluru, recently demonstrated that the nature of the chiral activity of millimetre sized rice-shaped grains can be tuned with the help of 3D printing.
- Team of scientists from JNCASR reported the discovery of a novel molecule that connects the outer kinetochore to centromeric chromatin.

Important Highlights of Major Programmes:

- Sixty-six students joined different degree programmes at the centre and the current student strength of the Centre is 349. During this period, 55 students received degrees on completion of their respective degree programmes.
- Fifteen students have joined the Summer Research Fellowship; 19 have joined the Project Oriented Biology Education program (POBE) and 19 joined the Project Oriented Chemistry Education program (POCE) and 14 visiting fellows have joined the Visiting Fellowship program (VFP).
- The Graduate Research Internship Program (GRIP) has been launched with effect from September 1, 2021, for students in the final year of their B.E./B.Tech. /M.S./M.Sc./Int. M.S./MBBS looking to add credits from a research internship to their degree. 107 applications have been received for the GRIP and 26 have been selected.
- Twelve science outreach programmes were organized including teacher training workshops, workshop on learning science through experiments, workshops on learning physics through experiments, workshop on learning chemistry through experiments

and interactive lecture program in Biology. The programmes were participated by 5928 students of class XI and XII and 696 teachers.

Important Output Indicators:

S.No.	Parameters	Output
1.	Papers in refereed journals	252
2.	Papers in Conferences	2
3.	Number of Ph.Ds. produced	34
4.	Foreign Patents filed	5
	Foreign Patents granted	5
5.	Indian Patents filed	7
	Indian Patents granted	6
6.	Number of Technologies/Designs and other intellectual products commercialized	2
7.	Number of Technology leads awaiting transfer	2
8.	Research Manpower trained (other than Ph.Ds)	106
9.	Technical Manpower trained	10

5.13 Raman Research Institute (RRI), Bengaluru

The institute focuses research on Astronomy & Astrophysics, Light & Matter Physics, Soft Condensed Matter Physics and Theoretical Physics.

Major Accomplishments:

- Recent observations of an ultraluminous X-ray source (ULX) by astronomers at the Institute has enabled them to place constraints on the accretion state, disk geometry and upper mass limit of the central compact object. The analysis revealed that the observed ULX hosts a stellar mass black hole.
- Astrophysicists at the Institute have proposed that cosmic rays while propagating through the Milky Way galaxy interact with matter in giant molecular clouds producing other cosmic rays, primarily electrons and positrons, and that these new cosmic rays are the origin of the rise in positron flux.
- RRI experimentalists and collaborators have successfully demonstrated real time imaging through fog. They employ a novel low-cost method that utilizes an inexpensive incoherent light source, a low-cost scientific camera, and a software developed for this purpose.
- Experimentalists at the Institute have fabricated a GO-Ag nanoparticle hybrid via a novel

laser-based technique. The synthesized hybrid nanostructure exhibited high antibacterial action resistance to *Escherichia coli* (*E. coli*) opening up potential applications in antibacterial coatings.

- Simultaneous measurement of both single-molecule DNA supercoiled conformations and enzyme-dependent bulk conformational changes was demonstrated.
- Bacterial motion is “active”, as they move by propelling themselves with a velocity that changes direction randomly. Some bacteria, like *Myxococcus xanthus* and *Pseudomonas putida*, exhibit a unique kind of direction reversing active motion, whereby, in addition to a diffusive change of direction, the motion also completely reverses its direction intermittently. How far does such a microorganism typically disperse in a given time? How long does it take (first-passage time) to find a food source? Theorists at the Institute have answered these crucial questions by analyzing a theoretical model of such motion.

Important Highlights of Major Programmes:

POLIX is an X-ray Polarimeter Instrument for Astronomical Observations under development at the Raman Research Institute. It is the only instrument in the energy band of medium energy X-rays, 8-30 keV, and is the main payload on the soon to be launched dedicated ISRO satellite XPoSat. A completely in-house design, and development, of the Qualification Model (QM) of POLIX was completed in the current year and has successfully undergone space qualification tests like vibration test and environmental test at the UR Rao Satellite Centre (URSC).

Important Output Indicators:

S.No.	Parameters	Output
1.	Papers in refereed journals	109
2.	Number of Ph.Ds. produced	6
3.	Research Manpower trained (other than Ph.Ds)	11
4.	Technical Manpower trained	16
5.	Indian Patent filed	1

5.14 SreeChitraTirunal Institute for Medical Sciences & Technology (SCTIMST), Trivandrum

The research areas of the Institutes focus on Biomaterials Research and Development, Biomedical Device Development, Technology Transfer and Industrial Partnerships, Quality Management Systems, Testing and Technical Services, Research, Advanced Patient Care in Clinical Super-specialties in Cardiac and Neuro Sciences along with Human Resource Development in the above said areas and Public Health.

Major Accomplishments:

- SCTIMST has developed two biomedical implant devices namely Atrial Septal Defect (ASD) Occluder and Intracranial Flow Diverter Stents in collaboration with National Aerospace Laboratories, Bangalore (CSIR-NAL) using superelastic NiTiNOL alloys.



Chitra ASD Occluder

- The First Heart Failure Biobank in the country established under Heart failure Centre of Excellence (CARE-HF) supported by ICMR.



- The technology of Beta Tricalcium phosphate and Hydroxyapatite was commercialized by M/s Onyx medicals Pvt Ltd, UP under the brand name Fraclink.



- The Department of Neurosurgery of the institute performed the first successful superficial temporal artery- anterior cerebral artery (A3) bypass, using a bridge graft for a complex Distal anterior cerebral artery aneurysm. This rare surgery has been attempted only in a few Centres in the world and is the first such reported case from India.
- The institute has started advanced medical treatment facilities like 3D printing and simulation for cerebral and aortic aneurysms for better patient management, Zero-TE MR imaging of the skull to demonstrate the bony abnormalities in brain MRI to reduce the radiation risk.

Important Highlights of Major Programmes:

- State of the art Digital Radiography system-Prorad 2FC-600mA - capable of performing all spectrum of radiographic imaging including whole spine stitching, new outpatient clinic in the Department of Cardiology- Comprehensive Device and Arrhythmia Clinic (CDAC), Geriatric Pain Care and Regenerative intervention Services and Cardiology Specialty Review Clinics were inaugurated.
- A website, dedicated to Moyamoya disease, a rare cause of stroke predominantly in children was inaugurated.
- The Cognition & Behavioral Neurology subsection (CBNS), Dept of Neurology, SCTIMST was involved in development, multilingual harmonization and validation of the Indian English and Malayalam versions of the ICMR-NCTB. The toolbox was launched virtually. This multilingual (5 Indian languages) test battery provides a standardized set of cognitive tests that are culturally appropriate and available in different languages for our country. It is made available for clinical and research purposes to diagnose mild cognitive impairment and dementia.
- Achutha Menon Centre for Health Science Studies (AMCHSS), SCTIMST developed an interactive dashboard to visualize the COVID-19 situation in India.

Important Output Indicators:

Sl. No.	Parameters	Output
1.	Papers in refereed journals	340
2.	Chapters in Books	8
3.	Papers presented in Conferences	96
4.	Number of Ph.Ds. produced	19
5.	Foreign Patents filed	11
6.	Indian Patents filed	17
	Indian Patents granted	13
7.	Number of Technologies/Designs and other intellectual products commercialized	2
8.	Number of Technology leads awaiting transfer	14
9.	Research Manpower trained (other than Ph.Ds)	110
10.	Technical Manpower trained	395
11.	M.Tech/M.Sc./M.Phil projects guided	14

5.15 S. N. Bose National Centre for Basic Sciences (SNBNCBS), Kolkata

Areas of focus of the Centre are Physics of nanomaterials including application-specific materials and nanodevices; 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 and application of ultrafast spectroscopy in; Collective behavior in quantum and classical condensed state including driven systems, ultra-cold quantum gases and spin transport through Quantum wires; Theoretical work on black holes and its cosmological consequences and astro-chemistry. Selected problems in Quantum field theory, Statistical Physics and Non-Linear Dynamics.

Major Accomplishment:

- The Scientists of the Centre found theoretical explanation for unique reversing motion of bacteria.
- The S N Bose Centre in collaboration with IIT Madras has discovered chemicals to help make gas hydrates faster.
- Developed a magnonic nanochannel array by periodically tailoring perpendicular magnetic anisotropy using electric field, a step which can potentially revolutionize on-chip data transfer and processing.
- Developed a high-response optical detector based on n-ZnO/p-Si nanowires core-shell

arrays decorated with plasmonic Au nanoparticles that works in the from 300 nm to 1100 nm.

- Scientists from S. N. Bose National Centre for Basic Sciences in collaboration with Saha Institute of Nuclear Physics have shown that Body fluids can provide a clue for early detection of colon cancer colon cancer.
- S. N. Bose Centre's High-Performance Computing facility has been listed within top 50 supercomputers India based on the survey carried out by CDAC Bangalore. The cluster has a theoretical performance of 222.40 TFlops catering the computational need of the vibrant computational activity of the Centre.



High Performance Computing facility

Important Highlights of Major Programmes:

- Conducted spectroscopic studies of Low-mass Galactic M-dwarfs, M giants and AGB stars.
- A construction of novae grid model using photoionization code CLOUDY is successfully implemented by SNBNCBS to estimate physical parameters of novae.
- Optical/Near-IR spectra of several planetary nebulae are analyzed to estimate their physical parameters.
- Thermodynamic utility of non-Markovianity from the perspective of resource interconversion.
- Protecting quantum correlations in presence of generalised amplitude damping channel: the two-qubit case.
- Exploration of heterogeneity length and timescales for ionic deep eutectics.

- Experimentally determined the ortho-to-para ratio (OPR) for D₂O nuclear spin-isomers in the isolated gaseous phase to be (1.95±0.16):1 by using high-resolution cavity ring-down spectroscopy coupled with quantum cascade laser.
- Exploration of the energetic and entropic cost due to Turing and Hopf instabilities in nonlinear open system.
- Microscopic insight to specificity of metal ion cofactor in DNA cleavage by restriction endonuclease EcoRV.
- Demonstrated the nano-hollow spheres of MnFe₂O₄/CoFe₂O₄ function as electromagnetic wave absorbers and are suitable for high-frequency applications.
- Examined the temperature dependence of structural dimerization and electronic dimerization in bond-order-wave phase in strongly correlated spin models.
- Identified the origin of flat band formation in twisted bilayers of transition metal dichalcogenides.
- Explained the anomalous temperature dependent resistivity in FeSi through the electron-phonon interactions. A method was found of deriving effective Hamiltonians for multiphoton processes for atoms in cavities that works well in general situations.
- In the gravity dual of a field theory, the entanglement temperature was holographically computed from the entanglement entropy.
- The position distribution of active particles under different stochastic resetting protocols was calculated by SNBNCBS.
- A performance peak for *E.coli* chemotaxis was found which results from a competition between sensing and adaptation modules of the signalling network.

Important Output Indicators:

S.No.	Parameters	Output
1.	Papers in refereed journals	199
2.	Papers in Conferences	4
3.	Number of Ph.Ds. produced	20
4.	Indian Patents granted	4
5.	Number of Technologies/Designs and other intellectual products commercialized	1
6.	Number of Technology leads awaiting transfer	6
7.	Research Manpower trained (other than Ph.Ds) Integrated PhD	17
8.	Technical Manpower trained (Summer Project)	24
9.	M.Tech/M.Sc./M.Phil projects guided	18

5.16 Wadia Institute of Himalayan Geology (WIHG), Dehradun

The Institute's focus is to study various geological and geophysical aspects of the Himalaya, including glaciers, earthquake precursors, landslides, biodiversity and climate-tectonic interaction and the geodynamic evolution of the Himalaya.

Major Accomplishment:

- Established that the detachment of huge rock-ice mass from 5600 to 3600 masl in Raunthi catchment caused Rishi-/Dhaulti-ganga Flash Flood (Feb. 7, 2021) in UK state
- Explored geomorphic indices, post-failure run-out, spatio-temporal patterns of rainfalls and earthquakes, which imply landslide damming sites in Satluj valley of HP state
- Established wet phases during 15.4-12.9 and 11.3-10.1 kyr BP with a dry phase and Younger Dryas (YD) cold interval during 12.9-11.3 kyr BP using speleothem samples in Meghalaya, and linked monsoon variability with socio-economic growth in South Asia
- Estimated site response function in Central Seismic Gap corresponding to high-rise, tall, 3–4-storey, double-story, single-story structures to understand the earthquake hazards
- Explored spatio-temporal heterogeneity in a post-glacial lake at Lahaul NW Himalaya, which shows strengthened summer monsoon during medieval climate anomaly, and weakened monsoon during Little Ice Age
- Established two NE–SW trend low strain rate (~ 20 nstrain/a) zones: (a) Ramganga-Baijro and (b) Nainital-Almora with locking width of ~ 72 and ~ 75 km and no major surface ruptures due to earthquakes in last 100 years, which hint for future earthquake
- Established that Dokriani Glacier has negative annual mass balances with cumulative mass loss of -3.86 ± 0.27 m.w.e. and average loss of -0.32 ± 0.02 m.w.e. a⁻¹
- Shown by paleo-geographic reconstruction that the Neo-Tethys Sea was open and connected through East and West coast of India, NE India, western Himalaya, most of the Middle East countries and Mediterranean area during the Middle Eocene (47-37 Ma)
- Recorded Oligocene fossil *Nalamaeryx* (Tragulidae, Mammalia) from Ladakh Himalaya and established that *Nalameryx* fed plants that grew under xeric conditions

Important Highlights of Major Programmes:

- Established from the geochemical characteristics and microfacies studies that the carbonate rocks of Disang Group in the Assam–Arakan basin, northeast India, have been formed in low energy environment during Campanian–Maastrichtian age (~ 70 -65 Ma).

- Prepared field excursion guide on Geology, Structural, Metamorphic, and Mineralization Studies for the Mandi-Kullu-Manali-Rohtang Section of Himachal Himalaya benefit of students and young researchers.
- Magneto-telluric resistivity survey along the Rohtak-Delhi section in NCR region suggests that Mahendargrah Dehradun fault is the basement fault with probable location between two resistivity blocks.
- Established multiple phases of tectonic activity in the Yangui River basin in the Indo-Myanmar Range, which corroborates with the seismogenic potential and oblique geometry of the Churachandpur-Mao Fault present in the area.
- Established the first record of the oldest glaciation (~52 ka) in the upper Kali Ganga valley, Kumaon Himalaya.
- Recognized and established two major phases of paleo-wild fire around 2.81-2.55 ka BP and around 1.56-1.37 ka BP from a peat sequence in the arid regions of Indus Valley, Ladakh Himalaya.
- Prepared the regional scale landslide susceptibility map of the state of Uttarakhand, and large scale landslide susceptibility map of the Mussoorie township, Goriganga valley (Kumaun Himalaya), and accordingly, different hazard zones were differentiated.
- Mapped several active faults in the Kumaun-Garhwal regions of Uttarakhand to understand the seismic hazard along the Himalayan Frontal Thrust in the Uttarakhand State.
- A study carried out in Pensilungpa Glacier (PG), Zaskar Himalaya, Ladakh, revealed that the glacier has been retreating due to low winter precipitation and increasing summer temperature in this region. Further, the last four years (2015–2019) data show that the glacier has retreated by $\sim 27 \pm 11$ m at an average rate of 6.7 ± 3 m a⁻¹.
- Established that glaciers in the upper Rishi Ganga catchment (Nanda Devi region, Garhwal Himalaya) lost ~ 26 km² (10%) of the glaciated area between 1980 and 2017 and the Equilibrium Line Altitude (ELA) of the glaciers fluctuated between 5200 and 5700 m asl.

Important Output Indicators:

S.No.	Parameters	Output
1.	Papers in refereed journals	132
2.	Books	1
3.	Chapters in Books	20
4.	Number of Ph.Ds. produced	11
5.	Research Manpower trained (other than Ph.Ds)	93

5.17 National Innovation Foundation-India (NIF), Gandhinagar

The areas of the Institute include the Incubation and promotion of technological grassroots innovations including those which stems from children creativity and to add value to India's outstanding traditional knowledge base.

Major Accomplishments:

- An Innovation Portal (www.innovation.nif.org.in) was developed by NIF with more than 1.15 lakh innovations scouted from common people of the country, covering engineering, agriculture, veterinary and human health covering a variety of technology domains like energy, mechanical, automobile, electrical, electronics, household, chemical, textiles, farm / cultivation practice, storage practice, plant variety, plant protection, poultry, livestock management, nutraceuticals etc.
- Improved prototypes of various innovative technologies namely Tamarind deseeding machine, sunflower deseeder, Coconut breaking machine, Pedal operated rice pounding machine, Leg operated mouse, device for assisting in filling grain in gunny bags, Tractor operated weeder for cotton crops etc. were developed.
- Refined prototypes of students selected under INSPIRE Awards – MANAK were developed.
- NIF facilitated a Technology Transfer arrangement of Tractor operated paddy transplanter between the grassroots innovators and John Deere India Private Ltd, a leading multi-national agricultural machinery manufacturer thereby reestablishing the fact that grassroots innovations have an inherent merit with a global appeal.
- Three outstanding traditional knowledge-based nutraceutical products namely two variants of tea formulations for (i) Digestive health (ii) Immunity booster and (iii) Healthy cookies were developed and launched by Bio Neutra Innovations Private Limited, Pune; a start-up incubated by NIF thereby strengthening the linkage between outstanding traditional knowledge with mainstream entrepreneurship movement and start-up eco-system of the country.

Important Highlights of Major Programmes:

- A total of fifteen thousand innovations and traditional knowledge practices from grassroots innovators and knowledge holders were scouted.
- Agriculture plant varieties like HRMN 99 apple were abundantly transplanted in association with North Eastern Region Community Resource Management Society (NERCRMS), North Eastern Council (NEC), M/o DoNER.

- Technologies like areca nut peeler, head load reducer and fruit nipper, water turbines, Handpump, Sanitary napkin machine, Multipurpose Processing machine, rural egg incubator, multi tree climbers were disseminated primarily in remote areas like NE region. Mosthwak, an Outstanding Traditional knowledge-based mosquito repellent cream was widely disseminated in the States of Meghalaya and Tripura.
- NIF coordinated INSPIRE Awards – MANAK and a total of 7.05 lakh innovations were received from school students (53% being girls) across the country representing all States and UT's. The 8th NLEPC (National Level Exhibition and Project Competition) to arrive at and recognize top 60 innovative and creative students was successfully concluded.

Important Output Indicators:

S.No.	Parameters	Output
1.	Papers in refereed journals	1
2.	Books / Monographs	6
3.	Papers in Conferences	3
4.	Indian Patents filed	71
5.	Indian Patents granted	96
6.	Plant Variety Applications submitted under PPV&FR Act 2001	4
7.	Plant Variety Applications granted under PPV&FR Act 2001	7
8.	Number of Technologies/Designs, other intellectual products commercialized	5
9.	Scientific Outreach Programmes organized	450
10.	Original Science Communication Content Designed	3
11.	Scientific Lectures/Training Programmes organized	30
12.	National Missions Led and Coordinated	2
13.	Number of Innovators trained	120

5.18 Technology Information Forecasting and Assessment Council (TIFAC), New Delhi

Areas of Focus of TIFAC are Technology foresight exercises, Vision 2035, nurturing Innovation, patent support, support to MSME clusters, capacity building and Technology Assessment.

Major Accomplishments:

- Two new initiatives (i) Shramik Shakti Manch (SAKSHAM)- a dynamic job portal for mapping the skills of Shramiks vis-à-vis requirements of MSMEs to directly connect

Shramiks with MSMEs and facilitate enrollment of 10 lakh blue-collar jobs & (ii) Seaweed Programme for commercial farming of seaweeds and its processing for value addition towards boosting national economy were launched.

- Technology of customized 3D printed surgical drill guides for guiding surgeons to plan surgeries like shoulder implant replacement and acetabular fractures etc. designed, developed and scaled up under the support of Srijan Program.
- The technology of 'Single Use dynamic Bed Bioreactor (SUB) for manufacturing of Vaccines and Biologics' successfully scaled up under the Srijan Programme.
- TIFAC prepared a document titled 'S & T Approach for Addressing Resurgent COVID-19 (STAARC)' highlighting technology and policy interventions required to contain COVID-19 surge.
- Under the "Assessment of Technology Maturity for AatmaNirbharta (ATMA)" programme, TIFAC collected information on 80 technologies developed and patented by public-funded academia and R&D labs and carried out assessment of their readiness level, relevance and market potential for extending handholding support towards commercialization.
- IIASA and NITI-Aayog along with TIFAC have partnered to develop MESSAGEix modelling framework for NITI Aayog for national energy system and energy policies.

Important Highlights of Major Programmes:

- Phase-II of SAKSHAM (Shramik Shakti Manch) Programme has been initiated towards large scale registration of Shramiks and MSMEs on the portal to facilitate the skill profiling of the shramiks and their placement in the MSMEs.
- TIFAC has taken initiatives towards piloting the telemedicine / tele diagnosis program by using sensors for health data generation and EHR design for e -Sanjeevni platform of CDAC
- Under TIFAC-SIDBI Technology Innovation Programme, two technologies viz. (i)GPS/ GIS based minefield recording and retrieval systems useful for the Indian Army and (ii) portable medical grade oxygen generation system to use locally available Sodium/ Calcium-based zeolite developed by Indian start-ups, were assessed and technically recommended by TIFAC.
- Four technology foresight studies on opportunities for processing of fruits & vegetables, ethnic foods, fish and spices focusing on the North Eastern Region of India were completed.
- TIFAC has taken up a few projects of strategic importance like Climate modelling, River resilience and Biodiversity issues in Hindukush region, with the International Institute for Applied Systems Analysis (IIASA), Laxeburg, Austria.

- TIFAC successfully coordinated for capacity building of Women Scientists on IP issues.

Important Output Indicators:

S. No.	Parameters	Output
1.	Papers in refereed journals	7
2.	Books/Monographs	1
3.	Chapters in Books	3
4.	State-of-the-art-Reports Published	4
5.	Scientific Outreach Programmes organized	12
6.	Original Science Communication Content Designed	3
7.	Popular Science Books/Newsletters published	1
8.	Scientific Lectures/Training Programmes organized	7
9.	Number of students trained	93
10.	Number of school/college/university teachers trained	500
11.	Number of Innovators / Officers trained	24
12.	Data Bases Compiled	6

5.19 North East Centre for Technology Application & Reach (NECTAR), Shillong

NECTAR focuses on providing last mile guidance and support to north-eastern States in technology applications for socio-economic activities.

Major Accomplishments:

- NECTAR has supported a project to produce natural fiber-based eco-friendly yoga mats made of locally available water hyacinth.



Yoga mats



Terracotta



Pottery

- NECTAR has supported two vital projects, one on improving sustainability of Traditional Terracotta and Pottery Business in Asharikandi, Dhubri, Assam and other is for preservation of ancient heritage art of 'Chareitaba Pottery' (Coil Pottery) in Imphal-East Manipur.

- NECTAR has set up four Arsenic Mitigation Plants (developed technology by IIT Kharagpur) on pilot basis in schools and colleges as instructed by the state Public Health Engineering (PHE) Department, Govt. of Assam, and expansion in other affected areas are in advanced stage.
- NECTAR has setup technology-based production facility of disposable organic sanitary napkins from banana, pineapple, and bamboo waste. Local women workers were engaged with training and skill development to run the facility independently for their livelihood generation.
- A series of training and skill development programs on Commercial poultry Layer Farming, making of Herbal pellets and Basic training on vermicomposting have been conducted at NIT, Arunachal Pradesh.
- The cultivation of saffron, which was so far confined in Kashmir, was successfully grown in Sikkim in last season, has now been extended to two more sites in Arunachal Pradesh and Meghalaya, in the current season, with the interventions of NECTAR.



Saffron cultivation

Important Highlights of Major Programmes:

- NECTAR-Bamboo Cane Development Institute (BCDI) has successfully developed various Bamboo products like Bamboo Cricket Bat, Bamboo Bottle, Laptop Stand, Bamboo Amplifier and other utility items through engaging local artisans by providing Special Purpose Machines and tools to explore potential usage of Bamboo resources available in Tripura and other parts of North Eastern Region.



Bamboo based products developed at NECTAR-BCDI

Fifteen days skill and development program on bamboo bottle making for Tripura Rural Livelihood Mission at Agartala, five days on food products using bamboo shoots, like cookies and pickle manufacturing, one-week bamboo tool kit processing training and one-month training programme for 27 nominated participants from Madhya Pradesh State Bamboo Mission were organized.

- NECTAR has initiated three Geospatial application projects in North East. The projects are on Mapping of Fruit cultivation areas in Ribhoi and East Khasi hills district of Meghalaya, Mapping of Medicinal and Aromatic and Dye yielding plants of Assam and Micro level Mapping of flood prone and most vulnerable areas of Assam.

Important Output Indicator:

S.No.	Parameters	Output
1	National Conferences Organized, sponsored, and participated	26
2	National Level Online Webinars organized (Lock down series)/ Participated/talks delivered	21
3.	Number of persons who attended various science outreach programs/conferences etc.	6
4.	Number of students trained	4

5.20 Vigyan Prasar (VP), Noida

The Institute focuses on science communication popularisation & extension.

Major Accomplishments:

- Vigyan Prasar (VP) uses multiple approaches to deliver value-added scientific and technological information/ learning for a wide array of stakeholders. VP has established a network of science clubs and ventured into the areas of science communication, training, gender and technology communication, publishing popular science books/

monthly science magazine, developing knowledge products including Audio & Video Programmes for Radio and television.

Important Highlights of major Programmes:

- VP published 12 periodicals per month in different Indian languages and 12 popular science books.
- VP produced more than 300 films for India Science and organized more than 100 seminars/webinars.
- Total social media outreach of the institute was more than 10 lakhs.
- Science communication popularisation and extension in-Indian Language.
- Institute started science communication courses at various universities.
- Started community radio stations for the elderly to keep them abreast with science & technology.
- Institute completed 30 episodes of AIR Series on Artificial Intelligence.
- VP published fortnight Covid Newsletter throughout the year.

Important Output Indicators:

S.No.	Parameters	Output
1.	Papers in refereed journals	12
2.	Books/Monographs	18
3.	Chapters in Books	40
4.	Papers in Conferences	48
5.	National Conferences Organized	40
6.	State-of-the-art-Reports Published	24
7.	Original Science Communication Content Designed	400
8.	Popular Science Books/Newsletters published	100
9.	Scientific Lectures/Training Programmes organized	60
10.	Data Bases Compiled	22

5.21 Indian Academy of Sciences (IASc), Bengaluru

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 publishing scientific journals magazines, Recognition of scientific talent, to provide inputs for

policies that pertain to science and translation, scientific meetings, discussions, seminars, symposia and science education courses and workshops.

Major Accomplishments:

- Over 1590 peer-reviewed articles in 19454 pages have been published in 12 thematic journals and the entire content 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.
- Twelve thematic special publications and 5 books were published.
- Under the Summer Research Fellowship programme, 1,017 students and teachers availed 2 months' fellowship.
- Twenty-one Lecture Workshops and 5 Refresher Courses were organised.

Important Highlights of Major Programmes:

- 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 1000 print versions of Resonance journal was 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*.
- Thirty-Seven outstanding scientists from India and one foreign scientist were inducted into the Academy Fellowship and Honorary Fellowship respectively.
- The Associateship programme was introduced in 1983 to identify and encourage promising young scientists. Eleven promising young scientists were selected. The Associateship is tenable for a minimum period of 3 years or a maximum period of 6 years.
- The Academy annually holds scientific meetings, symposia and public lectures and encourages other similar activities to provide means of exchange of scientific knowledge among scientist and to bring new knowledge to the attention of scientific community. During the reported period the 32nd Mid-Year Meeting 2021 and 87th Annual Meeting were held virtually.
- Dr. Catherine Rosemary Martin, FRS., Professor of Plant Sciences at the University of

East Anglia and project leader at the John Innes Centre, Norwich, occupied the Janaki Ammal Chair and delivered online lectures in October 2021.

- The Academy collaborated with the other two National Science Academies in the country viz., INSA, New Delhi and NASI, Allahabad for implementing Science Education Programmes.

Important Output Indicators:

S.No.	Parameters	Output
1.	Books/Monographs	5
2.	National Conferences Organized	2
3.	Original Science Communication Content Designed	114
4.	Popular Science Books/Newsletters published	5
5.	Number of persons who attended various science outreach programmes/conferences etc.	~ 1000
6.	Scientific Lectures/Training Programmes organized	49
7.	Number of students trained	7350
8.	Number of school/college/university teachers trained	360
9.	Number of Innovators trained	893
10.	Number of Innovations Registered	11658
11.	Data Bases Compiled	6
12.	Compendia of Historical Data compile	1

5.22 Indian National Academy of Engineering (INAE), New Delhi

A brief overview of the major activities/achievements of Indian National Academy of Engineering (INAE) is as under:

Major accomplishment:

- The INAE Youth Conclave 2021 was organized jointly with IIT Bombay; NITIE, Mumbai and ICT, Mumbai online. The five themes of the Conclave were Waste to wealth; Digitization and revolution in logistics; Engineering intervention to fight against COVID-19 and healthcare management and Teaching and learning in pandemic.
- Engineers Conclave 2021 was organized jointly by INAE and International Solar Alliance (ISA) as a virtual event. The two themes of the conclave were “Engineering challenges for de-carbonizing the Indian Economy” and “Achievements of Indian Engineering - Azadi ka Amrit Mahotsav”.
- Ten nominees were conferred Abdul Kalam Technology Innovation National Fellowship.

Important Highlights of Major Programmes:

- The 15th National Frontiers of Engineering Symposium (NatFoE-15) was organized jointly by INAE with IIT Hyderabad as a virtual event. The four themes for NatFoE-15 were Artificial Intelligence & Machine Learning; Advances in Materials & Manufacturing Technology; Infrastructure & Unconventional Energy and Rural Entrepreneurship. The National Competition on Innovation in Manufacturing Processes for engineering students and practitioners was dovetailed with this event.
- A Digital Platform had been created to facilitate INAE Fellows submitting nominations online for Fellowship, schemes and awards; conduct of webinars and digitizing of INAE activities. Several new features were introduced in the modules for review of Fellowship nominations, schemes and awards during this year.
- The 4th INAE- National Academy of Engineering of Korea (NAEK), Korea Workshop on “What’s next in Aerospace Engineering and Materials” was organised. The workshop focused broadly on the following three domains: Aerospace Engineering systems and Aerodynamics; Innovation for Materials in Aerospace industry and Additive Manufacturing for Aerospace industry.

Important Output Indicators:

S. No.	Parameters	Output
1	Books/Monographs	1
2	International Conferences Organized	1
3	National Conferences Organized	3
4	Journals Published	1
5	Number of students trained	59
6	Number of school/college/university teachers trained	25

5.23 Indian National Science Academy (INSA), New Delhi

The areas of focus are the Promotion of science in India and harnessing scientific knowledge for the cause of humanity and national welfare.

Major Accomplishments:

- Indian National Science Academy (INSA) is a national body of Indian Science devoted to the pursuit of identifying, nurturing excellence in sciences, assisting stakeholders with aspect of policies on science. INSA achieved all its objectives fully in respect of interfacing with international science bodies. The Academy recognizes Indian scientists excelling in their work by electing them as Fellows covering all sciences, engineering, medicine, agriculture and interdisciplinary research.

Important Highlight of Major Programmes:

- During the year, three special publications namely, Vignettes for Success in Academia -A Guide for Young Researchers, Drug Discovery and Drug Development-The Indian Narrative (In collaboration with Springer), and Host Immunity and Vaccines Covid-19-A White Paper were published.
- The Academy elected 40 Fellows and 3 Foreign Fellows to the Fellowship.
- Thirty-six young researchers were selected by the Academy for the INSA Medal for Young Scientists.
- Fifteen outstanding teachers were honored with INSA Teachers Award.
- Under the Science Promotion Programme, the Academy supported 02 Distinguished Professors, 70 Senior Scientists, 20 Honorary Scientists, 31 Emeritus Scientist for advanced research in their specialized disciplines.
- Under the INSA Visiting Scientist Program, sixty scientists were awarded Visiting Fellowships to conduct collaborative research and training in India.
- Twenty-eight research projects on aspects of History of Science in India were supported.
- Two researchers selected for INSA Young Historian of Science Award.

Important Output Indicators:

S.No.	Parameters	Output
1.	Books/Monographs	3
2.	Journals Published	3
3.	Scientific Outreach Programmes organized (Webinar)	17
4.	Scientific Lectures/Training Programmes organized	7

5.24 The Indian Science Congress Association (ISCA), Kolkata

The Indian Science Congress Association (ISCA) is working on the popularization and advancement of science by organizing seminars, symposia, discussions, popular lectures, quiz contest etc. through out the year.

Important Highlights of Major Programmes:

- Published ISCA bi-monthly journal Everyman's Science.
- ISCA and its chapters organized various webinars/training programs/workshops etc. in the following areas:

- New Horizons in cancer biology and therapeutics.
- Advances in Science and Technology.
- Science for Peace and Development”.
- Paradigms and opportunities for cross disciplinary research and social sciences with a focus on ‘national development’.
- Science and Technology in the service of common man.
- Science and Technology for Women Empowerment.
- Ozone protection to pollution.
- Sciences and Technology Communication.
- Several Other conference/workshop/seminar/Lecture series were also organized in association were other university/institutions series.
- Future of Science, Technology Innovation: Impacts on Education, Skills and Works”.
- Big Data Analytics & Cloud Computing.
- Earthquake Risk Reduction: Perception, Mitigation and Management.
- Geological and Mineral Significance of Meghalayan.
- Biodiversity Conservation & Future Strategies.
- Women in Science and Technology: Career and Opportunities.
- Science Temper: Indigenous Knowledge.

Important Output Indicators:

S.No.	Parameters	Output
1.	International Conferences Organized	3
2.	National Conferences Organized	14
3.	Scientific Outreach Programmes organized	2
4.	Number of persons who attended various science outreach programmes/conferences etc.	2000
5.	Scientific Lectures/Training Programmes organized	5

5.25 The National Academy of Sciences-India (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 Accomplishments:

- The Academy organized more than two dozen Webinars under the Jagrukta Abhiyan for Covid-19 pandemic.
- The Academy also organized several activities for combating the menace of malnutrition in view of the poor health status of women, children, and the rural population of the society.
- 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 0.788; PNASI, Sec. A received Impact Factor (IF) as 1.544; and the PNASI, Sec. B received CiteScore as 1.7.
- A bookentitled 'The Ten Most Beautiful Experiments in Science', was also published.
- The Academy organizes an Annual Session and a Symposium every year to sensitize the PG students, researchers, and young scientists from all over the country. Due to COVID-19 pandemic the 90th Annual Session of the NASI, was organised on onlinemode, on Feb. 25-27, 2021, which was attended by more than 300 dignitaries and the participants; a symposium on 'Towards a New Healthcare regime for the Nation', was also held during the session. Similarly, the 91st Annual Session was organized on Dec. 4-6, 2021; and a Symposium was held on 'Interface between Biological and Physical Sciences towards Atmanirbhar Bharat'.
- Library services were enriched through digitization of the library and subscribing more books. The Singhania library is connected to National Knowledge Network (NKN). Free of cost Internet facility is also being provided to the students and research scholars.

Important Highlights of Major Programmes:

- The NASI together with other two Science Academies - Indian National Science Academy, New Delhi and Indian Academy of Sciences, Bangalore is jointly sponsoring the Summer Research Fellowship under the joint Science Education Panel.
- In the past the NASI has made scientific galleries on Ganga, Brahmaputra and Cauvery at Prayagraj, Guwahati and Mysuru, respectively. These galleries are equipped with enormous scientific information in interactive domain. The exhibits are dynamic and depict scientific and logical demonstrations/explanations on various natural phenomenon, to cultivate scientific temperament and enthuse the visitors to conserve nature.

Important Output Indicators:

S.No.	Parameters	Output
1.	Journal Published	14
2.	Books	2
3.	Chapters in Books	5
4.	National Conferences Organized	15
5.	State-of-the-art-Reports Published	2
6.	Scientific Outreach Programmes organized	98
7.	Original Science Communication Content Designed	5
8.	Popular Science Books/Newsletters published	6
9.	Number of persons who attended various science outreach programmes/conferences etc.	49022
10.	Scientific Lectures/Training Programmes organized	46
11.	Number of students trained	1200
12.	Number of school/college/university teachers trained	80
13.	Number of Innovators trained	178
14.	Number of Innovations Registered	254
15.	Data Bases Compiled	2
16.	Foresight Reports and Analyses Prepared	2

CHAPTER 6

SCIENCE AND ENGINEERING RESEARCH BOARD

The Science and Engineering Research Board (SERB), a Statutory body of Department of Science and Technology (DST) has taken several significant steps in advancing R&D in frontier areas of science and engineering in 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 identifying and supporting new areas of science have continued 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, had taken key decisions which have profound influence in the S&T landscape.

6.1 Initiatives of the Board include:

SERB – PRISM (Project Information System & Management): SERB has developed a real-time information retrieval portal “SERB – Project Information System & Management (SERB – PRISM)” that provides information related to research support extended by SERB over the years. SERB-PRISM provides a platform to provide project details, research outcomes, facilities created and their achievement, making a strong scientist-scientist and science-society connect. SERB-PRISM will be a significant step forward in SERB’s commitment towards transparency, accountability and dissemination of research outcomes originating from SERB funding, while allowing researchers to look at research trends, learn about cutting-edge science, locate critical equipment in their vicinity and help seek collaborations across disciplines.

SERB Centre for Energy Transformation and Storage: In exploring long-term solutions for sourcing sustainable energy by developing indigenous technologies, SERB has opened up new R&D platforms to integrate new opportunities in smart energy transformation, storage, and management to offset our dependence on conventional energy, provide stable power to off-grid areas, and support the EV revolution. Accordingly, SERB solicited R&D proposals for Centre for Energy Transformation and Storage in three specific areas:

- Electrochemical energy storage systems for micro-grid installations
- Technologies for utility-scale high-capacity batteries
- Transparent photovoltaics for devices and surface integration

Special Call on Critical Components and Innovations in Oxygen Concentrators (Joint SERB-TDB Call): Considering emerging healthcare requirements to combat the COVID 19 epidemic, SERB announced special call to catalyze R&D on critical components and innovations concerning Make-in-India Oxygen Concentrators. The call sought investigation and innovation in the development of (individual/portable) oxygen concentrators in domains of alternate materials and mechanisms for oxygen separation; design, development, and manufacturing of critical components such as valves and oil-less compressors, design improvements for greater performance, AI-optimized oxygen flow devices, and oxygen-level IoT sensors etc. Total 130 proposals were received under the special call and 11 projects were recommended for support by the Expert Committee.

SERB Centres on AI-based Earth Systems Modeling: The SERB Board approved setting up of up-to 3 Centres of Excellence (CoE) for developing AI & ML approach to geohazard and weather & climate prediction. Accordingly, SERB solicited R&D proposals to establish three such interdisciplinary and multi-institutional CoEs in the arena of the Earth and Atmospheric Sciences in the country on the following areas:

- AI & ML for better weather and ocean forecasting, and long-term environmental sustainability.
- Deep learning models for early warning of extreme geohazards.
- AI/ML models to predict climate extremities and climate change mitigation, through high-precision analytics.

SERB-FIRE (Fund for Industrial Research Engagement): Fund for Industrial Research Engagement is an initiative under the Industry Relevant R&D (IRRD) Scheme of SERB. FIRE aims to support research and development to solve critical problems which are relevant industries on a public private partnership mode. The participating industries should partner with the academics and should share 50% of the cost. SERB-FIRE will further help drive impetus to create a transformative research mind-set to foster novel and impactful research ecosystem in the country.

The program with a co-funding mechanism between SERB and industry has been conceived in collaboration with Intel India, GE India and Applied Materials India Private Limited (AMAT). FIRE addresses wide set of research opportunities in the space of Artificial Intelligence (AI)/ Machine Learning (ML), platform systems, circuits & architecture, Internet of Things (IoT), materials & devices, security, next-generation gas turbines, additive manufacturing, engine services technology, electrical systems, digital technologies etc.

SERB - Centres for Antibody Engineering: SERB seeks to advance research in antibody technology by establishing integrated antibody engineering platform(s) in India through R&D centres. The vision of these centres is to drive innovative and interdisciplinary collaborative research in antibody engineering and build critical infrastructures for technology driven

solutions. SERB solicited proposals for establishing centres in antibody engineering research in:

- R & D for antibody generation and modification (a) Multidisciplinary approaches in antibody production including biosimilars, purification, functionalization strategies and scale-up; development of novel antibody libraries. (b) Antibody conversions, Humanization, fragment engineering, post-translational modifications. (c) Novel technologies, such as new display and hyper-mutation technologies, Human B cell clone selection and expansion.; novel vector systems and library platforms.
- ADC Therapeutics: Antibody-based drug conjugates, ADC-based biosimilars; pre-clinical trials and validation of models for therapeutic applications involving antibodies; pharmacokinetic study and safety assessment modules; study and development of novel effector functions.
- Antibody-based diagnostics: Development of high-quality detection of pathogens and immunodiagnostic test kits.

SERB Science and Technology Award for Research (SERB-STAR): SERB-STAR is a prestigious award instituted by SERB to recognize and reward outstanding performance of Principal Investigators (PIs) of SERB Projects. The Award acknowledges exemplary contributions in research and motivates the PIs of ongoing projects for outstanding performance. Each Awardee is given a fellowship of Rs. 15,000/- per month, research grant of Rs. 10 lakh per annum and Rs. 1 lakh per annum as overhead charges for a period of three years. Nineteen Scientists were awarded SERB STAR in 2021-22.

National Science Chair: Eminent scientists, Prof. Rahul Mukherjee, Indian Institute of Management Kolkata; Prof. Bhim Singh, Indian Institute of Technology Delhi; Prof. M. Lakshmanan, Bharathidasan University Tiruchirappalli; Prof. Seyed Ehtesham Hasnain, Indian Institute of Technology Delhi and Prof. B. K. Thelma, University of Delhi South Campus, New Delhi were conferred the prestigious National Science Chair in 2021-22.

Global Research Council – 9th Annual Meet: Global Research Council (GRC) is a virtual organization comprising of the heads of the scientific research councils and research funding agencies. Established in the year 2012, GRC acts as a platform to discuss contemporary issues in science and research and aims to foster high quality research collaborations between global research funding agencies. SERB participated in its 9th Annual Meeting held on an e-platform.

National Postdoctoral Fellowship (NPDF) of SERB – Extension of Fellowship of NPDFs due to COVID 19 Impact: Taking note of the impact of COVID-19 on the planned research work of National Postdoctoral Fellows (NPDFs), SERB had approved extension of tenure of the Fellowship of 2018 & 2019 Batches of NPDFs for a period up-to six months with fellowship. The extension allowed the NPDFs to complete the work as originally planned and suffered due to lockdown and other impacts due to the pandemic.

6.2 Implementation of the following new scheme:

SERB-POWER: SERB had approved institution and implementation of a Scheme: SERB-POWER (Promoting Opportunities for Women in Exploratory Research) to mitigate gender disparity in science and engineering research funding in various S&T programs in Indian academic institutions and R&D laboratories. SERB-POWER is specially designed to provide structured effort toward enhanced diversity in research to ensure equal access and weighted opportunities for Indian women scientists engaged in research and development activities. Women Scientists in regular service in academic and research institution were be supported under two categories, namely, SERB –POWER Fellowship and SERB –POWER Research Grants. The details are given below:

SERB-POWER Fellowship: - Successful Women Scientists were provided a personal Fellowship of Rs. 15,000/- per month in addition to regular income and a Research grant of Rs. 10 lakh per annum for a period of three years. A total of 12 nominations for SERB-POWER Fellowship were recommended in the first-round selection.

SERB-POWER Research Grant: - POWER Grants will empower women researchers by funding them under following two categories:

- Level I (Applicants from IITs, IISERs, IISc, NITs, Central Universities, and National Labs of Central Government Institutions): The scale of funding up to 60 lakhs for three years.
- Level II (Applicants from State Universities / Colleges and Private Academic): The scale of funding up to 30 lakhs for three years.

A total of 93 women scientists were awarded R&D projects under SERB-POWER grant.

6.3 SERB on Covid-19:

The Board was in forefront in initiating value-added programmes to address different facets of R&D management on COVID-19 pandemic. The Board continued its support in key R&D initiatives on COVID-19 by identifying projects through CRG COVID-19 Calls, IRHPA COVID-19 Calls and MATRICS COVID-19 Calls.

6.4 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:

- The J.C. Bose National Fellowship is meant to recognize active, performing scientists and engineers for their outstanding performance and contribution. A total of 10 nominations for J C Bose Fellowship was recommended in the first-round selection.
- 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 40 years. A total of 23 Ramanujan Fellowship were sanctioned.

- 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 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 for accelerated development of scientific and technological progress for the overall economic prosperity of the nation. During the reporting period 37 accomplished scientists have been offered VAJRA Faculty positions.
- Five projects were sanctioned under "SERB-SUPRA (Scientific and Useful Profound Research Advancement)" that seeks to explore new scientific breakthroughs, with long-term impact on our fundamental scientific understanding.
- IMPacting Research INnovation and Technology (IMPRINT): SERB continued to steer the IMPRINT - II Programme of DST- Ministry of Education 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.
- The Board continued to support scientists and technologists belonging to weaker sections of the society through 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.
- Accelerate Vigyan (AV) Scheme: The inter-ministerial scheme Accelerate Vigyan (AV) was launched in July 2020. 'ABHYAAS', a program of AV scheme, is an attempt to boost Research & Development in the country by enabling and grooming potential PG / PhD level students by developing dedicated research skills in selected areas / disciplines / fields through its two components- High-End Workshops ('KARYASHALA') and Training and Skill Internships ('VRITIKA'). This is especially important for those researchers who have limited opportunities to access such learning capacities / facilities / infrastructure. Total 197 and 94 applications received under Karyashala and Vritika, respectively. Total 70 and 43 applications were recommended for support under Karyashala and Vritika, respectively by the ABHYAAS Expert Committee (AEC).

6.5 Programme Advisory Committees continued to play a decisive role in providing core research support to scientists. Highlight of some of the Core Research Grant (CRG) projects are depicted below:

- Corneal scars are a serious cause of visual impairment and blindness affecting millions, worldwide. Conventional treatment for blinding corneal pathologies is corneal transplantation. However, corneal transplantation has many limitations like, but not limited to, global lack of donor corneal tissue and post-operative issues such as immune rejection, infection, and glaucoma. Recent advances in regenerative medicine have opened the alternative possibility of using stem cells for treating corneal diseases. In this line project has been supported to investigate the optimization procedure for isolation, preservation, transportation, and delivery feasibility of human limbus-derived stromal/mesenchymal stem cells (hLMSCs) for clinical use and can be one of the alternate treatments of corneal scars. As part of the objective investigators showed that during transit the container maintained with an average temperature of 18.6 ± 1.8 degree Celsius were recovered with high cell viability compared to average room temperature ie 31.4 ± 1.2 degree Celsius. Also the encapsulated hLLMSCs with alginate beads showed greater survival rates without altering their phenotypic characteristics.

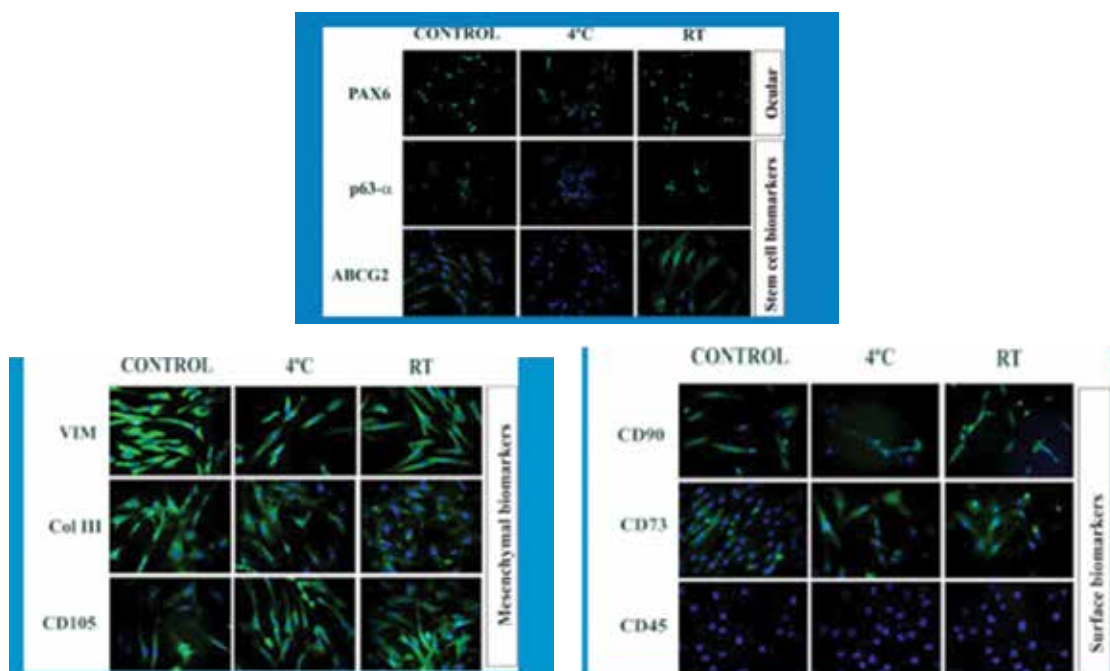


Figure Phenotypic expression of the biomarkers by hLMSCs after encapsulation and transit with appropriate biomarkers using immunostaining method.

Alginate encapsulated hLSMCs of both groups, stored/under transit for 3 days have shown the expression of Pax6+, stem-cell biomarkers (ABCG2+, p63-α+) and the mesenchymal biomarkers (VIM+, CD90+, CD105+ and CD45-) with respect to the control cells.

From the study investigators suggest that alginate encapsulation is an effective method of hLMSC preservation offering high cell viability over prolonged durations in transit at RT, therefore, potentially expanding the scope of cell-based therapy for corneal blindness.



The interesting findings were published in Scientific reports (2019) vol 9: 1-11.
(DOI No : <https://doi.org/10.1038/s41598-019-53315-x>)

Figure. Collage of images showing the process of encapsulating hLMSCs in sodium alginate and their transport at room temperature.

- **Project on *Investigation on Machine Learning approaches for optimisation of process parameters for Additive Manufacturing and accelerated design of patient specific hip implants, based on Finite Element Analysis* sanctioned at Indian Institute of Science, Bangalore**

The project is started with experimental optimization of DED process parameters for stainless steel. Now that the parameters are optimized towards obtaining desired combination of microstructure and properties, these parameters will be used as input to ML algorithms.

As-received SS316L austenitic steel powder is characterized to determine the shape and morphology (as shown in Figure 1) by scanning electron microscopy (SEM). The SEM analysis reveals the particles are spherical and uniform. Small satellite particles can be seen from the SEM images. Particle size distribution is characterized by Laser particle size analyzer (as shown in Figure 2).

The samples were etched to understand the solidification microstructure. The optical micrographs and SEM of the etched samples can be observed in the Figures 3. The grain boundaries and cellular substructures can be clearly seen.

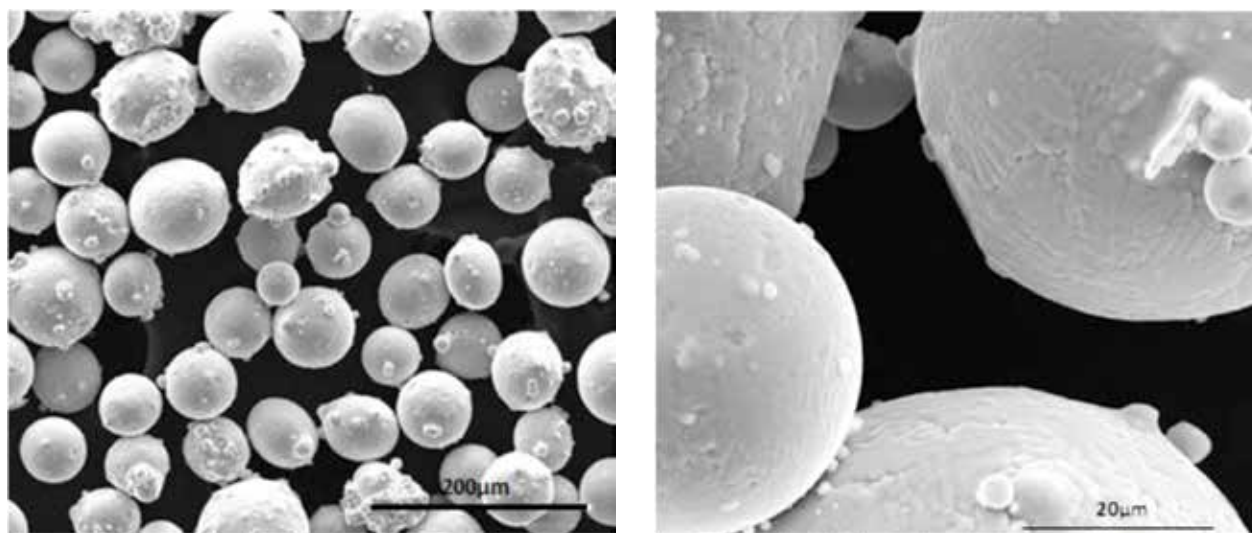


Figure: Scanning Electron micrographs of the SS316L

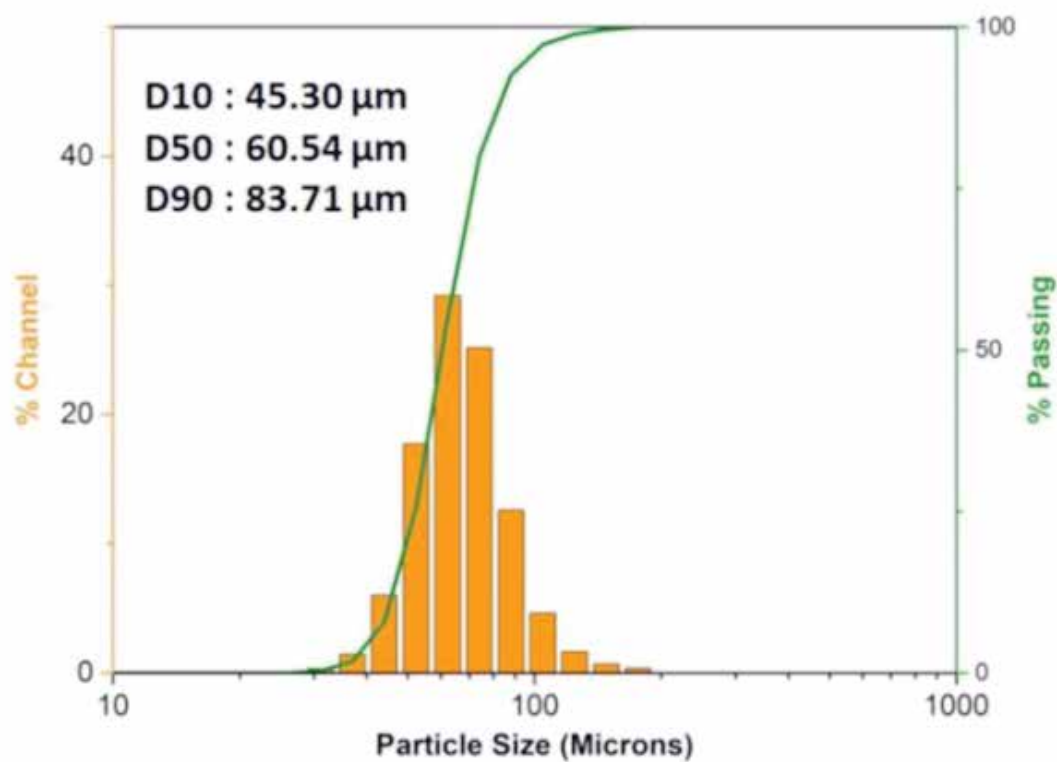


Figure: Particle size distribution analysis of the SS316L powder

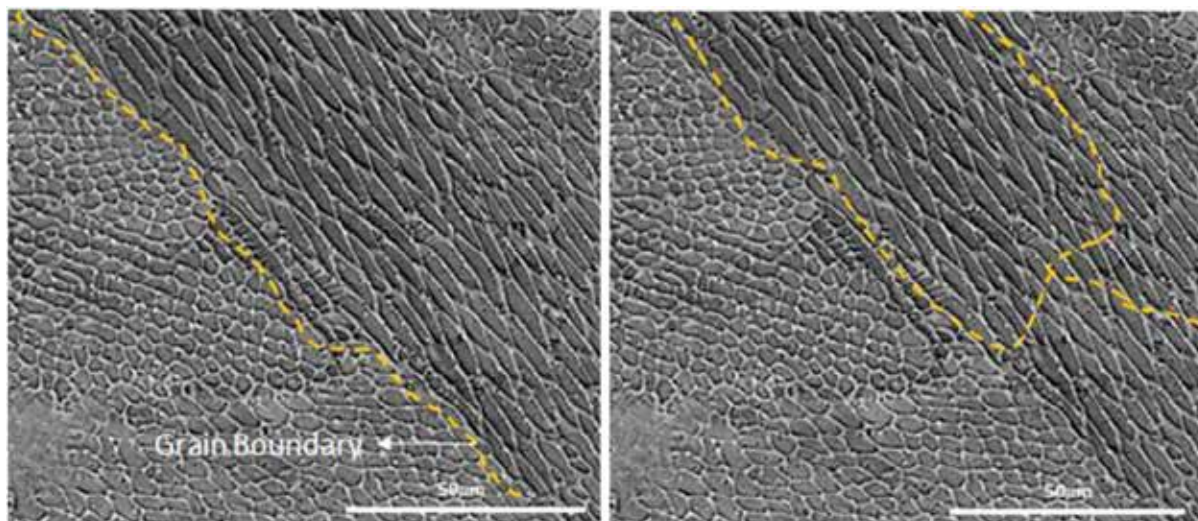


Figure: SEM of the 3D printed SS316L sample revealing the cellular structure

- **A project on *Large Scale Anisotropy in the Universe* sanctioned at Indian Institute of Technology Kanpur**

Many cosmological observations indicate a violation of isotropy with a preferred axis pointing roughly in the direction of the Virgo supercluster. In this project PI has studied such signals, developed data analysis techniques for future observations as well as developed theoretical models in order to explain deviation from isotropy.

Statistical isotropy is a basic postulate of Big Bang cosmology, enshrined in the cosmological principle. Theoretically, however, this principle is purely an assumption and is inconsistent with causality unless we invoke inflation. The basic argument is that at very early time the Universe may be inhomogeneous and anisotropic. During inflation a small patch of the Universe undergoes exponential inflation and, after about one e-fold, is well described by the isotropic and homogeneous FRW metric. In an earlier paper, PI's group has shown that perturbative modes generated during this early phase can affect observations today. The wavelengths of these modes would be very large, perhaps larger than the size of the horizon. In Das et al (JCAP 07(2021)035) PI has shown that these superhorizon modes nicely explain the excess dipole seen in large scale structures. In a recent preprint (Tiwari et al arXiv:2111.02685) PI's group have shown that these modes also explain the Hubble parameter discrepancy seen in data, as shown in the figure below. In this plot the lower line is the Hubble parameter extracted by CMB observations, while the data points are extracted from local measurements. The upper line shows our theoretical estimate for small redshifts. Hence the observed cosmological discrepancies, such as large-scale anisotropy, Hubble parameter discrepancy may all be explained in terms of the superhorizon modes or equivalently by invoking an early phase of inflation.

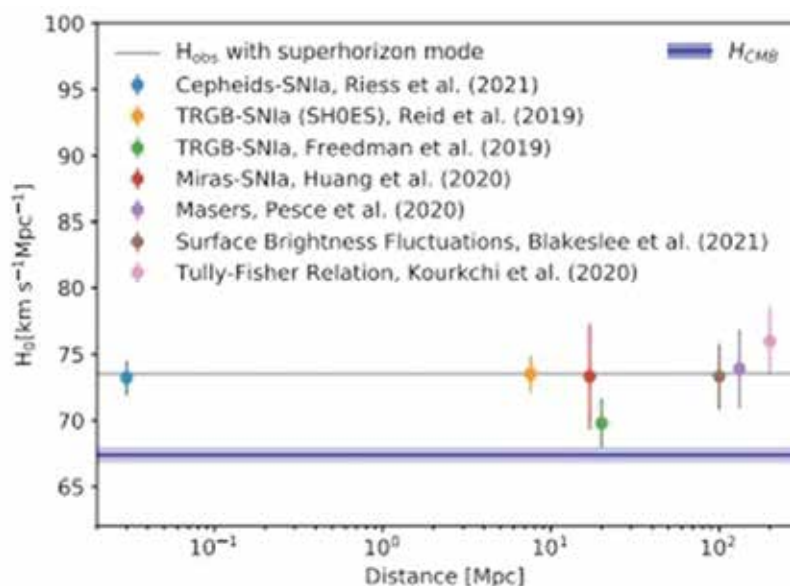


Figure. Apparent value of Hubble–Lemaître parameter with direct measurements at different distances.

Interesting results were emanated from R&D projects supported under SERB-SUPRA. Highlights of one of the projects are given below:

A project on Is molecular engineering the key for newer breakthroughs in Quantum Information Processing? Sanctioned at IIT-Bombay

The project addresses the issue of enhancement of fundamental understanding that controls the coherence time, eventually paving way for the rational design of molecular qubits with longer coherence time at higher temperatures, ideally at the room temperature.

Besides $S = \frac{1}{2}$ systems, a molecular complex with $S \geq 1$ combined with large zero-field splitting would of interest as this yields a well-isolated doublet suitable for addressing them as Q-bits or as multiple Q-bits commonly called as Q-dits. In this regard, in silico search for Mn(III), Co(II), and Cr(II) SMMs were performed, and the role of spin-phonon coupling in controlling the anisotropy is directly correlated to the T_1 relaxation time is computed. Both the experimental and in-silico studies suggest the importance of ideal D_{3h} symmetry in obtaining larger anisotropy. Deviation from this ideal D_{3h} geometry was found to significantly diminish the anisotropy (Figure 1).

A second system that has been investigated with $S = \frac{1}{2}$ is based on vanadyl ion (or oxovanadium (IV) cation) that has been incorporated in the form of a 2-D lattice which packs into a layered solid (Figure 3). This compound has been isolated and structurally characterized. Investigations on the EPR characteristics of this molecule and its possible utility as a Q-bit will be explored in the coming year.

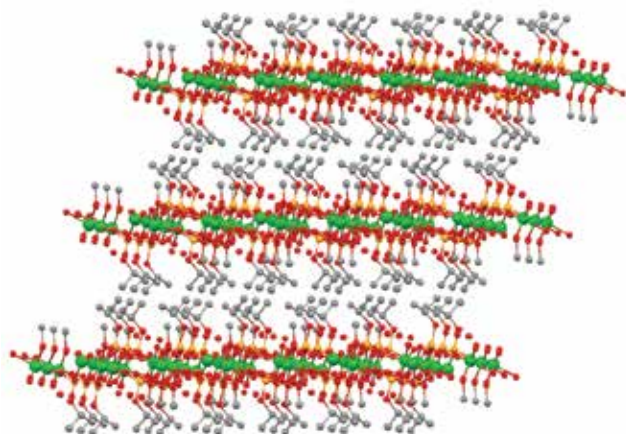


Figure. (left) Diagram showing oxovanadium(IV) organophosphate based layered solid.

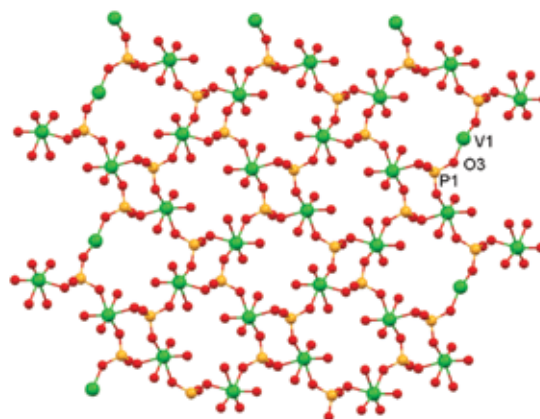


Figure. (right) Perpendicular view of a single sheet showing fused 16- and 8-membered V-O-P rings where the V(IV) centres are periodically arranged; carbon atoms omitted for clarity.

6.6 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. Highlights of one of the projects is given below:

- **Project on *Application of Nanoparticles in ESP for Inactivation of Microorganisms and Degradation of VOCs for Air Purification* sanctioned at IIT-Bombay**

Detailed methodology has been developed to synthesize TiO₂ based materials and experimental design developed to synthesize NPs of different properties. The design of experiments has been done to using experimental parameters such as precursor and solvent choice, percentage of solvent and water in solution, the drying temperature, time and method, calcination temperature and doping concentration for NP synthesis.

The photocatalytic reactor that is conceptually designed and fabricated (shown in Figure). The photoreactor shown below is conceptualized in such a way that few parameters can be studied simultaneously.

Bacterial disinfection model was developed for a model bacteria. The disinfection rate was investigated for various TiO₂ based NPs under different experimental conditions (light intensity, catalyst loading etc.). Optimization was done to understand conditions under which maximum disinfection can be achieved. It was found that doped TiO₂ is more effective under certain conditions. This gives an idea for screening of TiO₂ nanomaterials and conditions that may be effective for inactivation

Mathematical model has been conceptualized and developed for gram negative bacteria (*Serratia marcescens*) considering all the parameters that impact the bioaerosol disinfection in air. The important parameters that impact the disinfection such as relative humidity, Nanoparticle dose, Light intensity, air velocity (retention time) were considered in the photocatalytic disinfection model.

ESP has been conceptually designed as per the requirements of nanoparticles coating and bacterial disinfection. Mathematical model developed in this work can be used for other systems and can be a good tool for designing of the large scale bioaerosol disinfection for different practical settings. Indoor air purification and biological contaminant treatment and theoretical determination of efficiency of photocatalytic disinfection.

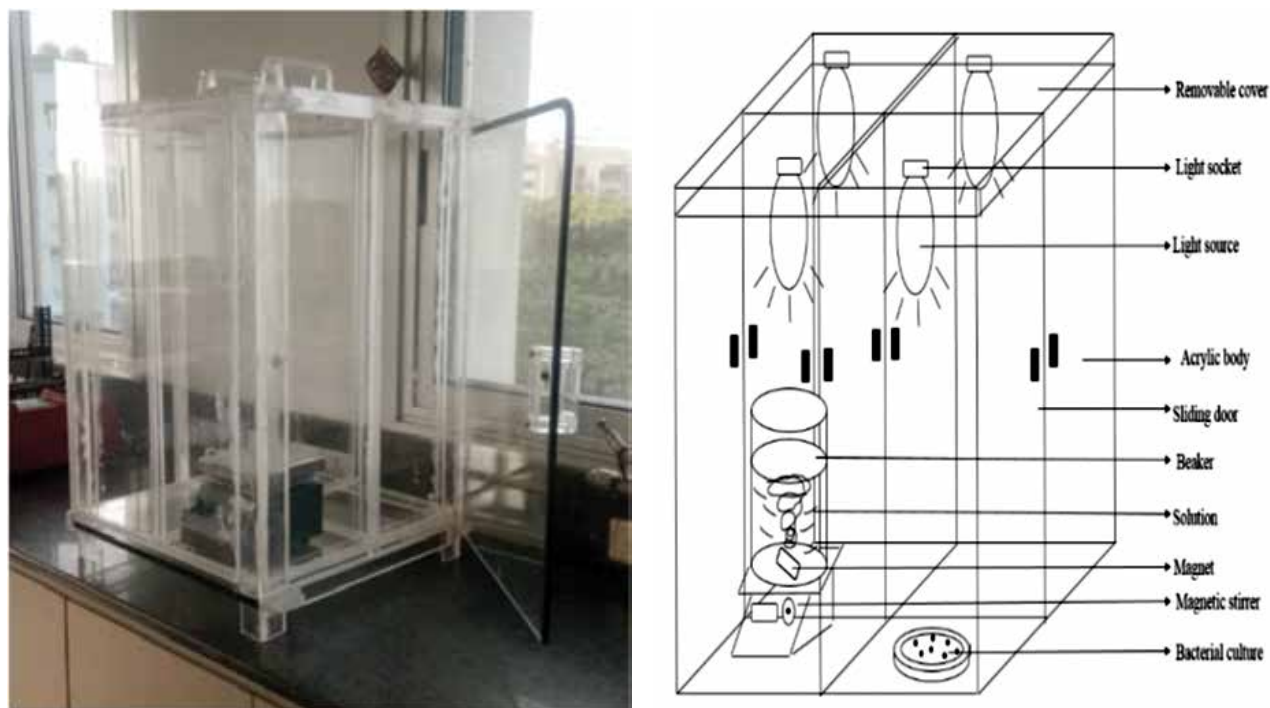


Fig.. Customized fabricated photo reactor and its design for multiple purpose inactivation

6.7 In the reporting period 391 young researchers have been offered National Postdoctoral Fellowship. The NPDP 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. Highlights of one of the fellowships awarded in the past is given below:

Development of a lossy mode resonance based fiber optic biosensor array platform for Ochratoxin-A detection in foods at Indian Institute of Technology Madras, Chennai

Optical fibers (FT400UMT, ThorLabs) of 400 μm core diameter and 0.39 NA procured from Thorlabs were used as the substrate to prepare U-bent probes. To develop the sensor platform, initially, straight optical fibers of 25 cm length with a sensing length of 1 cm in its middle portion were prepared. The decladded fiber (cladding removal) was then manually bent into a U-shape with a diameter of 1.4 ± 0.2 mm (optimized for maximum sensitivity) by exposing it to a butane flame. The SEM micrograph of the U-bent sensing region is shown in Fig.1.

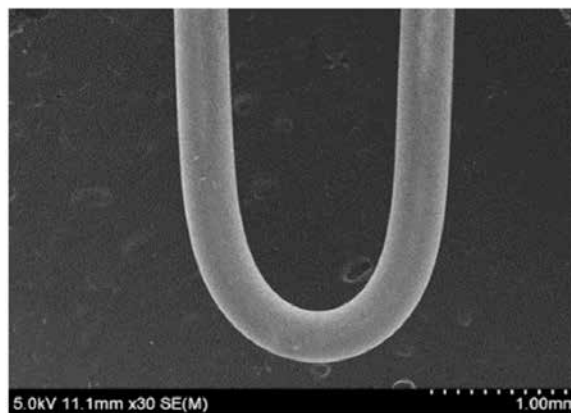


Figure: SEM micrograph of the U-bent sensing region

The U-bent fiber probe tip is then dipped into a custom-made glass sample holder/vial as depicted in Fig.2a for further material depositions in the probe fabrication procedure and sample analysis carried out in real-time with online monitoring. The photograph of the U-bent probe fabricated with the legs connected to source and spectrometer is shown in Fig. 2b.

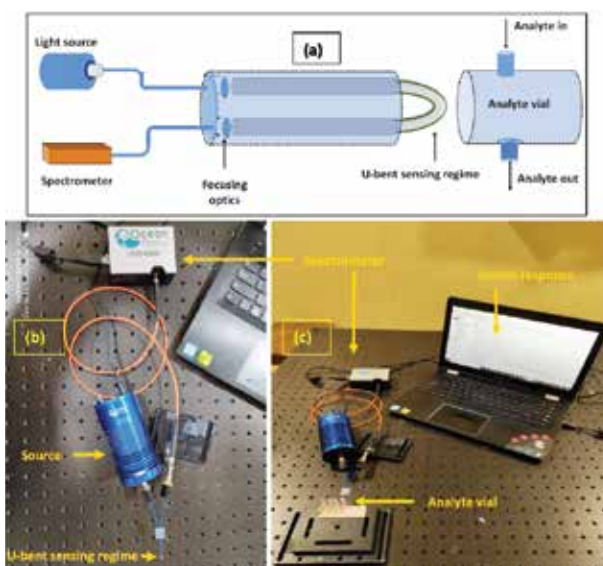


Figure: U-bent probe fabricated with the legs connected to source and spectrometer

Conclusions:

A localized surface plasmon resonance-based U-bent fiber optic sensor for the ultrasensitive detection of Ochratoxin A in a label-free manner is developed. The study provides both a methodology and sensor device to selectively detect ultra-low concentrations of OTA in food samples. A compact U-bent optical fiber sensor is functionalized employing metallic nanoparticle and composite solution of ZIF-8 and antibody specific to the food toxin. The in-situ crystallization of ZIF-8 along with the guest material as antibody tuned the porosity of ZIF-8 to ensure antibody encapsulation without leaching. Also demonstrated the utilization of dip-type fiber optic sensor device in rapidly detecting OTA traces in a label-free immunoassay format in grape juice. The user-friendly and cost-effective system developed can also be fabricated as a handheld, field-deployable sensor using a simple pair of LED-photodetector, which allows easy handling by non-skilled personnel as well. The device can meet food safety requirements in houses, food industry, and poultry farms.

6.8 The online portal www.serbonline.in has been made operational for most of the major schemes of SERB.

TECHNOLOGY DEVELOPMENT BOARD

Technology Development Board (TDB) is a unique government organization (a statutory body under administrative control of Department of Science & Technology) with a very specific mandate to provide financial assistance to the industrial concerns and other agencies attempting development and commercialize applications of indigenous technology or adapting imported technology for wider domestic application.

The Board was constituted through Technology Development Act, 1995 and has commenced its activities from 1st September, 1996. This year, on 1st September, 2021 TDB has completed 25 years of its dedicated service to the nation. The first Board of TDB had legendary missile man of India and Bharat Ratna, Late Dr. A.P. J. Abdul Kalam amongst them.

In pursuance to its mandate, TDB accepts applications for financial assistance throughout the year from all sectors of economy such as Health & Medical, Engineering, IT, Chemical, Agriculture, Telecommunications, Road Transport, Energy & Waste Utilization, Electronics, Defence, Civil Aviation, Textile, etc.

Agreements Signed during 2021-22

- TDB has signed a Loan agreement with M/s Botlab Dynamics Private Limited, New Delhi, a startup incubated at IIT Delhi for the project titled “Design and Development of a Reconfigurable Swarming System Consisting of 500-1000 Drones for 3D Choreographed Drone Light Shows”. In drone swarming, flying hundreds of drones simultaneously while controlling their flying pattern through a single software platform is a technological challenge. To achieve this goal, Botlab team has indigenously developed all the necessary components, including both hardware and software such as the flight controller (brain of the drone); precision GPS; motor controller; Ground Control Station (GCS) algorithms etc. For this project, TDB has sanctioned a Loan Assistance of Rs. 250.00 lakh out of the total project cost of Rs. 665.84 lakh vide a loan Agreement dated 08.11.2021.
- TDB has signed a Loan agreement with M/s Manjeera Digital Systems Private Limited, Hyderabad for the project titled “Development and Production of Receiver Modules for NavIC and GPS” to commercialize NavIC and GPS receiver modules. For this project, TDB has sanctioned a Loan assistance of Rs. 473.00 lakh out of total project cost of Rs. 1425.00 lakh vide Loan Agreement dated 13.12.2021.

Call for Proposal “Commercialization of technologies by the startups for SELFRELIANT INDIA”

TDB, in a proactive approach, issued a ‘Call for Proposals’ inviting applications from Indian Start-ups and Innovators having indigenous innovative technologies across sectors which are ready for commercialization on July 16, 2021. In response to the call, a total of 56 applications were received covering different sectors viz. Energy and Waste Utilization, Information Technology, Health and Medical, Agriculture, Engineering, Electronics, Defenses & many others.

Impact of Call for Proposal issued for “Fighting COVID-19”

Though a special call made during 2020 seeking solutions for fighting COVID 19, TDB helped several startups to commercialize their products like testing kits, masks, sanitisers, thermal scanners, and medical devices to bring about meaningful contributions in India’s fight against COVID 19. Some of the science-based startups / companies funded under this call are Mylabs, Nanoclean Global, Thincr Technologies, Evobi Automations, Latome Electric India, Briota Technologies, and Cocoslabs Innovative Solutions etc. who are playing critical role in combating COVID 19 pandemic and helping the nation deal with the crisis.

25th Foundation Day of TDB on 1st September, 2021

TDB celebrated 25th year of its foundation on 1st September, 2021. The event marked the presence of Dr. Jitendra Singh, Hon’ble Minister of State for Science & Technology (Independent Charge), Prof. K Vijay Raghavan, Principal Scientific Adviser to Govt. of India (Virtual), Dr. VK Saraswat, Member, NITI Aayog, Dr. Renu Swarup, Secretary, Department of Science & Technology (Additional Charge), Prof. Ashutosh Sharma, Former Secretary, Department of Science & Technology, Dr. Krishna Ella, Founder, Bharat Biotech, Dr. K. I. Varaprasad Reddy, Founder, Shantha Biotech, Dr. Kiran Mazumdar Shaw, Chairperson, Biocon Limited & Ms. Akshara, Co- Founder, Coco Labs. At the event, Hon’ble Minister unveiled TDB’s Special Report on Signature Companies funded by TDB.



STRENGTHENING SURVEY AND MAPPING ACTIVITY

8.1 SURVEY OF INDIA

Survey of India the national mapping agency (NMA) of the country bears a special responsibility to ensure that the country's domain is explored and mapped suitably, provide base maps on 1:25K/50K/250K scales for expeditious and integrated development and ensure that all resources contribute with their full measure to the progress, prosperity and security of our country now and for generations to come. In an innovative effort to use new technology to make mapping activities easier and more efficient, Survey of India (Sol), under the Min of Science & Technology planned to use professional grade drones for Large scale Mapping (LSM) and Svamitva Project under the ministry of Panchayati Raj (MoPR) in the country

Sol expert advice is being utilized by various Ministries and undertakings of Govt. of India in many sensitive areas including settlement of International Borders, State Boundaries and in assisting planned development of hitherto under developed areas. To fulfill the above responsibility Sol carried out the following activities during 2021-22

TECHNICAL ACTIVITIES IN SURVEY OF INDIA:

Departmental Activities:

8.1.1 High Resolution National Topographical Data Base (HRNTDB):

With the rapid development and industrialization in the country, there is a tremendous pressure on the resources which makes planning & utilization of resources more challenging. Effective planning for the development requires accurate resource mapping at optimum resolution. Survey of India has undertaken preparation of HRNTDB for entire country by using High Resolution Satellite Imageries (HRSI) to cater for accurate high-resolution data requirements/ demands from various users and organisations.

The following activities are being carried out for generation of HRNTDB:

- Data Acquisition using professional Survey Grade Drones/procurement of HRSI
- Ground Control Provision (GCPs)/ High Precision Levelling

- Geo-referencing of High-Resolution Satellite Imagery (HRSI)/ Data Processing
- Feature Extraction
- Ground Validation
- Establishment of Continuously Operating Reference Stations (CORS)
- Geoid Model Development
- Preparation & updation of Administrative Boundary Database
- Toponymy (Place Names)

Achievements:

HRNTDB:

§	HRSI procured	= 5704 Sq.Km
§	Geo-referenced	= 528 Sq.km
§	Feature Extraction	= 18253 Sq.Km
§	Ground validation	= 400 Sq.km
§	Final data preparation	= 164 sheets on 1:10,000 scale

8.1.2 Defence Series Maps (DSM)

Status of printing of DSM sheets/maps:

DSM on 1:50K scale	DSM on 1:250K scale	Secret / Top secret
Printing (Maps)	Printing (Maps)	Printing (Maps)
1809	32	22

8.1.3 Administrative Boundary Database:

Administrative boundaries database comprises data of the administrative set-ups across districts & states in the country. First cycle of preparing ABDB data up to village level had been completed in the past as this layer is an important component of NTDB also, however next cycle of preparing latest up-to-date ABDB data is under process. 481 Districts completed and data uploaded on G2G Portal <https://g2g.indiamaps.gov.in>. Work in the states of Rajasthan, Assam & West Bengal is under progress and will be completed soon.

Toponymy (Place names): Survey of India is responsible to prepare Toponymy (Place Name) data layer as one of the fundamental dataset layers as per mandate of Sol, National Map

Policy (NMP) -2005. These names are field verified to ensure correct linguistic phonetics in spellings followed with transliteration as per approved system. Primarily the place names are depicted in English language in Topographical maps. Sol transliterated the Toponymy layer in all 22 languages as mentioned in constitution of India. Toponymy layer in all 22 languages is available on Sol public portal... <https://indiamaps.gov.in/>



Bengali



Gujrati

8.1.4 Geoid Model Development:

Geoid is an equipotential surface of Earth's gravity field which best fits in a least square sense, global mean sea level. To realize this hypothetical surface, Survey of India has been conducting field works on massive scale which includes high precision levelling, GNSS observation & Gravity observation all over the India. Geoid Model Development for the states of Uttar Pradesh, Uttarakhand, West Bengal, Bihar and Jharkhand is completed and for the rest of the country is under progress.

8.1.5 CORS Network:

Establishment of CORS network in the states of Uttarakhand, Uttar Pradesh, Haryana, Karnataka, Rajasthan, Maharastra, Madhya Pradesh is completed (Nearly 40% country covered for CORS) & for the state of is Under progress.



CORS Station

8.1.6 International Boundary:

- The 4th JBC between India and Bangladesh was held at New Delhi from 21st to 23rd September 2021. The Bangladesh delegation was led by Md. Moyazzem Hossain, Director General, Department of Land Records and Surveys, Bangladesh and Indian delegation was led by Mr. Naveen Tomar, Surveyor General of India.
- The Joint Technical Level Meeting between the Survey organization of India and Bhutan on boundary talks was held at Jaigaon, India from 8th and 9th September 2021. The delegation from Survey of India was led by Col Ranjan Negi, Director, Meghalaya & Arunachal Pradesh GDC, Shillong along with other dignitaries, viz member from respective state Govt. IBD(SGO), New Delhi, MHA & MEA of India and the delegation from Bhutan was led by Mr. Sangay Dorji, Director, Specialist, International Boundaries, Bhutan.



Joint Technical Level Meeting between India & Bhutan

8.1.7 Onlinemaps Portal (<https://onlinemaps.surveyofindia.gov.in/>):

The Govt. of India in Feb 2021 announced the liberation of the Geospatial Policy of India. It has announced a new Geospatial policy to unlock new avenues for business, private sector, and research institutes to build applications and drive innovation in the creation of digital public goods. *SoI in association with NIC has launched a new portal “onlinemaps” on 17th of August 2021 by the Secretary DST Prof. Ashutosh Sharma, at Raman Auditorium, DST, New Delhi.*

With the launch of this online portal, the users(citizen of India) will no longer have to visit the SOI offices, and they can easily purchase and download products online at their doorstep through Bharat Kosh payment gateway of Govt of India. The Onlinemaps portal provides a range of digital products like Digital Geographical Map, Railway Map, Political Map, Digital

Geographical Road Map, Digital Geographical Physical Map of India, Open Series Map Scale, and so on to citizens of India



Inauguration of Online maps portal by Secretary, DST

- 4518 Maps in PDF and 17 digital products are available on the portal.
- 12181 Individuals/private and 75 Govt. organization are registered with the portal
- A revenue of Rs. 1627746 generated till date.
- 83339 (Approx. cost Rs. 50000000) free maps has been downloaded till date.

G2G Portal (<https://g2g.indiamaps.gov.in>): SOI's G2G Portal Application is a web-based GIS solution designed primarily to visualize on map through functionalities like layer list, search nearby, base maps, import shape files etc. and to draw, download layers etc. Defence forces and paramilitary forces based on their request. Credentials have been generated for 720 Government users.

Benefits:

- Free access of accurate & authoritative GIS-ready spatial data.
- Free uses of data for Consultative, Research & Education Purposes
- Free access to various base maps viz Imagery, Hill Shade and Vector data.
- NTDB as service for various G2G applications.
- Facilitate users with data correction/update
- Facilitate users to develop value added products/datalayers
- Serve the nation through Research, Linkages, outreach, Capacity building & better governance with effective resource management



8.1.10 Spelling of Geographical names:

New names / Change names request received for 17 Railway Stations, 21 places and 02 Islands names were processed for Standardised /Romanized spelling as per Indian System of Transliteration. These requests are duly verified in the field by State Geo- spatial data centres before submission to the DST/ MHA.

8.1.11 International Boundary Verification/Certification:

Scrutiny of 306 maps, certification of 247 maps release of 435 maps. Rs. 18730/- from Central Govt, Rs.30650/- from State Govt. & Rs. 93630/- from Private publications has been received till 31 December, 2020.

8.1.12 Training & Capacity building:

National Institute for Geo-informatics Science and Technology (NIGST), Hyderabad is a premier institution providing training & capacity building in the field of Surveying, Mapping, Photogrammetry, Geodesy & GIS. Besides training to officers and staff of Survey of India, NIGST also imparts training to other Government Organisations, Private Individuals, Scholars from various Afro-Asian countries and for the students from the neighbouring developing countries.

NIGST is well equipped with traditional as well as modern instruments, used for Surveying, Geodesy, Conventional and Digital Cartography, Photogrammetry and Map Printing and is manned by highly qualified and experienced teaching staff.



UAV/Drone Training at NIGST

No. of trainees passed out during this year:

	Completed			Under progress			Total
	Offline	Online	Total	Offline	Online	Total	
Departmental	17	366	383	17	06	23	406
Extra Departmental	141	79	220	16	00	16	236
	158	445	603	33	06	39	642

8.1.13 Extra-Departmental Projects:

SVAMITVA: A Central Sector Scheme of Ministry of Panchayati Raj was nation-wide launched by the Hon'ble Prime Minister on National Panchayati Raj Day, 24th April 2021, Sol has successfully completed the pilot phase of scheme (2020-2021) in 9 states. SVAMITVA Project is aimed to map abadi area of all villages across the country (approx 6.62 Lakh villages) rural village on 1:500 Scale using Professional Survey Grade UAV/Drone by Survey of India.

This project has two major components:

- CORS Network establishment.
- Drone based Large Scale Mapping.



Data acquisition in the field

Achievements:

Activities	Data acquisition (villages)	Data processing (villages)	Feature extraction (villages)	Final GIS data submitted (villages)
	80890	70303	65994	6938

National Hydrology Project (NHP):

National Hydrology Project aims to improve the management of water resources and flood forecasting hence Sol has been entrusted with the responsibility to generate, prepare and provide various types of Geo-spatial datasets i.e. for mapping/preparing the Digital Elevation Model (DEM) of 0.5m, 3- 5m for River Basin areas (plain), up to 5 km on both the sides of river and GIS ready data of SOI Topo sheets on 1: 25 K scale.

Achievements:**Generation of 0.5 m Digital Elevation Model (DEM) for approx. 71,204 Sq.Km:**

- Aerial Data Capturing - 37764 Sq.km. completed
- Data processing – 17876 Sq.km. completed
- DEM generation - 6906 sq. Km. completed

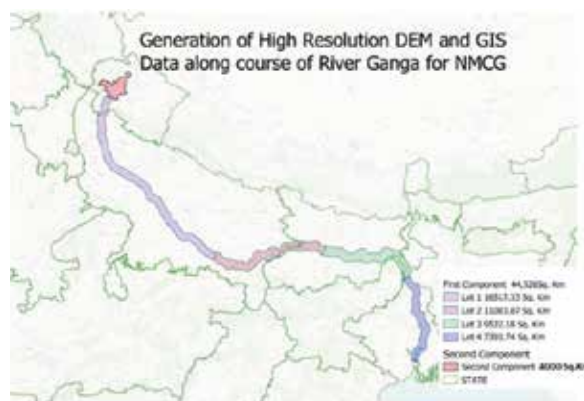
Generation of GIS data & 3-5 m Digital Elevation Model (DEM) for approx. 8.35 lakh Sq.Km:

- Digital Data generation – 336200 Sq.km. completed
- Ground validation -15851 Sq.km. completed

Continuously Operating Reference Stations (CORS)

- CORS network established in Uttarakhand, Uttar Pradesh, Haryana, Karnataka, Rajasthan, Maharastra, & Madhya Pradesh.
- Geoid Model for Uttarakhand, Uttar Pradesh, West Bengal, Bihar, Haryana, Goa & Jharkhand completed.

National Mission for Clean Ganga (NMCG):



Survey of India has been tasked for generation of High-Resolution Digital Elevation Model (DEM) of 0.5 metre resolution and GIS based for the part of River Ganga and Hugli under '**Namami Gange Programme**' covering up to 10 km extent on both sides of the river using latest Technology

Total Project area is 44526 Sq km Targeted Project completion timeline is 31st March 2022.

Advantages:

- To enable effective mechanism for management and monitoring, in Pollution abatement and river rejuvenation.
- To create Spring Inventory and facilitating rejuvenation intervention
- To provide GIS database support system (g-governance) for effective decision making.

Achievements:

0.5 m Digital Elevation Model (DEM) and GIS ready database

- LiDAR Data Acquisition 12640 Sq.km completed.
- Feature Extraction completed – 96 Sheets

Geoid Model Development

- UP, Bihar, Jharkhand, West Bengal & Uttarakhand completed.

Web Hosting & Application Development

- Development of customised application development under progress at GIS&RS Directorate Hyderabad.

Large Scale Mapping for States & UTs: large scale mapping project, to generate up-to-date digital topographical map for the entire state is being carried out using Professional Survey Grade Unmanned Aerial Vehicle / Drone. Deliverable include:

- Ortho- rectified imagery (ORI) at 5cm GSD
- High Resolution Digital Elevation Model (DEM)
- Village maps
- GIS database

Following is the status of state-wise progress:

Haryana: Target area 44,212 km² covering revenue villages in all districts.



Data acquisition (sq.km.)	Data processing (sq.km.)	Feature extraction (sq.km.)
13497	11010	821

Karnataka: Target area nearly 51,000 km² covering revenue villages in 06 districts on 1:5,000 scale.



Data acquisition (sq.km.)	Data processing (sq.km.)	Feature extraction (sq.km.)
2014	2196	382

Andhra Pradesh: Resurvey of all kinds of lands including agricultural lands, Abadi (Rural village sites) and Urban habitations in the part of Andhra Pradesh covering an area of about 40,000 Km² area to be mapped on 1:500 scale.



Data acquisition (sq.km.)	Data processing (sq.km.)	Feature extraction (sq.km.)
4704	3618	2052



Andaman & Nicobar: Target area nearly 1000 Km² be mapped with on 1:500 scale.

Data acquisition (sq.km.)	Data processing (sq.km.)	Feature extraction (sq.km.)
782	782	782

Geomagnetic Bulletin (Sabhawala Observatory): Geomagnetic Observations have been continued at Digital Geomagnetic Observatory, Sabhawala for determination of Horizontal Force (HF), Vertical Force (VF) and Declination (D). These observations are aimed to monitor and record different components of geo-magnetic variations and are necessary to control the baseline values of the magnetograms.

Publication of Indian & Hugli River Tide Tables: Indian Tide Table-2021 & Hugli River Tide Table -2021 have been published and supplied to the indenters as per their demand on payment basis.

Declination Chart: Printing & Publication of Declination Chart epoch 2020 is completed.

8.2 NATIONAL ATLAS & THEMATIC MAPPING ORGANISATION (NATMO):

National Atlas and Thematic Mapping Organisation (NATMO) is functioning under the administrative control of the Union Ministry of Science & Technology (Department of Science & Technology), Government of India. It is the premiere and only mapping Organisation of the country to showcase all thematic aspects of nature and society to cater the requirements of different sectors from national planning program to scientific and academic sectors of the country.

NATMO's journey started with publication of the "National Atlas of India" (1957) in Hindi as "*Bharat Rashtriya Atlas*" which was highly appreciated by the Planning Commission of India as a necessity for different developmental activities. Since then, NATMO has published more than 20,000 maps of National interest.

NATMO has the largest repository of spatial and non-spatial data processed with great accuracy using visible through its enterprise geoportal with state-of-the-art data center infrastructure and technology. With changing times, NATMO also keeps pace with the latest technologies like GIS, GPS and remote sensing. Recently, NATMO has set up its own datacenter and geoportal for providing online thematic map services through its enterprise geoportal.

The mandate of this organization includes:

- Compilation of National Atlas in English, Hindi and other regional languages with timely up-dation.
- 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 programs.
- Providing unrestricted map service to all sections of the society.
- Other activities entrusted through the Administrative Ministry from time to time.

MAJOR ACTIVITIES AND ACHIEVEMENTS DURING THE YEAR 2021-22

Research Achievements: Institute Projects

National Atlas of India: National Atlas of India is the flagship publication of NATMO first published in the year 1957 as ‘भारत राष्ट्रीय एटलस’ (Hindi). Later on, published in English as ‘National Atlas of India’. Since then, this publication is being updated and revised keeping pace with the administrative changes in respect of states, districts etc. Conversion of this publication into digital mode is going on and it will be accessible through NATMO geoportal very soon.

The project was assigned to NATMO to have India’s National Atlas like the other countries of the world and also to depict the country in respect of its administration, geology, demography, culture, environment, etc. in thematic map form.

As a reverential dedication towards the Nation by National Atlas and Thematic Mapping Organization (NATMO) on the occasion of the 75th anniversary of the independence of India, commemorative volume of this flagship publications has been taken up to portray the transformation of India during more than seven decades of its independence. This new and revised edition mainly focuses on the changing aspects of selected segments like administrative divisions, demographic pattern, tourism, land use pattern, industry, tribal development, agriculture, climate and pollution scenario of India (Fig: 1 & 2) and also highlights developmental facets of different Welfare Schemes taken up by the government time to time.

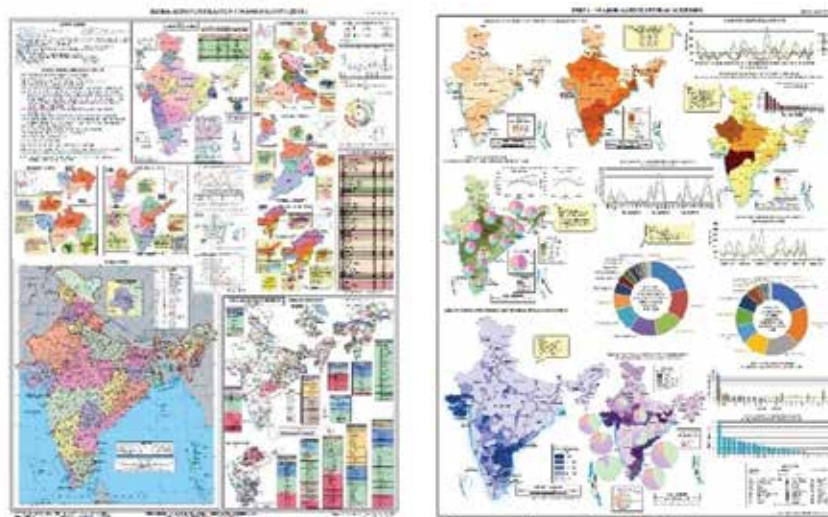


Fig 1: Admin. Changes and Working Population (1951-2011) Fig 2: Agricultural Schemes of India

District Level Mapping:

District Planning Map Series (DPMS): District Resources Maps are prepared to provide complete information on physiography, geology, geomorphology, demography, culture of a district to act as a ready-reckoner to the planners, researchers and students. Information of a particular district is available both in hard copy format and in the web-portal through Web Map Service (WMS). This year 9 (Nine) district maps of four states completed and published (Fig 3)

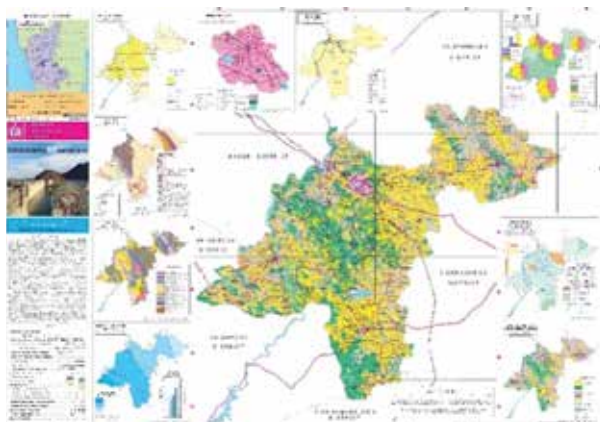


Fig 3: Davangere district map of Karnataka State

District Level Administrative Mapping of Districts: NATMO has initiated district administrative mapping showing boundary up to the village level. Village boundary is the basic administrative unit and required to show all necessary details to record information pertaining to administrative matters. This also helps to show village level information pertaining to

different thematic aspects like demography, wealth and livelihood patterns, etc. This year 45 (Forty-five) maps have been prepared for the country in digital platform available both in hard copy as well as soft copy format shown below (Fig 4)

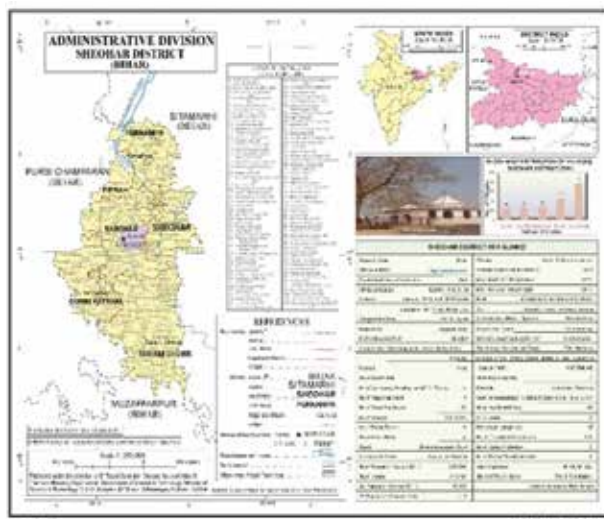


Fig 4: Administrative map of Sheohar District, Bihar

Golden Map Service (GMS): This project has been initiated with the aim to prepare large-scale map of the urban conglomerations of the country consisting with minute-level information relevant to the available utilities, communication, and land use. Primarily, this map will provide locations of any site of the country in Black and white on web either by place-names or by Geographical co-ordinates. Secondly it will provide connectivity between locations for a variety of social, economic, administrative operations related to elections, crime, rural marketing, relief and supply etc. useful for the planners, architects, tourists and the citizens as well. This year Amritsar, Dibrugarh, Bela-Pratapgarh and Puducherry have been completed under GMS project (Fig-5).

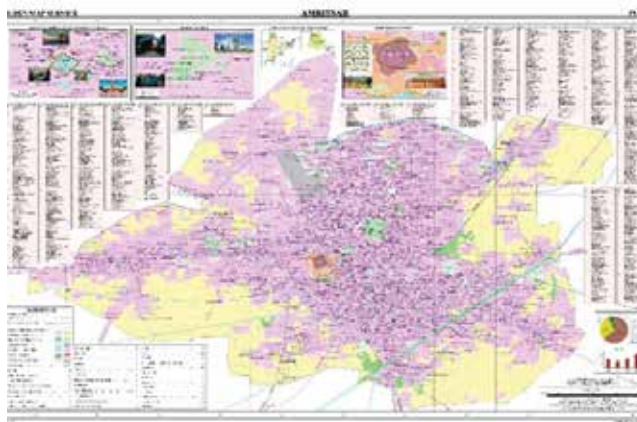


Fig 5: DPMS Map of Davangere

Thematic Maps: NATMO regularly prepares thematic maps on various aspects like religion, Pollution, Farmers Welfare Scheme, Health Infrastructure of India, Migration, Scheduled Tribe Disability Status, Ethnicity of PVTGs of India (Fig 6-7).



Fig 6: Land Use Land Cover Map of India



Fig 7 : Pollution Map of India

NATMO also prepares thematic maps on various aspects of tourism like Adventure tourism, Trekking and Tourism etc. which are of great demand among the tourists. In order to attract more tourists in Kedarnath from the country as well as from abroad this special “**Kedarnath Tourist Map**” has been prepared portraying the disaster of 16th and 17th June, 2013 affected the lives of more than 4000 pilgrims and local people along with the old and new trek routes (Fig 8).

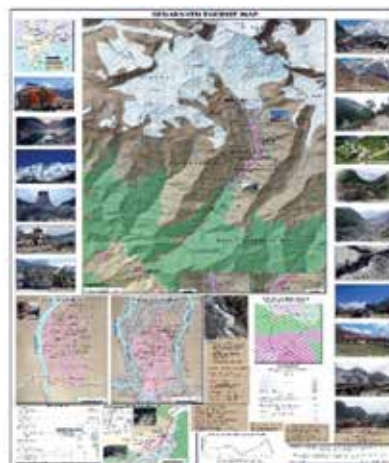
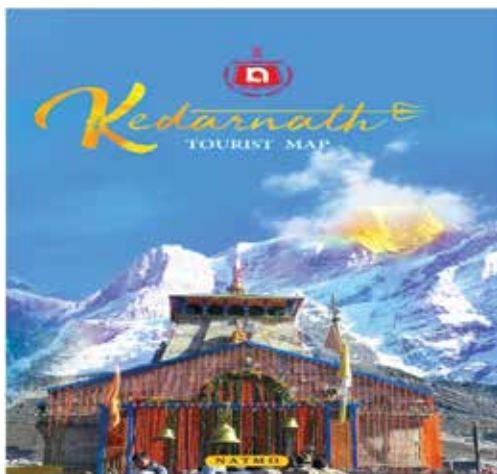


Fig 8: Tourist map of Kedarnath Temple

Thematic Atlas: Cultural Heritage Atlas: India has a rich cultural tradition that is actually an outcome of continuous synthesis that has absorbed many outside influences through ancient

civilization and enriched by the influence of the Greek, Roman, Scythian, Turks, Russian, Arab and European civilizations. Indian Civilization is based on religious and moral values, philosophy and ethical systems in which lie its unity and strength and a deep sense of oneness that make it possible to live in peaceful coexistence with tolerance.

The second edition of Cultural Heritage Atlas has been developed on digital platform and explained in a sequential manner incorporating some more information under six broad categories viz. i. Introductory Maps; ii. Religion and Philosophy; Ancient Origin iii. Bhakti Movement; Medieval Devotionalism; iv. Social Reform: Modern PeriodvArt and Culture vi. Performing Arts of Indian Origin (Fig 9) for providing a wider and broader analytical finding to the user in view of the relevance of the subject.

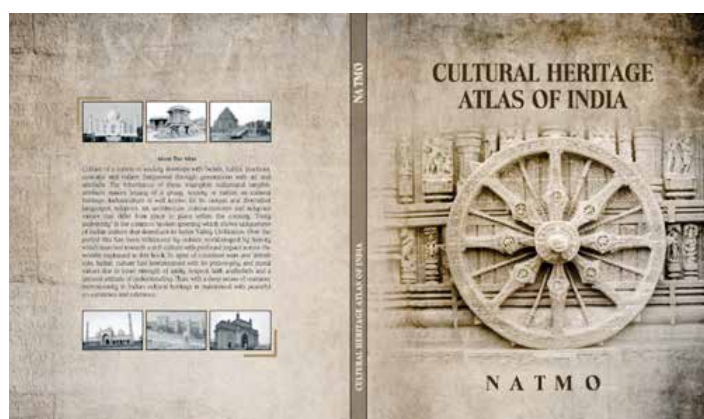


Fig 9: Cultural Heritage Atlas of India

Special Project: Atlas for Visually impaired (Braille): To disperse the technological development amongst the people who cannot get it due to their visual disability, NATMO initiated the project to prepare Maps and Atlases in Braille Script which are considered the most unique product fulfilling the societal commitment of the organization towards nation building. The project was initiated during 90's and has evolved to a much appreciable product at present in terms of quality, presentation and also user acceptance. This year NATMO has prepared the following Atlases in Braille Script:

- Braille Atlas of Andhra Pradesh State;
- Braille Atlas of Assam State;
- Braille Atlas of Jammu and Kashmir State;
- Braille Atlas of Telangana State;
- Braille Atlas of Gujrat State;
- Braille Atlas of West Bengal State;
- Braille Atlas of Odisha State.

NATMO has procured Artificial Intelligence based digital embosser solution to equip the braille mapping with state-of-art technologies. It will mark a new era in the production of Braille maps and atlases for differently-abled community who are facing great challenges to come to the main stream of life.

Research Achievements: *Extra departmental Projects*

NATMO has made a significant achievement during this year by working on extra departmental projects with organizations of very high repute. Details of each collaboration is as below.

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.

Like other countries Women in India are facing the challenges of gender inequalities in the social sectors and even in the professional setback. The biggest challenge to the planners of today is to look forward for equality and equity by reducing gender gap in all sectors of the society. With this aim the project has been funded by SEED division of DST under three objectives – (i) to visualize the present status of women empowered by Science and Technology, (ii) to identify the gender gap and locate areas of opportunities for women in Science and Technology and (iii) to envision priority areas for improving livelihood status of women and empower them.

The project is focused on district level scenario highlighting the women empowered and to visualize the gaps where women are lagging behind along with its demographic, economic and social status (Fig 10). This multi-dimensional project contains 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.

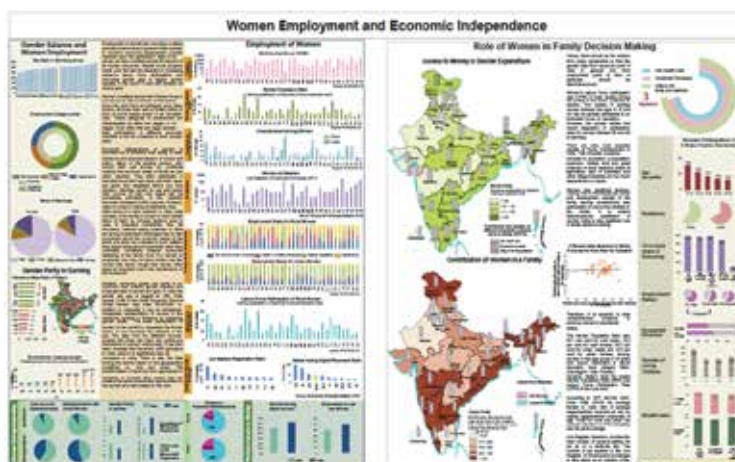


Fig 10: Status of Indian women in employment sector

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.

National District Relief Force:

In order to provide map services for the societal benefit at the time of emergency, NATMO is preparing 'Utility Information Maps' of the Districts for National Disaster Relief force (NDRF).

This year, two district maps with customized format has been shared with NDRF at the time of disasters and natural calamities like 'Yass' for their use during rescue operations. Accordingly, South Twenty-Four Parganas District (Fig 11) and Purba-Medinipur District of West Bengal have been completed and handed over to them.

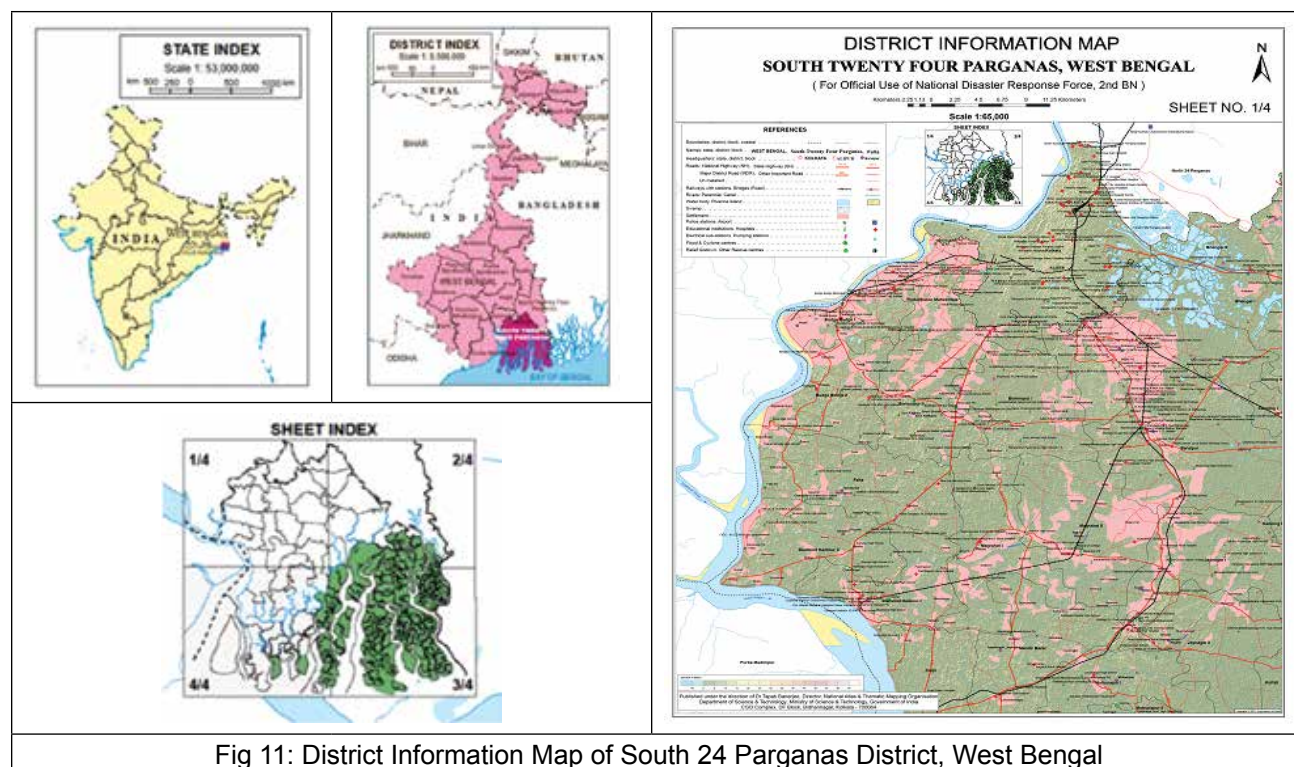


Fig 11: District Information Map of South 24 Parganas District, West Bengal

TECHNOLOGY DEVELOPMENT

Enterprise Geoportal: In order to bring digital transformation of all services sectors and ensure fast and easy access to information and public services, NATMO, took the initiatives to create a robust platform using state of art technology that could support publishing, sharing and consuming of all our products on a web-enabled environment. Thus, it is envisioned that Digital transformation will ensure the primary objective of 24x7 access to information like

WMS, WFS, WCS etc. in compliance with OGC standards and services to all the stakeholders spread across the internet through NATMO Enterprise Geoportal geoportal.natmo.gov.in.

The enterprise Geoportal of NATMO is now popular by the name *MANCHITRAN*, officially launched on 17th August 2021 by the Hon'ble Secretary DST on a virtual platform attended by several dignitaries from DST, SOI and NATMO (Fig 12). *Manchitrان* provides scope for geospatial data visualization, searching and querying. A good number of thematic layers are already populated where users could get feel of cartography and GIS blended. NATMO geoportal is based on web application powered by IGIS which is an indigenous product aligned with Make in India initiatives.



Fig 12: Inauguration of Manchintran, the Enterprise Geoportal of NATMO by the Secretary, DST

COVID-19 Dashboard: The Covid-19 Dashboard of NATMO (geoportal.natmo.gov.in/covid19/) launched during 2020 is continuing with seamless up-dation of data to help in making informed decisions for various stakeholders.

Other Achievements:

International Congress on Digital Mapping: This year NATMO organized the **40th INCA international Congress** from 10th to 12th Feb 2021 at Hyatt Regency, Kolkata. This international seminar has been organized for Indian National Cartographic Congress with the theme of **Digital Mapping Innovations in Make India Initiatives** (Fig 14). His Excellency, the Hon'ble Governor of West Bengal inaugurated this International Congress. In the seminar 69 paper presented by the researchers and scholar with 16 (sixteen) lectures delivered by special invitees from different national and international organisations.



Fig 14: Inauguration of INCA Seminar by His Excellency, Governor of WB

Development of Digital Lab on Braille Mapping: NATMO is only mapping organization in the country to prepare Braille maps for the Visually impaired students. The journey started during 90's with indigenous technology and over the period of time the Braille mapping unit has been upgraded with Artificial Intelligence (AI) based Digital Embossing Solution with much appreciable product (Fig 15) at present in terms of quality, presentation and also user acceptance.



Fig 15: Braille Embossing Solution with Braille Atlas as product

Other Services

Training and capacity building: This year, NATMO has conducted the following training courses

- CERTIFICATE COURSE on GIS for NATMO Officials and
- CERTIFICATE COURSE ON ADVANCED GIS in collaboration with SAIARD.

The prevailing pandemic situations and for different restrictions, training calendar could not be followed properly this year.

Documentation Centre and library: NATMO Documentation Centre and Library provides services both within the organization and outside to a good number of technocrats, professors, post graduate and under graduate students of Geography, Cartography, Remote sensing, Geology and Earth Sciences. At present there are approximately 22500 books, 54000 topographical sheets, 1250 NATMO maps, 1203 Atlases along with different important monthly journals on allied subjects.

Exhibition and fairs: NATMO's participation in exhibition and fairs have been limited due to the present pandemic situation. However it participated in 40th INCA International Congress at Kolkata from 10th -12th February 2021, 41st INCA International Congress at Punjab university from 27th -29th October 2021, 24th National Science Exhibition from 28th -31st October 2021 at Kolkata and IISF at Panaji, Goa from 10th -13th December 2021 (Fig 16). During the year NATMO earned approximately Rs 60000/- by selling NATMO publications.



Fig 16: Hon'ble Minister visited NATMO Exhibition Stall at IISF 2021 at Panaji, Goa

Webinars: In line with the “Azadi ka Amrit Mahotsav” an initiative of the Government of India to celebrate and commemorate 75 years of Independence of progressive India and the glorious history of its people, culture and achievements, NATMO is organizing 75 webinars on different themes to celebrate the achievements of the country during last 75 years.

CHAPTER 9

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.

9.1 General Administration

i. Inauguration of New State of the Art Building, Office Block-I, constructed at Technology Bhawan campus.

The Hon'ble Minister of State (I/C) for Science & Technology and Earth Sciences, Dr. Jitendra Singh, inaugurated the New State of the Art Building, Office Block-I, constructed at Technology Bhawan campus for the Department of Science & Technology (DST) and Department of Scientific & Industrial Research (DSIR) on 14.10.2021. The project envisages construction of new buildings comprising of two new Office Blocks, a 500-seater Auditorium, Canteen, Reception, CISF Block, Post office, Bank and other facilities as authorized under norms of MoUD (Ministry of Urban Development).



Inauguration of the New State of the Art Building by the Hon'ble Minister, S&T

2. The new office blocks have been constructed to accommodate DST, DSIR and some Autonomous Institutes under DST located at Delhi i.e. Science Engineering Research Board

(SERB), Technology Information Forecasting and Assessment Council (TIFAC), Technology Development Board (TDB), Vigyan Prasar, Indian National Academy of Engineering (INAE) as they were functioning from rented premises. Office Block-2 of the complex was completed in July, 2021 and the same has since been occupied by SERB, TIFAC, TDB, Vigyan Prasar, INAE. Office Block-I is also ready for occupation at present.



Unveiling of Ready Reckoner of the New State of the Art Building by the Hon'ble Minister

3. The buildings have the features like high-performance Double-Glazing Units (DGU) in structural glazing and thermal break polyamide profiles and Sun control louvres, permanent façade finish with ventilated dry cladding, internal partitions with acoustic drywalls for reduced loads, air conditioning with heating and cooling with VRV system and Mechanical Ventilation system, energy efficient LED lights with occupancy sensors, dual Plumbing for 100% use of treated water from STP, sensor based fittings in bathrooms, grid interactive solar power generation of 500KW, access controlled entry to buildings, art work as per DUAC norms, automatic Fire Alarm System & Fire Fighting System and video Surveillance (CCTV) System.



Block-II of the New State of the Art Building of Department of Science & Technology

(ii) Measures to contain impact of COVID-19 in Technology Bhawan

In the current year different parts of the nation have witnessed massive waves of COVID-19 cases which was accentuated in Delhi NCR Region in the months of April to July 2021. As the pandemic has been affecting several employees of the Department, several measures are being taken for mitigating the impact of COVID-19 outbreak.

Several posters on preventive measures on COVID-19 have been displayed in Technology Bhawan premises of the Department. In pursuance of guidelines of Department of Personnel & Training (DOPT), office specific guidelines were issued for maintenance of social distancing in the office premises, limited attendance of officers and staff on a particular working day, shifting to online and virtual meetings in place of physical meetings and switching to online e-office mode for office work, etc.

Following the guidelines of Ministry of Health & Family Welfare, orders are issued for work from home of 14 days for the officers/ staff who come in direct contact with a COVID positive case, diagnosed in the Department. The other officers/ staff who share the same Room/ Corridor of the COVID positive case are also advised to work from home for 48 hours for conducting sanitization activities in such Rooms/ Corridors. To facilitate working from home, the officers and staff have been provided with VPN access through NIC for accessing e-office portal from home.

A COVID Response Group was constituted, comprising of several officers and staff of the Department that provided support to the employees and their family members in terms of arranging hospitalization, logistic assistance, emotional support, etc. with a coordinated approach at the Department level. Yoga and meditation workshops were organised on virtual platforms during weekends for the employees and their families.



Online Yoga practice session organised in DST in collaboration with The Art of Living

In pursuance of the guidelines of the Government to contain spread of COVID-19 in offices and to provide a safe working environment to all officers/ Scientists/ staff of the Department,

several preventive measures are being taken. Ensured thermal screening of every employee and visitor at the main entrance of the Technology Bhawan using IR Thermometer to identify any potential infected case of COVID-19. Several sanitizer dispensers have been installed at the entrance of the building and other common areas.

Instructions have been issued to all the employees to ensure that they wear masks at all times in the premises. Face covers/masks & Hand Sanitizers were also provided to all officers/ Sections in the Department. Frequency of mopping/ cleaning activities increased to ensure complete and regular disinfection of entrance gates, meetings rooms/ conference halls/ open areas/ corridors, washrooms and all other frequently touched surfaces.

In view of the above measures, the normal functioning of the Department was maintained even during the second COVID wave of Delhi NCR Region in April to July 2021.

(iii) Celebration of Constitution Day

To commemorate the adoption of the Constitution of India by the Constituent Assembly on 26th November, 1949, the Department of Science & Technology had arranged yearlong programmes for celebration of the Constitution Day. The following activities were held in the Department:

- a) Constitution Day was celebrated on 26th November, 2021. The Hon'ble President of India lead the reading of the Preamble of the Constitution at 11 AM from Central Hall of Parliament which was broadcast live. Senior Advisor, DST and a large number of Scientists, officers and staff of Department of Science & Technology and Department of Scientific & Industrial Research joined the Hon'ble President in reading of the Preamble. The Constitution Day was also celebrated in subordinate offices and Autonomous Institutes/ Statutory Bodies under the administrative control of DST.



Constitution Day celebrations in Department of Science & Technology

- b) Constitution Walls have been prepared with posters of Preamble and Fundamental Duties of the Constitution at four prominent places in the Department.

- c) All the Scientists, officers and staff of DST, DSIR and PAO also participated along with their families and friends on the portals for “Reading preamble to the Constitution” and “Online Quiz on Constitutional Democracy” developed by Ministry of Parliamentary Affairs (<https://www.mpa.gov.in>) and had also shared certificates

9.2 Staff Position

Group A						
Category	General	SC	ST	OBC	PH	Total
Scientific	76	6	3	7	4	96
Non-Scientific	36	12	1	5	0	54
Group B						
Scientific	8	1	0	4	0	13
Non-Scientific	61	3	7	18	3	92
Group C						
Scientific	0	0	0	0	0	0
Non-Scientific	56	51	30	5	0	142

9.3 Parliamentary work

Parliament Unit serves as central coordinating point for all parliamentary work of the Department. It is responsible for handling entire parliamentary work of the Department. It ensures that the parliamentary work pertaining to the Department 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 Department of Science & Technology. The Unit coordinates work relating to consideration of Detailed Demand for Grants by the Parliamentary Standing Committee and also coordinates the visits of the Parliamentary Committees to various scientific institutions which are under the administrative control of this Department. The Unit has created an IT enabled searchable repository of Parliament questions answered in the past for easy retrieval and reference.

9.4 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. Besides monitoring the implementation of the Official Language Policy and the Annual Programme, Hindi Section helps in arranging 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 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 in FY 2021-22. Such as, during the year, quarterly meetings of Departmental Official Language Implementation Committee were organized. Likewise, Hindi workshops were organized to encourage the officers / staff of the department to conduct their maximum work in Hindi.

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.

A Hindi Advisory Committee has been constituted and its meeting was held on 17th December, 2021 in the chairmanship of Dr. Jitendra Singh, Minister of Science and Technology and Earth Sciences at India Habitat Centre.





Celebration of Hindi Pakhwara: Various Hindi competitions were organized and the successful participants were given cash awards and certificates in Hindi Pakhwara organized from **13 to 24 September, 2021** in Ministry of Science and Technology. The closing ceremony of the Pakhwada was organized offline. An internal '*Kavi Sammelan*' for officers and staff of DST was organized in Raman Auditorium to promote the use of Hindi.

9.5 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 January, 2021 to 31st December, 2021, a total of 1355 RTI applications and 77 First Appeals were received by the Department and out of which 1312 RTI applications and 76 Appeals have been disposed of as per the provisions of RTI Act, 2005.

9.6 Public Grievances

Grievance redress mechanism is an instrument to gauge and measure efficiency and effectiveness of an organization as it provides important feedback on its working. An essential

pre-requisite to make the public service delivery system more accountable and responsive is to have a robust public grievance redress and monitoring mechanism.

Department of Science and Technology has made concerted efforts to redress the grievances and appeals received from its stakeholders and the public at large.

A total of 2711 public grievances were received by the Department during the period from 1st January, 2021 to 31st December, 2021. In addition to this, there was a backlog of 96 grievances. Out of these 2807 grievances (2711+96), a total of 2690 grievances have been disposed of by 31st December, 2021.

Further, a total of 76 appeals were received in respect of public grievances during the period from 1st January, 2021 to 31st December, 2021. Out of these, 70 appeals have been disposed of by 31st December, 2021.

9.7 Vigilance

The Vigilance Unit of the Department of Science & Technology is headed by a Chief Vigilance Officer (CVO), who is a Joint Secretary of the Department. He is supported by a Deputy Secretary, Section Officer and other secretarial staff.

Apart from handling vigilance related cases of the Department, its subordinate offices and aided institutions, the Vigilance Unit 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 disciplinary proceedings having a vigilance angle. The Vigilance side maintains a regular touch both with the CVC and the CBI.

During 2021(as on 17.12.2021), the Vigilance Unit has dealt with the following number of complaints:

Source	Opening Balance	Recd. During the year	Total	Disposed	Balance
CVC	27	16	43	41	2
Others	46	51	97	89	8

The balance complaints are at various stages of examination and under process.

The Vigilance unit also 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 organizations, like Central Vigilance Commission, Central Bureau of Investigation and Department of Personnel and Training. The Department also maintains Agreed List in consultation with CBI and List of Officers of Doubtful Integrity of Gazetted status.

Besides, the CVO 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.

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 26th October to 1st November 2021 in association with the Department of Scientific and Industrial Research (DSIR). During this occasion, an Integrity Pledge was administered to employees of DST & DSIR by CVO, DST. Events like Essay Writing competition, Turncoat Debate, Slogan Writing Competition, Drawing Competition for Children of employees, Poster making competition, Story weaving competition were organized for DST/DSIR employees during this Week.

VIGILANCE AWARENESS WEEK 2021



Fig: 1 Integrity Pledge administered in DST



Fig: 2 Valedictory Function



Fig: 3 Drawings made by the Children of DST/DSIR employees

Emphasis on preventive vigilance is also laid as a measure to prevent the occurrence of vigilance cases. A presentation has recently been made by a statutory body of this Department in this direction for the introduction of preventive vigilance measures.

CHAPTER 10

AUDIT OBSERVATION

Annexure-I

Detailed position of Action Taken Notes (ATNs) to be included in the Annual Report for the year 2021-22 as per the table given below:

S I . 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 A T N s 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
1.	C&AG of India Report No. 6 of 2020- Compliance Audit Observations Union Government (Civil) for the period ended March, 2018.	1(14.1)	Nil	Nil	Nil
2.	C&AG of India Report No. 2 of 2021 for the year ended March, 2019- Compliance Audit Observations Union Government (Civil).	1 (11.2)	Nil	Nil	Nil

Annexure-II

Summary of important Audit Observations pertaining to DST: NIL

BUDGET

DEPARTMENT OF SCIENCE AND TECHNOLOGY Summary of Financial Requirement					
S I. No	Head of Development Projects/ Programmes/Schemes	(Rs. in crore)			
		Actual 2020-2021	BE 2021- 2022	RE 2021- 2022	BE 2022- 2023
1	Secretariat	128.56	123.40	109.34	115.00
2	Survey of India	423.68	533.60	474.54	526.10
3	NATMO	28.18	46.90	40.83	50.20
4	Autonomous Institutions and Professional Bodies	1374.82	1488.00	1488.00	1500.00
5	Science and Engineering Research Board	741.18	900.00	900.00	803.00
6	Science and Technology Institutional and Human Capacity Building	900.25	1101.80	986.20	1128.00
7	Research and Development	396.05	593.94	456.75	604.03
8	Innovation, Technology Development and Deployment	629.93	951.95	700.63	812.52
9	National Mission on Interdisciplinary Cyber Physical Systems	270.16	270.00	0.00	350.00
10	Technology Development Board	10.00	50.00	75.00	100.00
11	Science Counsellors Abroad	10.52	12.00	12.91	13.35
Total- DST		4913.33	6071.59	5244.20	6002.20

ABBREVIATION

AASC	Augmentative and Alternative Speech Communication
ACEs	African Center of Excellence
AEC	ABHYAAS Expert Committee
AI	Artificial Intelligence
AIPA	Apex Committee for Implementation of Paris Agreement
AISRF	Australia India Strategic Research Fund
AMAT	Applied Materials India Private Limited
AMT	Advanced Manufacturing Technologies
ARCI	Advanced Research Centre for Powder Metallurgy and New Materials
ASD	Autism Spectrum Disorders
ASEAN	Association of Southeast Asian Nations
ATNs	Action Taken Notes
AV	Accelerate Vigyan
AWSAR	Augmenting Writing Skills for Articulating Research
BAN	Body Area Network
BCIS	Beck's cognitive insight scale
BD	Big Data
BDTD	Biomedical Device and Technology Development Program
BELSPO	Belgian Federal Science Policy Office
BMC	Brihanmumbai Municipal Corporation
BIRAC	Biotechnology Industry Research Assistance Council
BIS	Bureau of Indian Standards
BNL	Brookhaven National Laboratory
BRICS	Brazil, Russia, India, China, and South Africa
CAR T	Chimeric Antigen Receptor T cell
CAWACH	Centre for Augmenting WAr on Covid 19 Health Crisis
CCP	The Climate Change Programme
CCUS	Carbon Capture Utilisation & Storage
CDRI	Central Drug Research Institute, Lucknow
CERI	Clean Energy Research Initiative
CHRA	Coastal Hazard, Risk Assessment and Reduction
CHW	Costal Hazard Wheel
CMM	Coordinate Measuring Machine
CII	Confederation of India Industry
CNN	Convolutional Neural Networks
CoE	Centre of Excellence
CORS	Continuously Operating Reference Stations
CRG	Core Research Grant
CPR	Centres for Policy Research
CPS	Cyber Physical Systems
CPSRI	Cyber Physical Systems Research Initiatives
CRIKC	Chandigarh Region Innovation and Knowledge Cluster

CSC	CAWACH Satellite Centres
CSRI	Cyber Security Research Initiatives
CSRI	Cognitive Science Research Initiative
CTEWP	Centre for Technological Excellence in Water purification
CURIE	Consolidation of University Research for Innovation & Excellence
CVO	Chief Vigilance Officer
CWIS	Coastal Water Quality Information System
DBT	Department of Biotechnology
DCLC	Direct Contact Liquid System
DDP	Device Development Program
DEGAS	DEspec Germanium Array Spectrometer
DEM	Digital Elevation Model
DESY	The Deutsches Elektronen-Synchrotron, Germany
DLEPC	District Level Exhibition and Project Competition
DLN	Diamond like Nanocomposite
DNB	The VIIRS Day/Night Band
DPMS	District Planning Map Series
DPR	Detailed Project Report
DRISHTI	Driving Innovation through Simulation Hub for Technologies in Interdisciplinary Cyber Physical Systems
DSEHC	DST-IITM Solar Energy Harnessing Centre
DSM	Defence Series Maps
DSRI	Data Science Research Initiatives
DUNE	Deep Underground Neutrino Experiment
ECB	Expert Committee on Bibliometrics
ECHA	European Chemicals Agency
ECIL	Electronics Corporation of India Limited
EDARI	Epidemiology Data Analytics Research Initiative
EDS	Electro-Dynamic Screen
E-MIAS	E Management of INSPIRE Awards Scheme- portal
EIR	Entrepreneurs-in- Residence
EMR	Extramural Research
ESW	Executive Software
EU	European Union
FAIR	Facility for Antiproton and Ion Research
FASIE	Foundation for Assistance to Small Innovative Enterprises
FBG	Fluidized Bed Gasifier
FDP	Faculty Development Program
FEEDS	Foundation for Environment and Economic Development Services
FICCI	Federation of Indian Chambers of Commerce & Industry
FIRE	Fund for Industrial Research Engagement
FFTD	Frontier and Futuristic Technologies Division
FIST	Fund for Improvement of S & T Infrastructure in Universities and Higher Educational Institutions

FOCAL	Forward Calorimeter
GATI	Gender Advancement for Transforming Institutions
GCPs	Ground Control Provision
GEAG	Gorakhpur Environmental Action Group
GEM	Gaseous Electron Multiplier
GI	Geographical Indication
GiSPVT	Greenhouse Integrated Semi-Transparent Photo-Voltaic Thermal System
GISE	Geo-Information Science & Engineering (GISE) Hub
GITA	Global Innovation & Technology Alliance
GLP	Good Laboratory Practice
GMS	Golden Map Service
GoI	Government of India
GoJ	Government of Japan
GPS	Global Positioning System
GPU	Graphics Processing Unit
GRACE	The Gravity Recovery and Climate Experiment
GSCST	Goa State Council for Science & Technology
GSGF	Global Statistical Geospatial Framework
GUJCOST	Gujarat Council on Science & Technology
HBOT	Hyperbaric Oxygen Therapy
HDRB	High Damping Rubber Bearing
HEIs	Higher Education Institutes
HESCO	Himalayan Environmental Studies and Conservation Organization
HGCAL	High Granularity Calorimeter
HIMCOSTE	Himachal Pradesh Council for Science, Technology & Environment
HPC	High Performance Computing
HRG	Himalayan Research Group
HRNTDB	High Resolution National Topographical Data Base
HSCST	Haryana State Council for Science & Technology
HTSTR	High Temperature Spin Test Rig
HV	Healthy Volunteers
ICD	International Cooperation Division
ICP	Inductively Coupled Plasma
ICT	Information & Communication Technology
ICP-AES	Inductively coupled plasma atomic emission spectroscopy
I:E	Inspiration to Expiration Time (I:E) Ratio
IFCPAR	Indo-French Centre for Promotion of Advanced Research
IGSTC	Indo-German Science & Technology Centre
IHDSRI	Indian Heritage in Digital Space Research Initiative
IKS	Indigenous Knowledge Systems
IMC	<i>Index Monitoring Cell</i>
IRTGs	International Research Training Groups
IISc	The Indian Institute of Science
IISF	India International Science Festival

ILTP	Integrated Long-Term Program
IMC	Index Monitoring Cell
IMPRINT	IMPacting Research INnovation and Technology
INAE	Indian National Academy of Engineering
IORA	Indian Ocean Rim Association
INSPIRE	Innovation in Science Pursuit for Inspired Research
INSPIRE -MANAK	Million Minds Augmenting National Aspiration and Knowledge
IoHT	Internet of Health Things
IoT	Internet of Things
IoTRI	Internet of Things Research Initiatives
IPR	Intellectual Property Rights
IRRd	Industry Relevant R&D
IRIS	Initiative for Research & Innovation in STEM
ISARI	Imaging Spectroscopy & Applications Research Initiative
ISEF	International Science and Engineering Fair
ISRF	India Science & Research Fellowship
i-STED	Innovation, Science and Technology led Entrepreneurship Development
I-STEM	Indian - Science Technology and Engineering Facilities Map
IUCAA	Inter-University Centre for Astronomy and Astrophysics
ITOFF	TMT Optics Fabrication Facility
USISTEB	U. U.S.-India Science and Technology Endowment Board
USISTEF	United States-India Science & Technology Endowment Fund
IUSSTF	Indo-US Science and Technology Forum
J&KRSAC	J&K Remote Sensing Application Centre
JSPS	Japan Society for the Promotion of Science
WISE-KIRAN	Knowledge Involvement in Research Advancement through Nurturing) Scheme as Women in Science and Engineering
KSCSTE	Kerala State Council for Science, Technology & Environment
LBNF	Long-Baseline Neutrino Facility
LIGO	Laser Interferometer Gravitational-Wave Observatory
LRB	Laminated Rubber Bearing
LCRB	Lead-Core Rubber Bearing
LSM	Large scale Mapping
MAD	Mutual Acceptance of Data
MBR	Membrane Bioreactor
MES	Material for Energy Storage
MGB	Mission Governing Board
MI	Mission Innovation
ML	Machine Learning
MONSTER	Modular Neutron Spectrometer
MoU	Memorandum of Understanding
MPAs	Marine Protected Areas
MPPLab	Mathematical Programming in Parallel Laboratory
MPVS	Madhya Pradesh Vigyan Sabha

MRI	Magnetic Resonance Imaging
MSL	Mobile Science Lab
MTA	Material Transfer Agreement
NATMO	National Atlas & Thematic Mapping Organisation
NCC	National Core Committee
NDRF	National Disaster Relief force
NLEPC	National Level Exhibition and Project Competition
NCSTC	National Council of Science and Technology Communication
NDA	Non-Disclosure Agreement
NDSM	Normalized Digital Surface Models
NEHU	North-Eastern Hill University
New Gen -IEDC	New Generation Innovation and Entrepreneurship Development Centre
NGCMA	National Good Laboratory Practice Compliance Monitoring Authority
NGP	National Geospatial Programme
NHHID	National Hub for Healthcare instrumentation Development
NHP	National Hydrology Project
NIDHI	National Initiative for Developing and Harnessing Innovations
NMA	National Mapping Agency
NMCG	National Mission for Clean Ganga
NMD	National Mathematics Day
NM-ICPS	National Mission on Interdisciplinary Cyber Physical System
NMP	National Map Policy
NM-QTA	National Mission on Quantum Technologies and Applications
NMR	Nuclear Magnetic Resonance
NMSHE	National Mission for Sustaining the Himalayan Ecosystem
NMSKCC	National Mission on Strategic Knowledge for Climate Change
NPDF	National Postdoctoral Fellowship
NPNST	National Programme for Nano Science and Technology
NRC	National Research Council Canada
NRDMS	Natural Resources Data Management System
NSDI	National Spatial Data Infrastructure
NSERC	Natural Sciences and Engineering Research Council of Canada
NSD	National Science Day
NSF	National Science Foundation
NSM	National Supercomputing Mission
NSTEDB	National Science and Technology Entrepreneurship Development Board
NSTMIS	National Science & Technology Management Information System
NUSTAR	Nuclear Structure, Astrophysics and Reactions
OECD	Organization for Economic Cooperation and Development
OGC	Open Geospatial Consortium
ORI	Ortho- rectified imagery
OSW	Observatory Software
OTT	Over The Top
PAC	Program Advisory Committee

PACE	Partnership to Advance Clean Energy
PCPM	Policy, Coordination and Programme Management
PECFAR	Paired Early Career in Applied Research
PEMFC	Polymer Electrolyte Membrane Fuel Cell
PFP	Patent Facilitation Programme
PFP	Policy Fellowship Programme
PIP	Peak Inspiratory Pressure
PMA	Primary Mirror Assembly
POWER	Promoting Opportunities for Women in Exploratory Research
PPP	Public Private Partnership
PRAYAS	PRomotion and Acceleration of Young and Aspiring Technology Entrepreneurs
PRISM	Project Information System & Management (SERB – PRISM)
PRP	Policy Research Programme
PRSC	Punjab Remote Sensing Service Centre
PSR	Polymerase Spiral Reaction
PSA	Principal Scientific Adviser
PSCST	Punjab State Council for Science & Technology
PUF	Polyurethane Foam
PURSE	Promotion of University Research and Scientific Excellence
PQP	Production Qualification Phase
QCD	Quantum Chromodynamics
QKD	Quantum Key Distribution
QuSTRI	Quantum Science & Technology Research Initiative
RAISE	Recent Advances and Innovations in Solar Energy (RAISE 2021)
RDSO	Research Designs and Standards Organisation
R&D	Research & Development
RI	Reverse Iontophoresis
RPC	Resistive Plate Chamber
RSF	Russian Science Foundation
RSMs	Regional Science Museums
RTI	The Right to Information Act
SAIF	Sophisticated Analytical Instrument Facilities
SAPCC	State Action Plan on Climate Change
SATHI	Social Awareness Through Human Involvement
SATHI	Sophisticated Analytical & Technical Help Institutes
SATYAM	Science and Technology of Yoga and Meditation
SCCC	State Climate Change Centres
SCSP	Special Component Plan for Schedule Castes
SDG	Sustainable Development Goals
SDRR	Spatial Disaster Risk Reduction
SEED	Science for Equity for Empowerment and Development
SEM	Scanning Electron Microscope
SERB	Science and Engineering Research Board
SHE	Scholarship for Higher Education

SHRI	Science and Heritage Research Initiative
SING	Small Immediate Need Grants
SISOCA	Speech- Input Speech–Output Communication Aid
SMI	System of Maize Intensification
SOI	Survey of India
SPP	Student Project Programme
SPM	Suspended Particulate Matter
SSA	Segment Support Assembly
SSP	Seed Support Program
SSR	Scientific Social Responsibility
SSTP	State Science & Technology Programme
SLEPC	State Level Exhibition and Project Competition
STD	Society for Technology & Development
STEM	Science Technology Engineering and Mathematics
STEMM	Science, Technology, Engineering, Mathematics and Medicine
STI	Science, Technology and Innovation
STIC	Sophisticated test and instrumentation centre, Kochi
STIEP	Science, Technology, Innovation Entrepreneurship Partnership
STIP	Science, Technology, and Innovation Policy
STUTI	Synergistic Training program Utilizing the Scientific and Technological Infrastructure
SUPRA	Scientific and Useful Profound Research Advancement
SUTRA-PIC	Scientific Utilization Through Research Augmentation – Prime Products/ Panchagavya from Indigenous Cows
SWAN	Scientific Women's Academic Network
SWASHRAY	Self-Reliance in Working around sustainable, helpful, reliable and high yielding processes and technologies
SWI	System of Wheat Intensification
SYST	Scheme for Young Scientist and Technologists
TAC	Technical Advisory Committee
TARA	Technological Advancement For Rural Area
TBI	Technology Business Incubator
TCS	Telescope Control System
TDB	Technology Development Board
TDP	Technology Development Programmes
TEC	Technology Enabling Centres for Universities
TEDP	Technology Entrepreneurship Development Program
TEM	Transmission Electron Microscopy
TFAR	Technology Fusion & Applications Research
TIASN	Technological Interventions for Addressing Societal Needs
TIDE	Technology Informatics Design Endeavour
TIEDS	Technology Incubation and Entrepreneurship Development Society
TIH	Technology Innovation Hubs
TMIR	Technology Mission for Indian Railways
TMT	Thirty Meter Telescope

TRCs	Technical Research Centres
TSO	Transmission System Operators
TSP	Tribal Area Sub-Plan
UIS	UNESCO Institutes of Statistics
UNESCO	United Nations Educational, Scientific and Cultural Organization.
UNGGIM-AP	UN-Global Geospatial Information Management-Asia Pacific
UNWGIC	United National World Geospatial Information Congress
USFDA	United States Food and Drug Administration
VA	Vigyan Ashram
VAJRA	Visiting Advanced Joint Research
VR	Ventilation Rate
UTs	Union territories.
WWF	World Wide Fund for Nature
WaSH	Water, Sanitation and Hygiene
WEDP	Women Entrepreneurship Development Program
WFOS	Wide Field Optical Spectrograph
WGSTI	Working Group Science Technology and Innovation
WHC	Warping Harness Cables
WICTRE	Water Innovation Centre Technology Research and Education
WISER	Women involvement in Science and Engineering Research
WISTEMM	Women in STEMM
WLCG	Worldwide Large Hadron Collider Computing Grid
WMS	Web Map Service
WMT	Waste Management Technologies
WOS	Women Scientists Scheme
WTI	Water Technology Initiative
2G	Second Generation
ZLD	Zero Liquid Discharge



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