



Science & Technology Led Excellence for **Inclusive Development**

**Brief Account of
Four Years Achievements
2014-2018**

Ministry of Science and Technology
Ministry of Earth Sciences
Government of India



**Council of Scientific & Industrial
Research (CSIR)**

Ministry of Science and Technology
Anusandhan Bhawan
Rafi Marg
New Delhi-110 001
India

Department of Biotechnology (DBT)

Ministry of Science and Technology
Block 2, 7th Floor, CGO Complex
Lodhi Road
New Delhi-110 003
India

**Department of Science & Technology
(DST)**

Ministry of Science and Technology
Technology Bhavan
New Mehrauli Road
New Delhi-110 016
India

Ministry of Earth Sciences (MoES)

Prithvi Bhavan, IMD Campus
Lodhi Road
New Delhi-110 003
India

Science & Technology
Led Excellence for
Inclusive Development

Brief Account of
Four Years Achievements
2014-2018



सत्यमेव जयते

Ministry of Science and Technology
Ministry of Earth Sciences
Government of India

Science & Technology Led Excellence for Inclusive Development

BRIEF ACCOUNT OF FOUR YEARS ACHIEVEMENTS 2014-2018

June 2018

Designed & Printed at
CSIR-National Institute of Science Communication and Information Resources (CSIR-NISCAIR)
Vigyan Sanchar Bhawan, New Delhi

FOREWORD

Dr. Harsh Vardhan

Hon'ble Union Minister
For Science & Technology and
Earth Sciences



INDIA'S progress in the field of science and technology has been exponential during the last four years and the R&D work has addressed many of the problems the society is facing now. Science is now regarded as one of the most powerful instruments of growth and development. India is ranked sixth globally in the number of scientific publications and ninth in the number of patents filed.

The increase in the budget allocations to both the ministries have once again reiterated the present Government's intent and resolve to give full support to Science and Technology endeavours for the cause of national development.

It gives me great pleasure, therefore, to dedicate this document that consolidates the achievements of the Ministry of Science and Technology and the Ministry of Earth Sciences during the past four years. Several scientific and technological developments have touched the lives of common people in the last four years.

The Ministry of Science & Technology and the Ministry of Earth Sciences have aligned several of their programmes with the Government of India's ambitious national missions such as Swachh Bharat, Swasth Bharat, Startup India, Make in India, Skill India, Digital India, Doubling Farmer's income etc. During the last four years, both the ministries have developed more and more synergy and started working together for addressing common areas. The mission launched by both the ministries are a judicious mix of fundamental and application science, which include Cyber-Physical-Systems, Supercomputing, Aroma and Medicinal Plants, Sickle cell anemia and Biopharma etc.

Both the ministries have several initiatives for facilitating the farmers and farming activities to improve crop productivity. Several new varieties of resilient crops with improved yields have been developed. Agro-meteorological advisories are being provided to farmers which benefits them in their day to day farming operations. During 2018-19, these advisories will reach 40 million farmers from the present 24 million. Similarly, the 'Biotech Kisan' is another such initiative which is assisting farmers in 15 agro-climatic zones.

The Aroma Mission for cultivation of aromatic plants has benefitted thousands of farmers. Biotechnological interventions have been introduced to improve soil fertility and biological health for high crop productivity

Ministry of Science Technology has been supporting and engaging in Research & Development for economic, efficient and environmentally safe energy generation and management. R&D activities have also been promoted with an aim to provide safe drinking water at affordable cost and in adequate quantity using appropriate Science and Technology interventions evolved through indigenous efforts.

The Ministry of Science & Technology has played a major role in building the Startup innovation ecosystem by supporting innovation research, technology development and product commercialization. There have been major programmes to support the incubation facilities across the country and work with institutes and universities to link them with the Startup and industry.

The Ministry of Earth Sciences has improved the quality of weather, climate, ocean, coastal and seismological services over the last four years. Under the Monsoon Mission, the Ministry of Earth Sciences developed the capability of generating high-resolution weather and climate forecasts including monsoon and tropical cyclones using advanced dynamical models.

The Ministry of Science & Technology has undertaken several initiatives that are people-centric and boost the income of farmers, as well as generate jobs for the socio-economic development of the North-Eastern region.

In this report, the details of achievements made by the Ministry of Science and Technology and Ministry of Earth Sciences in 17 different important themes are elaborated. Both the ministries are fully committed to harness science and technology for the socio-economic and inclusive development of the country.

Jai Hind



(Dr. Harsh Vardhan)

CONTENTS

S.No	Theme	Page
1.	Introduction	i-xii
2.	S&T for National Missions and Significant Sectors	
	Agriculture and Animal Husbandry	1-14
	Health for All: Swastha Bharat	15-36
	Waste to Value: Swachh Bharat	37-44
	Digital India	45-52
	Energy for All	53-66
	Water for All	67-78
	Environment, Climate Change and Natural Disasters	79-96
	Blue Economy: Deep Ocean Mission	97-104
3.	Start-up India: Fostering Innovation, Start-ups and Entrepreneurship Ecosystem	105-116
4.	Make in India	117-132
5.	Knowledge Generation and Discovery Research	133-140
6.	S&T infrastructure	141-148
7.	S&T Human Resources	149-162
8.	Rural and Inclusive Technologies	163-172
9.	Special Initiatives for North East	173-184
10.	Popularising and Communicating Science	185-196
11.	Global Connect: Promoting International Cooperation	197-214
12.	Way Forward	215-218

INTRODUCTION

THE role of Science and Technology in a nation's development is all pervasive. Performance of all sectors like Industry, Agriculture, Health, Energy, Water, etc. is critically linked to science and technology inputs and interventions. In essence, S&T has the potential to transform each of these sectors of economy and improve the living conditions of millions of our countrymen.

Ministry of Science & Technology and Ministry of Earth Sciences cover a very large canvas of R&D from the mysteries of the deep oceans to the Universe. The range encompasses grassroots innovators to top class scientists. The S&T activities impact right from a farmer in a remote corner of the country to sophisticated industries such as aerospace.

To cater to such a large audience, it is necessary that adequate investments are made in scientific research, innovation and technology development. The present Government has consciously given a boost to investment and provided higher allocations for science, technology and innovation promotion. The budget allocation for the Department of Science and Technology for five financial years starting from 2014-15 to 2018-19 was ₹19764 crores which is a whopping 90% increase over the preceding five years (2009-10 to 2013-14). Similarly, there was an increase of 65% for the Department of Biotechnology; almost 43% increase for Council of Scientific and Industrial Research, and 26% increase for the Ministry of Earth Sciences during this period.

S&T investments in India are yielding impressive results. India's 6th position in the world in scientific publications ahead of France, Spain and Italy is one such indicator. India's growth rate of scientific publications is around 14% as against the world average of 4%. India is positioned 3rd globally in nanotech research, which is another healthy sign of our capability in cutting edge areas of science and technology. The Council of Scientific and Industrial Research (CSIR) ranks 9th in the world among the 1207 government institutions in the Scimago Institutions Ranking World Report 2017.

The discovery of Gravitational Waves in 2017 has been hailed worldwide as one of the most fundamental scientific discoveries in recent times. It is a matter of great pride that 40 scientists from 13 Indian institutions are part of the LIGO-Virgo discovery paper published in Physical Review Letters. Scientists from two autonomous institutions of S&T Ministry viz. Indian Institute of Astrophysics, Bengaluru and Aryabhata Research Institute of Observational Sciences, Nainital contributed to this fundamental discovery. Our Government has approved the planned LIGO-India detector to be funded by the Department of Atomic Energy and the Department of Science & Technology.

S&T manpower is the foundation on which the edifice of Research and Development is built. During the last four years, enhancement of capacity building of scientists, teachers, young researchers and attracting

talented students to the study of science and making careers in R&D has been pursued very vigorously. The Department of Science and Technology and Department of Biotechnology are the two major players contributing nearly 66.4% of the extramural R&D support in the country.

Several new schemes have been launched to encourage and attract the scientific community to engage in R&D activities. Some of these new schemes are: Early Career Research Award; National Postdoctoral Fellowship (N-PDF) Scheme; Overseas Visiting Doctoral Fellowship; SERB Distinguished Investigator Award (SERB-DIA); Visiting Advanced Joint Research (VAJRA) Faculty Scheme, and Teacher Associates for Research Excellence (TARE).

During the last four years, many S&T activities have been realigned. Now, there is a judicious mix of fundamental science and application science. This year's budget announcement on Mission for Cyber-Physical-Systems is one such example of application science. Mission based projects on Supercomputing, Aroma, Sickle cell anemia, and Biopharma are some illustrative examples of application and solution science initiatives. The list of such initiatives is very large.

Innovation and start-up activities have received a big support during this period. Business incubation facilities have almost been doubled. During 2018-19 itself, 15 new Biotechnology Incubators and 15-20 new Technology Business Incubators will be established to incubate start-ups. Biotechnology Industry Research Assistance Council (BIRAC) alone would support 3000 additional start-ups next year. In the innovation chain, MANAK (Million Minds Augmenting National Aspiration and Knowledge) is another new initiative to broaden the base of our innovation pyramid to produce future entrepreneurs in large numbers. The programme has been targeted to encourage children to visualise needs of the society and inspire them to devise innovative solutions – 1 lakh top ideas from school children will be awarded every year.

Any S&T intervention that facilitates farmers and farming activities to improve crop productivity makes a huge impact on rural economy. Agrometeorological advisories to farmers is one such mechanism that benefits them in their day-to-day farming operations. During 2018-19, these advisories will reach 40 million farmers from the present 24 million level. Biotech Kisan is another such initiative that is assisting farmers in 15 agro-climatic zones. Similarly, thousands of farmers are getting benefitted under the Aroma Mission for cultivation of aromatic plants. Pt Deen Dayal Upadhyay Vigyan Gram Sankul Pariyojana for integrated development of cluster of villages in Uttarakhand through S&T interventions utilising local resources and local skills to provide opportunities of better livelihood at the local level is another example of a project targeted to benefit the common man.

Water Technology Initiative promotes R&D activities for providing safe drinking water at affordable cost and in adequate quantity using appropriate S&T interventions evolved through indigenous efforts. 174 R&D Projects addressing 20 site-specific challenges covering around 400 habitats across 23 states have been supported. Several affordable technology solutions have been demonstrated and deployed in the field.

Energy remains a critical factor in the socio-economic development of our country. Now there is a growing need for generating more and more clean energy. Programmes like Clean Energy Research Initiative are aimed at producing clean and green energy. Several technologies have been developed by the CSIR such as coal dust collecting and briquetting system, Solar Power Tree, Novel Hydro-electric Cell, etc. The country's first Second-Generation (2G) Ethanol plant has been formally inaugurated and subsequently transferred to Bharat Petroleum Corporation Ltd. (BPCL) and Hindustan Petroleum Corporation Ltd. (HPCL) to build commercial scale biomass ethanol plants based on the home grown technology developed under a project of the Ministry.

Tremendous success has been achieved during the last four years in fulfilling the dream of Swasth Bharat. The first indigenous low-cost Rotavirus Vaccine from an Indian strain was launched by the Hon'ble Prime Minister in 2015. This will save lives of millions of children from diarrhoea. Anti-diabetic herbal formulation viz. BGR-34 developed and approved by the Ministry of AYUSH and licensed to a pharmaceuticals company for commercialisation has been ranked 14th among 6367 drugs launched in Indian Pharma market in the last two years. A large number of drugs, diagnostic kits and healthcare products have been developed and transferred to industry for commercialisation in the last four years. A new programme on Science and Technology of Yoga and Meditation (SATYAM) has been launched to rejuvenate deeper scientific research in yoga and meditation – 60 R&D projects have been supported to address issues related to study of several practices of Yoga & Meditation to treat various diseases.

S&T collaborations with the best in the world benefit immensely our scientific community and R&D institutions. The Ministry being the nodal agency in the country for International S&T Cooperation agreements has vigorously pursued intense S&T engagements with the relevant countries to enhance our S&T capacity and capability. Some noteworthy international collaboration during the last four years are: India becoming a partner in the LIGO project for gravitational wave detection with agreement to set-up the detector station in India; India becoming an Associate Member State of CERN; Establishment of India-Israel Industrial R&D and Technological Innovation Fund (I4F) of US \$40 million; Newton Bhabha Fund – initiated with UK; Launch of India-Canada Centre for Innovative Multidisciplinary Partnership to Accelerate Community Transformation and Sustainability (IC-IMPACTS) programme; etc.

The present report highlights some of the major achievements of the Ministry of Science and Technology and the Ministry of Earth Sciences during the last four years. Activities under several other new initiatives towards Make in India, Digital India, Swachh Bharat, etc. initiated during the last four years have been briefly described in this booklet. It is hoped that the present report will be useful for the masses to appreciate the efforts made by both the ministries which are engaged in finding affordable solutions to problems being faced by the masses.



Ministry of Science & Technology
Government of India



Ministry of Earth Sciences
Government of India

VIGYAN SE VIKAS विज्ञान से विकास



"Science must meet the rising aspirations of our people."
-Narendra Modi

Science and Technology contributing
to National Missions



Inspiring Youth

10,00,000+
Students trained

50,000+
INSPIRE Scholarships for
University-level education

15,000+
PhD fellowships awarded

5,000+
Post-Doc fellowships awarded

Promoting Entrepreneurship

5,000+
Startups supported

200+
Incubators supported/established

800+
Technologies transferred



Department of Biotechnology
Ministry of Science & Technology



Department of Science & Technology
Ministry of Science & Technology



Department of Scientific & Industrial Research
Ministry of Science & Technology

**S & T for
National
Missions and
Significant
Sectors**



Agriculture & Animal Husbandry









Agriculture

Doubling Farmers' Income – Ensuring Food Security

WORLDWIDE, India ranks second in farm output. Agriculture and allied sectors like forestry and fisheries, which accounted for 17 to 18 percent of GDP in 2017-18, employ about 50% of the total Indian workforce. Agriculture is demographically the broadest economic sector and plays a significant role in the overall socio-economic fabric of India.

But there are significant challenges. There are more than a billion mouths to feed. Problems are mounting in the face of impending climate change, degradation of farmlands, increasing soil salinity, drop in groundwater, pollution of surface water, frequent droughts and so on.

With its resolve of doubling the income of farmers by 2022, the Government has put in place enabling policies. Apart from creating alternate sources of income and ensuring fair price for the produce, the focus in agriculture research is on:

- **Reducing input costs** 
- **Enhancing productivity** 
- **Reducing wastage** 
- **Tackling biotic/abiotic stresses** 

Resilient, High Yielding Crops

Department of Science and Technology (DST)

- Soybean variety MACS 1281 released and notified for cultivation in the Southern Zone. The variety has medium maturity, is resistant to stem fly, defoliators, pod borer and leaf folder, bacterial pustule and bacterial leaf blight.
- Soybean variety MACS 1460 identified for release in Southern (5 states), Eastern (5 states) and North Eastern Hill Zones of India. Shows wider adaptability & disease resistance, is suitable for mechanical harvesting, highly resistant to pod shattering and early maturing (88 days).
- Durum wheat variety MACS 3949 identified for cultivation under timely sown irrigated conditions in Peninsular Zone.
- Durum wheat variety MACS 4028 identified for timely sown rain-fed conditions in Peninsular zone. Has average yield of 19.3 q/ha, good milling quality, better nutritional quality, is resistant to black and brown rusts, and has 1000-grain weight of 47 g.

Council of Scientific & Industrial Research

- New varieties of ornamental and medicinal plants developed
- Include lemongrass, citronella, vetiver and canna lily plant
- Cultivation of these new varieties have significantly enhanced incomes of farmers.

Department of Biotechnology

- Bacterial blight resistant Samba Mahsuri Rice introduced into 90,000 ha in Tamil Nadu, Karnataka, Telangana & Andhra Pradesh
- 12 drought resistant varieties of rice developed
- Maize hybrid with high quality protein (Vivek 9) and increased pro-vitamin A developed
- High zinc rice to be available to farmers in two years after all India trials
- Bread wheat & durum wheat with high yield & high micronutrient concentration in optimum soil zinc developed and undergoing trials
- These varieties have helped improve productivity of the crops, addressed nutrient deficiency issues and high value crops have increased income of farmers.

Varieties developed through DBT sponsored projects

Crop	Variety developed	Trait
Maize	Vivek QPM-9 (improved)	Pro-vitamin A rich maize variety
Rice	PB 1121 'saltol' IWP 'saltol' ADT 43 'saltol'	Salinity tolerant rice variety
	Swarna-sub 1, IR64-sub 1	Submergence tolerant rice variety
	Samba-Mahsuri-sub 1	
	Pusa Basmati 1728	Resistance against xanthomonas
Wheat	Unnat PBW 347	Resistance against rust

New Varieties, Enhanced Income

- Short-duration, high-yielding menthol mint (*Mentha arvensis*) – CIM-Krantihis – fits well into the existing crop rotation without disturbing or replacing food crops. Will enhance productivity and help maintain Indian leadership globally.
- Improved variety of Ashwagandha (NMITLI-101) is rich in major withanolides (active compounds) such as withaferin A, withanone and withanolide A that are responsible for excellent immunomodulation activity.



- New variety of *Artemisia annua*, the only known source of natural artemisinin for treatment of cerebral/drug resistant malaria, contains 1.2% artemisinin (20% increase over the existing variety CIM Arogya) and yields 43-45 quintal per hectare dry herb, an increase of 10-12% in comparison to CIM Arogya, thereby increasing farmers' income by ₹10000 to 15000 per hectare within 3-4 months. The new variety has been licensed to IPCA Lab, Ratlam. Industry is also expected to have the benefit of reduced cost of production by a margin of 20%.



- In collaboration with Narcotics Department, Opium poppy variety yielding 10% thebaine (1-2% normal content) has been developed. India produces 3 tonnes of thebaine annually. Thebaine has a multibillion-dollar market. The demand of opium alkaloids stands at around 300 tonnes per annum.

Seaweed Cultivation – Coastal Wealth

Technologies for cultivation of *Kappaphycus alvarezii* and value addition through simultaneous production of hydrocolloid and liquid biofertilizer have been developed. The fishing community in coastal regions of Tamil Nadu has been trained in cultivation techniques. Presently >800 Self Help Groups (SHGs) are engaged in cultivation, with average income of ₹ 5000 per month per person. The liquid fertiliser is marketed by IFFCO under trade name 'Sagarika'.



Kappaphycus cultivation

Lucrative Floriculture

- New varieties of *Bougainvillea*, *Chrysanthemum*, *Gladiolus*, *Gerbera*, *Cala lily* and ornamental roses have been developed. In Himachal Pradesh, an area of 24.5 acre was brought under cultivation, generating employment of 14,700 man-days and net return of ₹ 1.45 crores during a calendar year.
- CSIR-IHBT has developed package of practices on *Lilium* cultivation including aspects regarding climate, soil preparation, propagation techniques, varietal selection, bulb size, time of planting, planting density, planting depth, irrigation, nutrition, hoeing, weeding, pinching, disbudding, insect and disease management, grading, packaging and transportation of flowers.



Above:
NBRI-HimJyoti
Left:
Bougainvillea

FarmerZone for Smart Agriculture

- A collective open-source data platform for smart agriculture, "FarmerZone" uses biological research and data to improve the lives of small and marginal farmers.
- Multi-purpose window for solutions on climate change, weather predictions, land, soil, disease, pest, water, planting material and marketing available for farmers anywhere in India and the world.
- Farmers can access the service directly or through local co-operatives to directly sell their produce.
- The first sentinel site of FarmerZone on potato crop has been approved for funding and the first sentinel site for potato farmers initiated.



Agro-Meteorological Advisory Services (AAS)

- Ministry of Earth Sciences (MoES) in collaboration with the Indian Council of Agricultural Research (ICAR) provides the Agromet Advisory Services (AAS) for farmers.
- These services help plan operations like sowing, irrigation, application of fertilizer and pesticide, harvest and protection of crops from weather disasters.
- The services are being operated across 608 districts of the country.
- About 24 million farmers are receiving crop-specific agro-meteorological advisories in vernacular languages. By the end of July 2018, it is planned to increase the outreach to about 40 million farmers.
- It is planned to augment the AAS network to sub-district level by setting up District Agro-Met Units (DAMUs) in 530 districts (including the 115 aspirational districts) in the premises of KVKs of ICAR, thus creating a network of 660 units.

National Certification System for Tissue Culture Raised Plants (NCS-TCP)

- Unique quality management system, the first of its kind in the world, that ensures recognition of Tissue Culture Production Facility for the production of quality planting material and certification of end products.
- Around 80 companies recognized for getting their planting material certified from the Accredited Test Laboratories; 2 Referral Centres and 5 Test Laboratories accredited under this system; so far, more than 275 million Tissue Culture plants have been certified.
- Third party assessment by National Council of Applied Economic Research (NCAER) concluded that the annual economic benefit for the farmers cultivating four principal crops (Wheat, Rice, Sugarcane and Cotton) was ₹ 42,000 Crore in 2015.

Position in 2014

About 7 million farmers received AAS in vernacular languages

Position in 2018

About 24 million farmers are currently receiving AAS in vernacular languages

Weather Services Rendered by Ministry of Earth Sciences

1. Weather forecasts, warnings and advisories for agriculture
2. Now casting (up to 6h in advance) for severe weather (covered 350 towns currently)
3. Agriculture (all districts & twice weekly) 5 day forecasts, nowcasts, extended range about 24 million farmers through SMS Economic Benefit more than Rs 50,000 Cr
4. Warnings for Cyclones, Heavy Rainfall, Heat Waves, Thunderstorms/Lightning
5. Forecasts for heavy rainfall up to 2-3 days in advance

#TransformingIndia

moesgoi



Biotech-KISAN Impacting Farmer's Lives through Science

- Biotech-KISAN is for farmers, developed by and with farmers; it empowers women, impacts locally, connects globally, is Pan-India, has a hub-and-spoke model and stimulates entrepreneurship and innovation in farmers
- Provides solutions to challenges of small and marginal farmers
- Thematic **Mahila Kisan-Biotech** Fellowships instituted in each zone so that women farmers can work with science laboratories to generate solutions for problems they identify
- Strong Scientists-Farmers Interaction Platform created
- Demonstrates and scales up programmes addressing water, soil, seed and marketing issues of local farmers with validated technologies
- Seven hubs in different agro-climatic zones have been recommended for funding.

Farmer-friendly Technologies

- Swasti Agro and Bioproducts has developed preventive “vaccines”, ecofriendly sustainable technology, and “healthcare system” – android, IOT-based analysis-advice system for plants.
- KN Biosciences has developed a biocontrol agent of a nematode that controls crop pests in an ecofriendly manner. The infective juveniles of nematodes kill the pests within 24 hours and make them inactive.
- Vermicompost fortified with ABM's (*Mycorrhiza*, *Acinetobacter*, *Bacillus megaterium*, *Pseudomonas spp.*) increased 15% yield compared to chemical fertilizer and benefitted more than 1100 farmers.
- **Easy to handle farmer-friendly soil analysis kit assesses the levels of primary nutrients (N-P-K), Electrical Conductivity (EC), and pH.**



Joining Forces Globally

Decoding Wheat Genome for a Healthy Yield

India was part of a strong consortium of 15 countries which joined hands to decode chromosome 2A. Bread wheat, with an estimated world harvest of more than 550 million tonnes, is one of the most important food crops in the world. Wheat breeders, however, have few genetic tools to help them select key agricultural traits for breeding and do not always know the genes responsible for the traits they need. Analysis of the wheat genome, in which India played a crucial role, will give breeders the tools required to select traits for a healthy yield.

Virtual India-UK Joint Centres in Agricultural Nitrogen

These centres were set up for effective management of nitrogen to give a major boost to agricultural research and soil health.

DBT Innovate UK

Post-harvest losses occur between harvest and the moment of human consumption. They include on-farm losses, such as when grain is threshed, winnowed, and dried, as well as losses along the supply chain i.e., during transportation, storage, and processing. DBT and Innovate UK are investing £10 million (£ 5m from Innovate UK and £ 5m from DBT) towards funding of seven projects on “Biotech approaches for tackling challenges in agriculture food sector”, with focus on enhanced rice milling and maximized valorization of rice milling by-products, bio-based packaging for fresh food; electrolyzed water for post-harvest washing and so on.

TIGR2ESS – Transforming India’s green revolution



A new UK-India collaborative programme TIGR2ESS (Transforming India’s Green Revolution by Research and Empowerment for Sustainable Food Supplies) was launched on 3rd February 2018. This £ 7.8 million programme is funded by the UK Global Challenges Research Fund (GCRF) to develop more resilient, equal and diverse food systems in India. It aims to define the requirements for a second, more sustainable, Green Revolution, and to deliver this through a suite of research programmes, training workshops and educational activities.

DBT and Innovate UK are investing £ 10 million (£ 5m from Innovate UK and £ 5m from DBT) towards funding of seven projects on “Biotech approaches for tackling challenges in agriculture food sector”, with focus on enhanced rice milling and maximized valorization of rice milling by-products, bio-based packaging for fresh food; electrolyzed water for post-harvest washing etc.





Aroma Mission – Creating Farmer Entrepreneurs

- CSIR has contributed significantly in the development, nurturing and positioning of the essential oil-based aroma industry in the country.
- This has led to creation of an ecosystem benefitting the farmers, industry, and next generation entrepreneurs.
- For the first time, cultivation has been extended to challenging regions such as Jammu & Kashmir, tribal areas in Chhattisgarh, flood- and drought-affected regions e.g. Cuddalore, Vidarbha, Kutch, North-East.

Jammu Kashmir Arogya Gram Yojana

- Aimed at enabling value-added cultivation of aromatic and medicinal plants.
- The Yojana has covered 10 Districts (Kathua, Udhampur, Reasi, Doda, Ramban, Kishtwar, Samba, Poonch, Jammu and Rajouri) comprising kandi land/rainfed land/ wasteland/unutilized land/snow bound areas.
- 107.82 ha of land was brought under cultivation, which resulted in employment generation of 26,959 man-days, and benefitted 399 farmers through income generation of ₹ 9.625 lakh.
- The efforts targeted at rural skill set enhancement through farm-based activities and technology support, provided training to 1745 personnel on specific agro-technologies.



Animal Husbandry — Towards Disease-free Healthy Animals

ANIMAL health focuses on collaborative research for new generation vaccines and diagnostics along with translation of existing candidate vaccines and diagnostics for field use around major animal diseases at affordable costs for small and marginal farmers.

Brucella-free Villages – A Mission Approach

Brucella infects cows, buffaloes, sheep, goats, deer, pigs, dogs and other animals and also humans. This disease causes



economic losses of about ₹ 28000 Crores/year. 'Brucellosis Free Villages' Mission was launched by Department of Biotechnology in 50 villages of 10 states in a phased manner. DBT also launched three new *Brucella* diagnostic kits.

Cattle Genomics: Improving Indigenous Livestock

India has the largest repertoire of cattle in the world. Indian cattle population is highly heterogeneous. 69% of Indian

cows are owned by the poor. In Phase-I of Cattle Genomics Programme at National Institute of Animal Biotechnology, Hyderabad, whole genome sequencing of five important milch breeds of cattle has been initiated. This will help in identifying pure elite animals of a particular cattle breed in its early age and also finding out traits of economic importance such as milk production and fertility.

Generating Disease Models

Transgenic disease model displaying alpha thalassemia was successfully generated. This will ease the generation of transgenic rats needed to create better human disease models for use in biomedical research.

A transgenic mice model expressing *Echidna* anti-microbial protein (EchAMP) gene in its mammary gland was developed – it was confirmed by expression of EchAMP protein in milk samples of transgenic mice. The study has significant and long-term impact in the area of antimicrobials.



Technologies for Animal Husbandry

- LEPTOLAT for detection of Leptospirosis
- LFA kit for detection of CPV maternal antibody level in pups
- Egg yolk semen extender for cryopreservation of bull semen
- KETOCHECK for detection of Ketosis
- Conductivity meter for detection of subclinical mastitis
- Photolyser and Portable incubator and LAMP device commercialized to M/s Endhiran Innovations LLP, Chennai.



LeptoLAT for diagnosis of Leptospirosis

Below: Egg yolk semen extender for cryopreservation

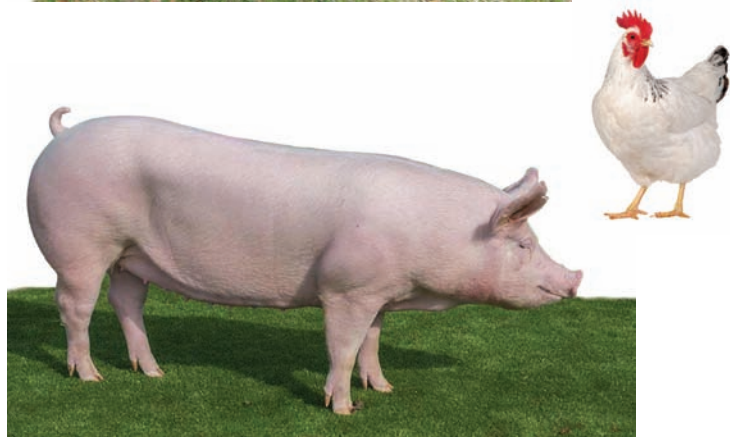


Left: Rapid Parvo detect kit



Left: Ketocheck for diagnosis of Ketosis





Improving Semen Quality, Enhancing Reproductive Efficiency

Availability of quality semen is a major constraint in successful implementation of artificial insemination programme. To improve semen quality and predict the fertility status of bull, transcriptomic profiling of bull spermatozoa is being worked out based on sperm parameters such as motility, membrane integrity, and mitochondrial function. Exogenous melatonin administration helped in preservation of semen and also enhancement of fertility rate of mithun.

Translational Research Platform

Translational Research Platform for Veterinary Biologicals in Tamil Nadu Veterinary and Animal Sciences University, Chennai has obtained NABL accreditation (IS/ISO 17025:2005) for diagnosis

of Bovine Trichomonosis & Brucellosis and initiation of cGMP licensing. Among various services, the platform is offering OIE approved diagnostic services of breeding bulls for Brucellosis, Trichomonosis and IBR in line with regulatory needs.

Infectious Bursal Disease Virus Vaccine

A Sub Viral Particle (SVPs) based infectious Bursal Disease Virus (IBDV) vaccine for immunization in chickens has been developed. This vaccine induces protective immunity in specific pathogen free chicks against very virulent IBDV challenge. This vaccine does not cause immunosuppression which was confirmed by an intact histological architecture of the bursa of Fabricius. The vaccine has also been validated in a poultry vaccine company M/s Globion Pvt. Ltd., Hyderabad.



Health For All





Health for All

Swasth Bharat

THE National Health Policy 2017 announced by the Government aims to strengthen and prioritize the road map of the government in shaping health systems. There is a major focus on bringing in new affordable health care interventions for prevention and treatment of diseases for promotion of good health across different sectoral sectors. In addition to health care interventions, there is also a major focus on the health care delivery system with the growing engagement of the private sector, specially startups and small industry. The availability of a proper technology translational mechanism is imperative to facilitate this.

National Biopharma Mission Launched

The first ever industry-academia mission to accelerate biopharmaceutical development in India was launched by the Cabinet Minister for Science and Technology, Earth Sciences, Environment, Forests and Climate Change, Dr. Harsh Vardhan in New Delhi in June 2017. The program, named Innovate in India (i3) is a game changer for the Indian Biopharmaceutical industry and involves an investment of USD 250 million with USD 125 million as a loan from World Bank. It aspires to create an enabling ecosystem to promote entrepreneurship and indigenous manufacturing in the sector.



The Biotechnology Industry Research Assistance Council (BIRAC) in collaboration with World Bank is implementing this mission. It brings together industry and academia to promote entrepreneurship and indigenous manufacturing in the bio-pharmaceutical sector.

Government approves Mission for Indigenous Biopharma product development

- Pan India mission to be implemented by BIRAC**
- A US\$ 250 M Mission with US\$125 M coming as World Bank funding**
- Will create an ecosystem for innovative indigenous product development by researchers, start ups and SMEs and make Indian Biotech Industry Globally competitive**
- India which today occupies only 3% of the Biopharmaceuticals Global Market aims to reach 5% by 2022**
- It will make the sector globally competitive over the next 10-15 years**
- It will transform the health standards of India's population through affordable product development**

In the next five years, the goal of the initiative is to bring five biopharma products vaccine, biotherapeutics, medical devices and diagnostics to the market. An ecosystem to facilitate the pipeline of products is being created.

India as a Leader in vaccine development and manufacture

The first indigenous low cost Rotav Virus Vaccine (RVV) from an Indian strain 116E was launched by the Hon'ble Prime Minister Narendra Modi in 2015. This vaccine is efficacious in preventing severe rotavirus diarrhea in low-resource settings in India. Introduced in 9 states, namely Odisha, Andhra Pradesh, Haryana, Himachal Pradesh, Assam, Tripura, Tamil Nadu, Madhya Pradesh and Rajasthan, the ROTAVAC® vaccine has received WHO prequalification in 2018 and has been included in India's Universal Immunization Program (UIP).

DBT's Indo-US Vaccine Action Programme (VAP) & the Vaccine Grand Challenge Programme (VGCP) scored high with achievements such as the development of the lowest cost rotavirus vaccine, which became part of the Universal Immunization Programme. Furthermore, the program is making major strides towards vaccine for diseases like malaria and dengue. It is estimated that one out of every six children over the world receive vaccines manufactured in India.

Malaria Vaccine: Vaccine for falciparum malaria is under toxicology assessment (JAIVAC 2) and vaccine for vivax malaria has completed Phase I trial (JAIVAC 1).



Launching of ROTAVAC® vaccine by Hon'ble Prime Minister Narendra Modi

Dengue Vaccine:

The International Centre for Genetic Engineering and Biotechnology (ICGEB) in collaborating with drug major Sun Pharma to use

the recombinant EDIII-based sub-unit dengue vaccine candidate to develop an injectable vaccine that protects against all four dengue strains that are endemic to India.

DBT paves road towards malaria prevention through vaccine research

DBT supported development of vaccines against *P. falciparum* and *P. vivax* malaria.

Department provided support to Malaria Vaccine Development Programme (MVDP), a consortium of DBT, ICGEB, Malaria Vaccine Institute (MVI), PATH, EMVI and WHO-TDR.

Currently MVDP is involved with development of candidate malaria vaccines at ICGEB.

Let us pledge for focused efforts on malaria treatment, prevention and control



On behalf of the Government of India, DBT is a part of the Coalition for Epidemic Preparedness and Innovations (CEPI), a new global alliance among governments, industries, academia, philanthropy, inter-governmental institutions, the World Health Organization and civil society organizations.

Dr. Harsh Vardhan, Hon'ble Minister for Science & Technology and Earth Sciences inaugurated the event in December 2016 in presence of all the stakeholders of CEPI and senior officials of Departments/Ministries concerned, such as the Department of Biotechnology, Ministry of External Affairs, DRDO, Ministry of Health & Family Welfare, Department of Pharmaceuticals, DCGI, etc.

Leading international efforts to address antimicrobial resistance



The India-UK Strategic Group on Antimicrobial Resistance (AMR) was launched in November 2016 by Dr. Harsh Vardhan, Hon'ble Minister for Science & Technology, Minister of Environment, Forest and Climate Change and Minister of Earth Sciences, and the UK Minister of State for Universities, Science, Research and

Innovation Jo Johnson. Prime Ministers of India and the United Kingdom announced a £6.5 million joint contribution dedicated to research on AMR.

DBT is also a member of the Joint Programme Initiative on AMR (JPIAMR), in partnership with the European Union, Germany has also expressed the desire to collaborate with DBT and has invited the Department to join the Global AMR R&D hub as a member of the Interim Board to participate in shaping the hub to maximize the impact of international research activities.

Addressing of anemia through iron-fortified rice

Appropriate technology has been developed on iron-fortified rice premix from broken rice kernels through the extrusion process. This iron-fortified rice premix matches with the normal rice kernel in shape and size, and when mixed with normal rice



Iron-Fortified Rice pre-mix



in the ratio of 1:100, provides approximately 50% of children Recommended Daily Allowance (RDA) of iron. An indigenously designed and fabricated demonstration facility on a pilot scale with a production capacity of producing 100 kg/day iron fortified rice premix was also established at IIT Kharagpur. Sensory studies are ongoing on a second version of the rice fortified with iron, vitamin B12 and folic acid was developed by IIT Kharagpur as per FSSAI guidelines.

Successful trial conducted on anaemic school children fed with iron-fortified wheat flour

Wheat flour fortification with elemental iron is technically challenging, primarily due to poor absorption from elemental iron and the presence of phytic acid. A randomized controlled study carried out by St. John's Medical College, Bangalore in iron deficient school children (6-12-year-old, with a total sample

size of 401 children) fed iron-fortified wheat-based meals during lunch time over a period of 7 months years. The study revealed a reduced prevalence of iron deficiency and iron deficiency anaemia as a result of the intervention.

Technology for double fortified salt composition containing iron and iodine to control both deficiencies

CSIR-CSMCRI has developed an innovative and cost-effective process for iodine and iron containing Double Fortified Salt (DFS) in an effort to combat iron and iodine deficiencies. The developed product retains micronutrient concentration for a prolonged period. Large scale community-based comparative trials are in progress in Bhavnagar and Vadodara to establish its safety and efficacy.

DBT supports food formulations for Severe Acute Malnutrition in Children

- Product made from **100% local ingredients** such as Soybean oil, Sugar, Milk powder & Peanuts
- Caloric dense (**550Kcal/100gm**), high in proteins, vitamins and minerals
- BIBCOL set up production facility for manufacture of RUTF for rehabilitation of malnourished children



Addressing of Severe Acute Malnutrition in children

In collaboration with the Ministry of Health and Family Welfare (MoHFW) and Indian Council of Medical Research (ICMR), DBT led a National Alliance on Severe Acute Malnutrition (SAM) to generate scientific evidence to inform public health policy. Through this alliance, BIBCOL, a Public Sector Undertaking (PSU) under DBT has developed Ready to Use Therapeutic Food (RUTF) under the brand name BIB POSHAN with financial support from the Department for the addressal of SAM in children. The product is made from 100% local ingredients and is licensed and registered under FSSAI.

The product is made from local ingredients such as soybean oil, sugar, milk powder and peanuts and is calorie dense, high in proteins, vitamins and minerals.

Improved Samba Mahsuri (ISM): A diabetic-friendly rice

Due to popularization of the Improved Samba Mahsuri (ISM) variety by CSIR, the cultivation area of ISM has been steadily increasing and is estimated to have been cultivated in an area of 130,000 hectares across the country in 2016. ISM has low glycemic index (that is, a value of 50.99), which is amongst the lowest value for several rice varieties tested and thus, is considered highly suitable for consumption by patients suffering from diabetes.



CSIR developed Improved Samba Mahsuri (ISM): A Diabetic Friendly Rice

Recognizing the seriousness of the problem of bacterial blight, CSIR-CCMB and ICAR-IIRR jointly developed resistant derivatives of Samba Mahsuri called Improved Samba Mahsuri (ISM)



It is estimated to have been cultivated in an area of **130,000 hectares** across the country

ISM has an unique feature of **low glycemic index**, making it highly suitable for consumption by patients suffering from diabetes as consumption of foods



CSIR Phytopharmaceuticals Mission

The CSIR Mission on Phytopharmaceuticals aims to increase cultivation to improve the availability of medicinal plants which are in high demand by global and domestic industry involved in the preparation of medicines of Indian traditional systems. Under this mission, it is proposed to prevent exhaustion of medicinal plants from their native locations by identifying the elite germplasm and conserving it by cultivation and in gene

Phytopharmaceutical Mission by CSIR

- Captive cultivation of medicinal plants
- Protection of threatened medicinal plants
- Technology Packages for production of GMP grade medicinal plant extracts
- Phytopharmaceutical development from important medicinal plants
- Intellectual Property generation, valuation and management
- Development of Digital Library of Indian Medicinal Plants
- Licensing of technologies and products



banks. Improved varieties, along with their agro technologies, will be developed to increase productivity and profitability per unit land area, and to make use of such areas which are affected by abiotic stresses such as drought, salinity, flood, shade etc. Efforts would be made to translate the potential clinical leads in different CSIR laboratories to develop them into phytopharmaceutical drugs, which would be made affordable and acceptable at global standards.

CSIR Mission on Sickle Cell Anaemia

Every year, approximately 5,00,000 children are born with Sickle Cell Anaemia (SCA) worldwide, with India accounting for nearly 50% of these cases. CSIR's Mission on SCA approaches the problem a four-pronged strategy of population screening and developing the counselling protocols; discovery and development of new lead molecules for management of SCA; genome editing and stem cell research approach; and affordable diagnostics.

Mission on Innovative Processes and Technologies for Indian Pharmaceuticals and Agrochemical Industries (IMPROTICS)

The Mission aims to develop cost effective, profitable processes for key drugs and agrochemicals. New or non-infringing processes that are free to operate shall be developed for pharmaceuticals. Several key starting materials and intermediates serving as import dependencies for the India pharma industry are identified and processes are proposed to be developed for those. This will enable Micro, Small and Medium Enterprise (MSME) industries to make and supply to Indian and international pharma companies. Thus, the mission would contribute to the 'Make in India' program and lead to improved health and food security for all Indians.

Mission on Nano-Biosensors and Microfluidics for Healthcare

Mission aims to use micro/nano-technologies in integration with micro-fluidics for the development of point-of-care, affordable and easy-to-use systems for healthcare applications such as:

- Rapid test card for Typhoid detection
- Label free, affordable and easy-to-use biosensor for detection of dengue virus infections in patient samples
- Device for the detection of cardiac biomarkers and cardiac risk management
- Devices for early stage Breast Cancer diagnosis
- Devices and nano-probes for early stage detection of Lung Cancer
- Devices for pre-diabetic and diabetic condition detection using invasive and non-invasive techniques
- Devices for detection of bio-markers for Mild Cognitive Impairment/ Alzheimer's disease

The endeavour is aligned with Government missions such as 'Ayushman Bharat' and 'Make in India'.

Streptokinase

Streptokinase is a vital, life-saver injectable protein drug that saves up to 40% of human lives after heart attacks, if given within a few hours of the onset of chest pain. CSIR-IMTECH has developed a portfolio of streptokinase technology which includes natural streptokinase; recombinant streptokinase; clot-specific streptokinase (third generation thrombolytic molecules); and the new generation clot-buster(s) (fourth generation thrombolytic molecules).

The technology of natural streptokinase of 'British' Pharmacopoeiac grade developed by CSIR-IMTECH was transferred to Cadila Pharmaceuticals. The price of the

imported brands in the country was also reduced by about 40%, resulting in a major saving to the Indian consumer and thus, making it within the reach of a common man. The recombinant streptokinase using the recombinant DNA route, has also been developed by CSIR-IMTECH which is roughly ten times more efficient as that of natural streptokinase production technology. The technology was transferred to Shasun Drugs and Chemicals, the development of which has led to making this vital life saver drug available to the consumer at affordable costs. CSIR's programme to develop technology for a domestic clot-buster drug was complicated as clot-buster drugs are not chemical but biotechnology drugs. While technology transfer and commercialisation were difficult, the endeavour led to expanded sales. The economic impact of CSIR streptokinase technologies, or the value that would be lost if CSIR streptokinase were not there, is about ₹ 580 crores for the patients, and based on the value of the life-years of surviving patients, of over ₹ 16,000 crores.

TulyTMRasburicase: TULYTM is a purified and sterile recombinant product of the enzyme urate oxidase, which is generally labelled as rasburicase. It is useful both in treatment and prevention of high uric acid levels. It also reduces the risk of acute renal failure and other life-threatening complications.

Novel processes for Eribulin, Nicotine and Bedaquiline

Serving as important drugs for health care, bench scale processes have been developed for all three molecules, for which synthesis at a large scale is necessary to serve the market demand. In all three cases, the developed routes are new and cost-effective. Eribulin (an anti-cancer drug) fragments are now made in lesser number of steps, Nicotine is made in one-step and Bedaquiline (anti-Drug Resistant TB drug) synthesis was achieved from commercially available starting materials at a low cost.



Hon'ble Union Minister for Health and Family Welfare handing over the license for commercialization to Optimus Life Sciences Ltd.

Non-vascular self-expandable stents

A new class of self-expandable stents based on a novel scroll design has been developed, allowing stents to meet the characteristics of shape memory alloy based stents. These stents could be made at much lower cost than the currently available ones and can be used in the treatment of numerous biliary tract diseases, ranging from benign biliary diseases to malignant structures.

Extracellular matrix, a wound healing matrix from porcine cholecystic, was transferred to Optimus Life Sciences. The product is a scaffold derived from animal tissue meant for wound healing, cornea repair and hernia repair.

Anti-diabetes herbal drug launched: Focused efforts towards affordable healthcare

CSIR has developed an anti-diabetic herbal formulation from a combination of natural extracts derived from six plant species mentioned in ancient Ayurveda texts. The drug, BGR-34, was approved by the Ministry of Ayurveda, Yoga and Naturopathy, Unani, Siddha and Homoeopathy (AYUSH) after it was tested on patients over a period of 18 months across states of Delhi, Himachal Pradesh, Haryana, Punjab and Karnataka. The drug, to be taken

as an add-on or adjuvant to existing diabetes treatment, helps in maintaining normal blood glucose levels, in addition to improving the immune system, releasing antioxidants and checking free radicals. About 67% patients showed normal blood sugar levels within 3-4 days of drug usage. The drug has been licensed to Delhi-based Aimil Pharmaceuticals for



commercialization. The herbal drug costs ₹ 5 per pill and has been launched in parts of North India. During the financial years of 2015-16 and 2016-17, the formulation earned a sale of more than ₹ 100 crores. BGR-34 has also been ranked at 14th position among the 6,367 drugs launched in the Indian pharma market in the last two years as per the survey conducted by All India Origin Chemists & Distributors Limited.

Development of herbal drug for dengue infection

A Technology Transfer Agreement was signed between DBT-ICGEB and an industry partner Sun Pharmaceuticals in May 2016 for taking forward the research lead already developed towards developing phytopharmaceutical drug.

***Butea* for bone health**

A project at The Central Drug Research Institute (CDRI), Lucknow is being developed on regulatory studies of standardized extraction of *Butea monosperma* for bone health (osteoporosis) to enable IND filing as phytopharmaceutical drug based on the research leads generated in earlier DBT funded project.

cGMP Pilot Plant for Herbal Preparations: Addressing country's need for validating and standardizing ayurvedic medicines the first national state-of-the-art cGMP facility for production of herbal preparations has been established in CSIR-IIIM. The facility, based on WHO and USFDA guidelines, has production capacity of 30,000 tablets & capsules per hour and 500 litres of liquid per batch. It has been issued license by the State Regulatory Authority (Drug & Food Control Organization). Recently, CSIR-IIIM also received permission to manufacture and market certain AYUSH drugs using this facility.

Nonclonable ID technology: An effective anti-counterfeit platform for medical product authentication

Counterfeit drugs have serious implications for pharmaceutical companies, government authorities and the general public. CSIR and Bilcare Ltd. have partnered to demonstrate the ability of a novel nonClonableID (nCiD) technology to address unmet needs in medical product authentication and patient compliance.

Affordable monitoring & diagnosis

Efforts are being made to reach affordable methods of monitoring and diagnosis of diseases and of patient care to common people. These include low cost diagnostic kits, technology for monitoring maternal and child health and products to ensure easy patient care in hospitals. Biodesign Programme in collaboration with the Biotechnology Industry Research Assistance Council (BIRAC) has developed several low cost devices for maternal and child care, and patient care diseases detection.

Development of highly sensitive and specific rapid 1- Day Dengue Diagnostic Kit

The highly sensitive rapid 1- day dengue diagnostic kit detects Dengue Virus (DENV) infection from the first day of fever, with a cost of ₹ 145/test to the distributors. The kit's performance was tested by Drug Controller Govt. of India and is currently being exported.

Development of affordable and point-of-need testing diagnostic systems for HIV and TB

CSIR in partnership with an industry has developed and launched a TB diagnostic kit, ReaSLR CSM Kit Ver 1.0. The kit has been made available for evaluation as well as sale. The HIV diagnostic ReaSTAT CD4 kit that has been developed is currently under large scale external validation.



Development of technology for a rapid diagnosis of Celiac Disease (CD) in humans

Diagnostic kits for Celiac

Disease (Celiac Microlisa & Celiac Card) supported by the Department was launched in 2014. These kits were developed through a collaborative, multi-institutional, inter-disciplinary approach and are rapid, sensitive, specific, and are much cheaper in comparison to the imported kits. The participating institutions were ICGEB, New Delhi, Translational Health Science and Technology Institute (THSTI), Gurugram; All India Institute of Medical Sciences (AIIMS), New Delhi, and have been made commercially available by industrial partner J. Mitra and Co. Pvt. Ltd

Highly Sensitive and specific rapid 1-Day Dengue Diagnostic Kit has been developed by ICGEB team with support from DBT



Plasma Gelsolin Diagnostic Kit for prematurity and sepsis

CSIR-IMTECH has developed two mass-production ready plate-based kits to estimate plasma gelsolin levels in humans leading to early detection of pre-term birth. After successful clinical trials, the diagnostic kit has been transferred to an industry for commercialization.

eSKIN: An in-silico Platform for Skin Data Analysis

A sophisticated but user-friendly software tool named "eSKIN" has been developed for skin system which enables modeling, simulations, analysis, and visualization. It has the ability to convert large scale high-throughput omics data into biomedical knowledge. The software is open for use and is available at the online platform of the industry partner, Persistent Systems.

Handheld FOT (Forced Oscillation Technique) device for improved detection and monitoring of airway diseases (PulmoScan)

CSIR-IGIB in partnership with industry has developed the world's first handheld, portable and battery-powered FOT device called PulmoScan, for measurement of lung function. It is a portable device with ability to run from the tablets without electrical supply. Its open tube design ensures disinfectability in Indian conditions where TB is a common problem.

Innovative devices to nurture mother and child health

Sohum helping early detection of hearing impairment in children

Sohum is a non-invasive and safe device for screening of neonates for hearing impairment with high sensitivity and specificity. This product



is licensed to Sohum Innovations and has been launched in India. The company is using seed the market strategy by providing products to various hospitals across India for eliciting feedback and adoption. The company has started making sales with three products sold so far. Sohum has executed a Memorandum of Understanding with the Government of Andhra Pradesh for phase-wise implementation and is in

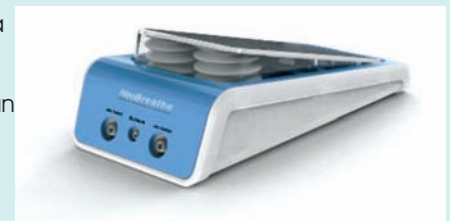


discussions with other state governments for product procurement.

NeoBreath: Foot-operated Resuscitation Device helping neonatal care

This product is a foot-operated resuscitation system that can free-up a hand of the device operator, thereby allowing use of both hands for holding the mask, leading to effective sealing and better ventilation. NeoBreath is licensed to Windmill Health and has been commercialized in India, as well as top hospitals of South Africa, Nigeria, Kenya and Mali. A few sample units have also been shipped to Rwanda, Chile, Peru and Argentina

and pilot sales in Africa and South America have started. More than 150 units have been sold by the company so far. The technology



has been sub-licensed to Phoenix Medical systems, Chennai for market outreach and sales.

Brun: Feto-maternal Parameter Monitoring System

This device is a safe, easy and cost-effective way to continuously monitor feto-maternal vitals of pregnant women,

which helps to reduce neonatal mortality. The product is licensed to Brun Health. The company has completed design for manufacturing for the product and is validating the technology at AIIMS, New Delhi and the product is yet to be commercialized.



Sishunetra

First-of-a-kind, low-cost wide field eye screening device for premature and term has been developed. The product has undergone extensive field trials and is ready to be launched in the Indian market by 2018.



Fetal Mom

This device functions as a fetal electrocardiogram and monitors uterine activity through signal extraction from maternal electrocardiogram, thereby eliminating the need for use of conventional transducers. The product has undergone clinical validation and is ready for launch.



Infant warmer – Bassinet and wrapper

The product was developed through DSTs support and was transferred to HLL Lifecare.



Innovative technologies for patient care

The focus of this initiative is on the development of devices and related technologies to ease patient care. The targeted categories include screening, diagnostic, surgical and life support equipments for clinical applications in healthcare sector.

Device to manage faecal incontinence, helping patient care in ICUs

This device helps to manage faecal incontinence in aged and infirm patients.



Soft Tissue Biopsy device helps collection of tissue samples with minimum skill for diagnosis

The device provides a safer, easier and cost-effective way to perform percutaneous aspiration needle biopsy.



Device developed to provide for concurrent biopsy and hemostasis

The device offers a safer, easier and cost-effective way to perform percutaneous aspiration needle biopsy, reduces skill and helps obtain consistent tissue samples for definitive diagnosis. helps, concurrent biopsy and hemostasis.

DPortable Device for Hand Sanitization helps patient care

This device is a simple, convenient and effective way for hand sanitization, helping patient care and is useful for hospital staff as well as patient care at home.

FlexiOH

FlexiOH is a breathable, washable and lightweight cast for immobilization of limb fractures.



Ostomy Management Appliance

The Ostomy Management Appliance is a safe, secure, bag-less solution for managing colostomy.

TJay

TJay, currently in the clinical trial stage, is the first of its kind holistic management solution for epilepsy. It consists of a wearable and an app for people with epilepsy (PWE), with a powerful analytic platform for doctors and healthcare professionals.



ACIX100

ACX100 is a microfluids-based immunoassays technology is a fast, accurate, reliable and cost-effective solution to improve healthcare standards of all; especially in remote and resource

limited settings. The technology can perform multiplexing, that is, it can test an array of proteins simultaneously from the same volume of sample.

Mobile Lab

The Mobile Lab is a compact portable clinical laboratory, in the form of a suitcase with a power backup facility. It consists of all essential instruments like Biochemistry Analyzer, Centrifuge, Incubator, Data Recorder/Mini Laptop with Patient Data Management Software, Micropipettes and other accessories.



Scintiglo

A smart, point of care, hand-held diagnostic device for rapid, reliable, economic and accurate quantitative estimation of urinary proteins.



Malaria Rapid Card Test

The kit is designed for differential diagnosis between Plasmodium falciparum and Plasmodium vivax.

AnuPath: Multi-analyte PoC device

AnuPath is a point-of-care medical device for management and early prevention of complications for diabetes, chronic kidney disease, anemia and malnutrition. The handheld medical device utilizes dry test strips for detection of biomarkers related to the respective disease.

Exocan

ExoCan has developed biofluids-based early cancer detection cum diagnosis kit operable at low costs. It is a two-step test to provide complete molecular information.



AINA Glucose Monitoring

The AINA device has been developed and commercialized to measure blood glucose, HbA1C, lipids (HDL, LDL, TrG), creatinine and haemoglobin.

Osteo3D

Osteo3D is a cloud-based 3D printing platform enabling surgeons to create 3D printable medical models online from any mobile, tablet, laptop or desktop computer.

Oral cancer screening camera

The product is a hand-held imaging device that uses trimodal imaging technology combining tissue fluorescence, absorption, and diffuse reflectance for screening and detection of oral cancers.

Prosthetic Leg

PSPR-3D-Tech is engaged in development of technology and manufacturing of affordable below-knee prosthesis innovative reverse engineering and 3D printing technologies enabling high level fit for greater comfort and strength.



Poorti kit:

Post-mastectomy breast prosthetics

The Poorti kit is an affordable and holistic post-mastectomy kit to restore confidence, dignity and femininity of breast cancer survivors.



VAPCare

VAPCare is a novel secretion and oral hygiene management system to reduce the risk of acquiring Ventilator Associated Pneumonia (VAP).

Tro Guard: Hip protective device

Tro Guard is a novel hip protective device developed by IIT-Delhi, with the technology for the manufacture of bone graft materials being transferred in 2016.

Tilting Disc Heart Valve

The second-generation cardiovascular products, namely the tilting disc heart valve and gel-coated vascular graft, has entered into the clinical trial phase.



Technology transfers for _____

The technology for the following innovations has been successfully transferred:

- Preparation of extracellular matrix scaffolds from mammalian cholecyst/jejunum/urinary-bladder
- Calcium Sulphate cement, process for Glutaraldehyde cross-linking of pericardium with anti-mineralization, Poly Vinyl Alcohol (PVA) sponge
- Rapid Urinary Tract Infection (UTI) diagnostic kit with antibiotic sensitivity test
- Fibrin sealant
- Blood/IV fluid warming system
- Vein viewer device

Hand-cranked defibrillator

The world's first electricity and hand-cranked dual powered defibrillator has been developed, serving use in regions without

reliable electricity such as in India, Africa, South America and Asia. Health units such as Primary Health Centres (PHCs) and Community Health Centres (CHCs) as well as emergency response units of security forces would benefit from this immensely. The price of this device would be 1/4th of the big brands, while providing similar or higher quality and reliability levels.

Haemoglobin (Hb) Calculator App

An android-based smartphone app called Haemoglobin (Hb) Calculator was developed for accurate and sensitive measurement of Hb. The application's higher sensitivity, specificity, accuracy and reliability make it an attractive alternative for Hb estimation in resource-limited conditions.

InDiatel: Diabetic healthcare unit

InDiatel, a telemedicine-based diabetic healthcare unit, was developed by Vellore Institute of Technology (VIT) in association with TMI Systems and launched in December 2017.

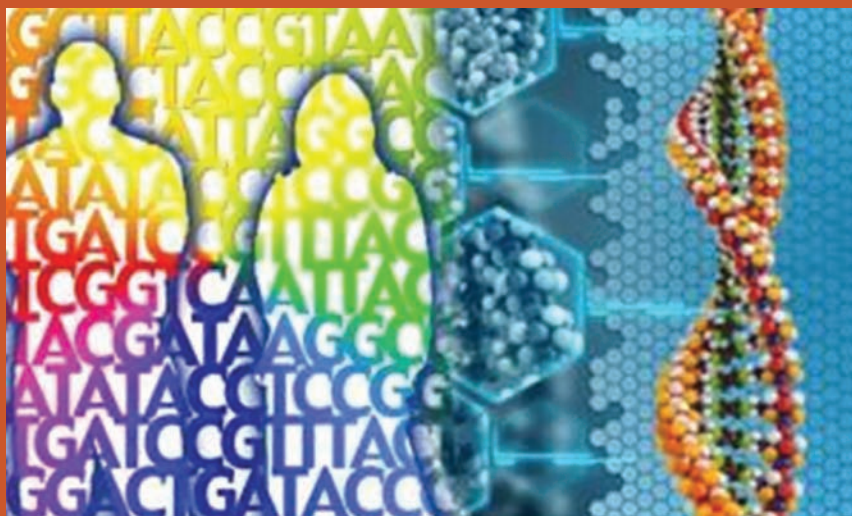


InDiatel – A Telemedicine based Diabetic Healthcare Unit



Diagnosis & treatment of human genetic disorders significantly augmented

The programme on Human Genetics & Genome Analysis provides genetic diagnosis, improved molecular medicine tools and counselling to families affected by common genetic disorders in India. As of now, 21 Genetic Diagnosis cum Counselling Units have been established, benefitting more than six lakh affected families, including one lakh tribal families.

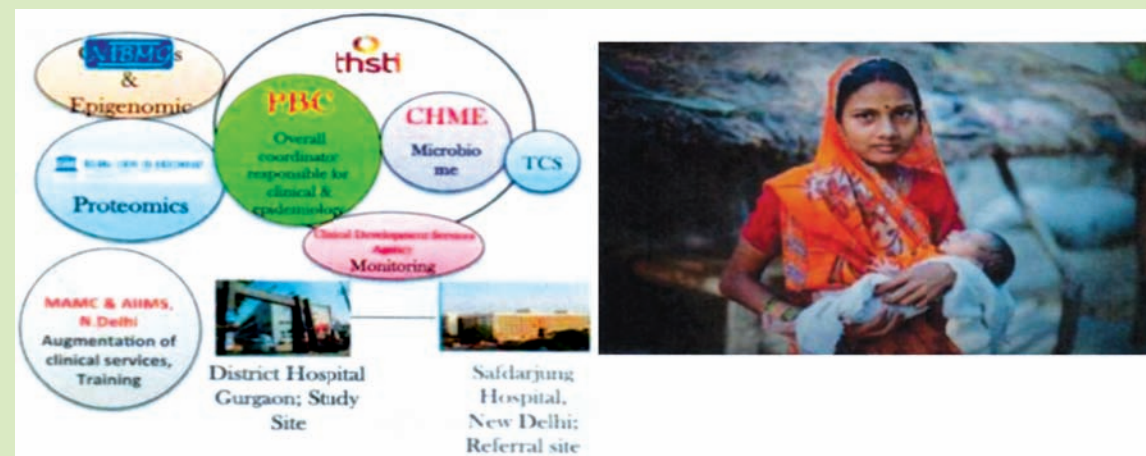


DNA typing

DNA typing of 25 autosomal markers in 53 ethnic groups (including tribal, caste and religious communities) revealed evidence of human migration from India to South East Asia.

Multi-institutional National Programme on preterm birth launched

The five-year Grand Challenge programme at a total cost of ₹ 48.85 crore envisages a multidisciplinary research effort to predict & diagnose Preterm Birth (PTB) by enhancing the knowledge of the underlying pathophysiological mechanisms. With a goal of enrolling



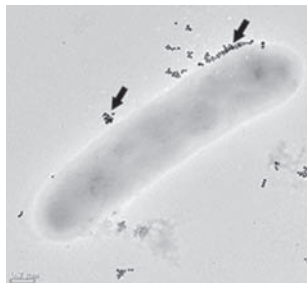
a total of 8,000 subjects, 1,108 women have already been enrolled in the cohort study. Early findings from the cohort study involving 1,000 mothers indicate that indoor pollution is associated with early birth, and that early shortening of the cervix is a risk factor for PTB.

Infectious disease research

DBT has taken up the challenge of addressing the prevention, detection & treatment of a large range and burden of infectious diseases. Recognizing the importance of collaborative research to address regional needs, DBT, in collaboration with DST, and Medical Research Council, Department of Science & Technology and the Government of South Africa, embarked on a collaborative research program on HIV, TB and TB/HIV. DBT has also initiated and inter-institutional HIV Research Program titled 'Cohorts for HIV Resistance and Progression in Indian Children and Adults'.

Indo-South African Collaborative Research Program on HIV, AIDS and TB

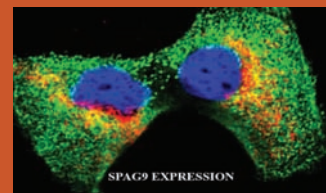
The collaborative program is under the framework of the bilateral Science & Technology Cooperation agreement between the Department of Science & Technology, Ministry of Science & Technology, Governments of India and South Africa. Three joint proposals in TB, HIV, TB/HIV have been sanctioned under this collaborative effort.



Cohorts for HIV Resistance and Progression in Indian Children and Adults

This networking program envisages building specific HIV cohorts and a related national database and bio-repository to enable the conduct of studies that will provide a better understanding of the disease to aid in the design and development of novel tools for treatment and prevention of HIV/AIDS.

Contributions to cancer research



DBT has helped identify causes of oral and breast cancer, the two major cancers affecting the Indian population in order to contribute to an increased understanding of the strategies for cancer prevention and effective treatment. The Department has achieved the following:

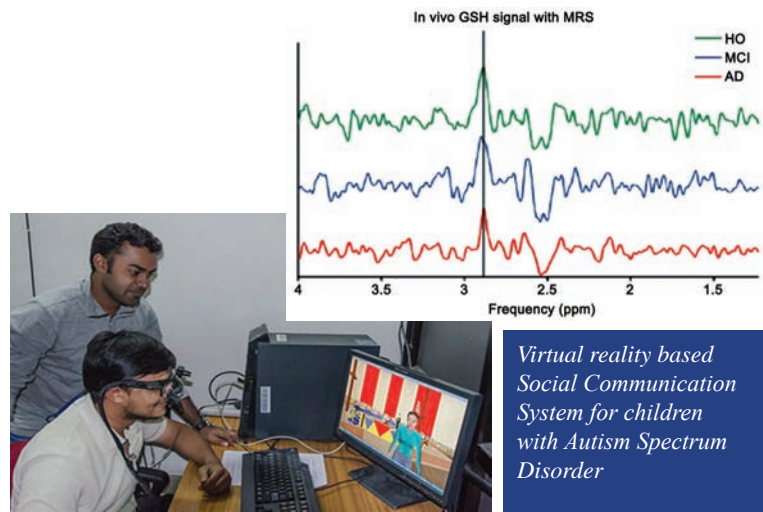
- Funded two Virtual National Cancer Institutes (VNCIs): Oral & Breast Cancer
- Multi-omics Analysis to Decipher Mechanisms of Hormone Resistance in Breast Cancer
- Fully functional Virtual National Oral Cancer Institutes. These are staffed by 5 to 7 investigators holding proven excellence in basic biology, clinical research and technology development
- Implementation of seven Units of Excellence. These units are mandated to extend the advancements made by the principal investigators in basic biology to pre-clinical and clinical areas. 113 pilot project grants for young investigators have been sanctioned and implemented to investigate new hypothesis for establishing proof-of-concept in cancer research.

Tools for diagnosis and management of mental disorders

Given the range of different types of mental disorders afflicting people DBT is working on specific problems that affects India. Dyslexia is a learning disability wherein school children do not achieve adequate reading skills despite normal intelligence, equal opportunity and adequate instruction. It is believed to have a worldwide incidence of 5-20% and in India, the incidence of dyslexia is believed to be 10% which brings our count of dyslexic Indian children to nearly 35 million.

Software for early detection of mental disorders

National Brain Research Centre (NBRC) has developed a software that can screen a person to predict predisposition to Alzheimer's and other mental diseases allowing for improved management of these disorders. The software conducts imaging to find out the chemical changes in the brain.



To promote cutting edge research in cognitive science, the Department of Science and Technology has supported around 200 Research and Development (R&D) projects through the Cognitive Science Research Initiative.

DALI (Dyslexia Assessment in Languages of India): Kit for early detection of dyslexia

DALI is a package developed by National Brain Research Centre, Manesar that contains screening tools for school teachers and assessment tools for psychologists in Indian languages to identify dyslexia. DALI will be the first indigenously developed screening and assessment tool to be standardized and validated across a large population of nearly 4840 children. The tools are available in Hindi, Marathi, Kannada and English and is currently being developed in other languages as well.



Science And Technology of Yoga And Meditation (SATYAM) to rejuvenate deeper scientific research in yoga and meditation

60 R&D projects have been supported to address issues related to the study of several practices of yoga & meditation

to treat various diseases such as schizophrenia, epilepsy, depression, early dementia, Mild Cognitive Impairment (MCI), Parkinson's disease, cerebral palsy, rheumatoid arthritis, Type 2 diabetes, Polycystic Ovary Syndrome (PCOS), Chronic Obstructive Pulmonary Disease (COPD), pulmonary function in chest trauma patients, lifestyle diseases, and improvement of quality-of-life. The selected teams involve clinicians, proponents of Yoga and scientists, among other from multi-disciplinary areas.

Award instituted by Technology Interventions for Disabled and Elderly (TIDE) program

The TIDE program instituted an award for the development of the best-assisted device and the Hon'ble Prime Minister gave the inaugural award during the 103rd Indian Science Congress.



Atlas for Visually Impaired (India)



The Union Minister for Science & Technology and Earth Sciences Dr. Harsh Vardhan released the Special Edition of "Atlas for Visually Impaired (India)" in English Braille

This Braille Atlas has been prepared by National Atlas and Thematic Mapping Organisation (NATMO) under Department of Science & Technology



Efforts are being made to make these atlases more cost effective than the current price of ₹ 600/- per atlas with 20 maps now.



@IndiaDST

@IndiaDST



'Ksheer Tester' Handheld GPS enabled device to detect milk adulteration

In order to address the issue of milk adulteration, a low-cost portable electronic system, named 'Ksheer-Scanner' and 'Ksheer Tester' have been developed which detects contaminants such as urea, salt, detergent, liquid soap, boric acid, caustic soda, and hydrogen peroxide in just 40-45 seconds. The device enables any person to track the location of the tested sample of milk and receive the test results through SMS on the device. The technology has been transferred to 2 companies for commercialization.



Degumming of Rice Bran Oil

A process of enzymatic degumming that produces prime quality rice bran oil has been developed. This eco-friendly process reduces phosphorus levels in rice bran oil from 0 to 5 ppm, enables more oil recovery at better quality while requiring less water and releasing less liquid effluent.



The process technology is commercialized and has also been demonstrated to 19 industries and 8 project engineering companies.

Carbonated Fruit Juices as an Alternative to Soft Drinks

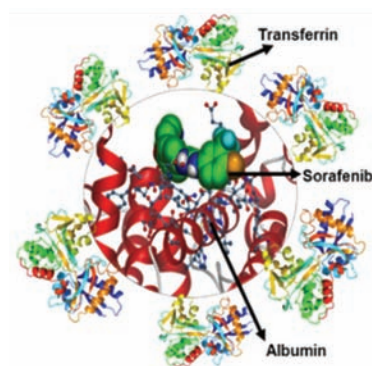
Standardized carbonated drinks based on grape, pomegranate, sweet lime, sugarcane and neera (coconut palm sap) flavours have been created by the technology



for carbonation of fruit juices. The fizzy fruit juice formulations, promoted as 'healthy' and 'nutritious' drinks are suitable for all age groups, and particularly suited to the carbonated preferences of the younger generation of consumers. The products have a shelf life of about 2-4 months at room temperature. The laboratory estimates indicate the cost of production of 300 ml of fruit juice to ₹ 16.

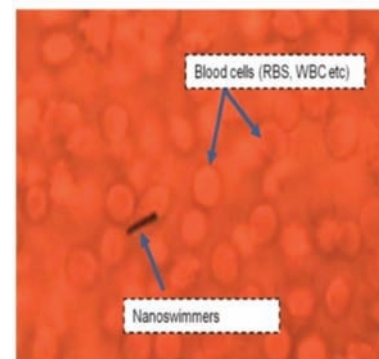
Protein Nanomedicine

A novel protein nanomedicine formulation was developed with tunable pharmacokinetic and bio-distribution properties achieved by gold (Au) cluster doping technology. The negative charge of human serum albumin nanoparticles (nAlb) was modified by doping with 25-28 atom clusters of gold. This study enabled loading of small molecule drugs at single molecule form.



Nanoswimmer

A system of artificial paramagnetic nanostructures was developed that can be manoeuvred remotely in bodily fluids, such as human blood, using small externally applied rotating magnetic fields. The novel system is being explored for clinical applications in cancer diagnostics and therapeutics.



Waste to Value: Swachh Bharat



एक कदम स्वच्छता की ओर





Waste to Value: Swachh Bharat

HON'BLE Prime Minister Shri Narendra Modi launched the ambitious 'Swachh Bharat Abhiyan' (Clean India Mission) on 2 October 2014 on the 145th birth anniversary of Mahatma Gandhi. The Ministry of Science & Technology is contributing towards new technology development for many initiatives under Swachh Bharat.

In addition, many new technologies that have been successfully demonstrated are now being transferred for commercial scale-up to the user agencies and departments. Various initiatives are being taken forward with the local Municipal Corporations and the Ministry of Drinking Water and Sanitation, as well as the Ministry of Urban Development under the Swachh Bharat Mission. Special initiatives for cleaning of

waste water have contributed significantly to the *Namami Ganga* project.

There has also been a major focus on conversion of waste to value. The effort is to demonstrate new technology that can help in the conversion of waste to value.

Under 'Swachh Bharat Abhiyan' (Clean India Mission), the Ministry of Science & Technology is contributing towards new technology development for many initiatives under Swachh Bharat.



Collaboration with Netherlands to Clean Delhi's Barapullah Drain

DBT has collaborated with Netherlands to initiate a project for cleaning Delhi's Barapullah drain. The project aims at 'new' wastewater management to ensure good quality fresh water, free of risk-causing contaminants and promoting productive, safe reuse of water.

A wastewater treatment plant to make dirty water potable is to be set up, apart from ensuring removal of heavy metals from the water body for reuse. Barapullah Nullah is a 12.5 km-long storm water drain responsible for about 30% of pollution in the Yamuna River collecting domestic sewage and polluting waste from small industry from the South zone to the East zone in Delhi.

Swachh Barapullah Drain

Department of Biotechnology partners with Government of the Netherlands and DDA to clean the open sewage water of Barapullah drain leading to river Yamuna.



- Reuse water for on site toilets
- Recover wealth: metals, organic compounds
- Reuse water for water park on site Sun Dial park
- Reuse water for irrigation, industrial purposes
- Potable water

PROJECT LOTUS:
Local Treatment of Urban Sewage Streams For Healthy



Department of Biotechnology India

Department of Biotechnology

@DBTIndia

Green Remediation Technology for Wastewater Treatment

A DBT supported project has developed a phytoremediation treatment process for the degradation of dyes from textile industrial effluents. The study showed that *macrophytes*



Ipomoea aquatica, *Alternanthera philoxeroides* (a massively rooted macrophyte), and *Salvinia molesta* showed a potential for textile dyes and effluent treatment at large scale (constructed wetland system) through rhizofiltration approach.

Empowered Septic Tank for Wastewater Treatment

Birla Institute of Technology and Science, Goa, has developed a financially affordable and simple-to-operate decentralised wastewater treatment system using bio-electrolysis for a community of 100 individuals.

Extensive testing of the effluent is underway.

BioUrja

BioUrja is a modular, compact and customizable bio-methanation system to handle various organic wastes developed by a startup GPS Renewable, through support from DBT and BIRAC. Easy to use, automatic, highly efficient and low footprints are key features that have helped BioUrja achieve worldwide recognition. With MIT and WWF recognizing the innovation, world-renowned partners and multiple patents, BioUrja promises a sustainable future for waste management.

Novel Bio-toilet Technologies

DBT, BIRAC and The Bill & Melinda Gates Foundation launched a 'Grand Challenge Call' focused on reinventing the toilet. Innovative Bio-toilet design ideas were generated focused on innovative solutions for less water usage, pathogen free and odour free discharge and bio-digestion of waste.

A demonstration has been set up in 100 schools in the North East using the new bio-toilet design. This is an off-grid, self-sustained, modular, electronic toilet for use in slums. It utilises solar energy and is integrated with mixed waste processing unit to ensure water and energy/fertilizer recovery.



Easy to assemble cost-effective toilets: A technology for low cost, light weight (< 500 kg) toilet with long shelf life (25-30 years) has been developed using textile reinforced concrete (TRC) panels for areas where toilet coverage is still incomplete. It is made in-situ and assembled in less than five hours. An MoU was signed with M/s. Smart Built Prefab Pvt. Ltd., Hyderabad, for technology transfer and manufacturing.

Precast ferrocement toilet core unit: A novel technology for industrial production of Precast Ferrocement Toilet Core (TOCO) units at an affordable cost has been developed. The technology involves casting of components of the structure at the manufacturing or production site, rather than location and transporting and assembling components at the site where the structure is to be located. This technology is useful for mass production of high quality toilet core units to cater to the needs of the people, and combines good design with modern high-performance components and quality controlled manufacturing procedures.

Molasses spent wash treatment gives algal biofuels: Algae biofuels may provide a viable alternative to fossil fuels. A new technology supported by BIRAC has been developed that can remediate pollution from wastewater of sugar or distillery industry and use it for enhanced production of algal biofuel. The fungus that produces enzymes for decolourisation of the polluted water has been grown and other microbes to be used in this process have also been screened and isolated.

Innovative Bio-toilet design ideas were generated focused on innovative solutions for less water usage, pathogen free and odour free discharge and bio-digestion of waste. Demonstration has been set up in 100 schools in the North East using the new bio-toilet design

Anaerobic digester converts household organic kitchen waste to biogas: An Anaerobic Digester has been developed for converting household organic kitchen waste to biogas. It has a capacity to convert up to 3 kg per day bio-degradable kitchen waste to 400 litre biogas, that can



be utilized as used as fuel. In the process, it will discharge about 2.5 litres of manure which can be used for building a kitchen garden. The technology has been transferred to Mailhem Ikos Environment Pvt. Ltd. and will also be utilised by Thiruvananthapuram Corporation.

Recycling waste plastic bags into tiles: A simple and novel process for recycling waste plastic bags and bottles to turn them into decorative coloured tiles has been developed. Such tiles can be used in building structures for the public. The technology has been transferred to M/s Shayna Ecounified India Pvt. Ltd., Delhi.



Bio-filter odour control for municipal solid waste treatment plants: Solid Waste (SW) treatment plants are facing public protests

due to odour in Municipal SW treatment plants. CSIR-NIIST has developed design of odour control ventilation system and bio-filters for treatment of large volume exhaust air from solid waste treatment facilities. The biofilters are operational at several locations.



Food waste digester cum biogas plant:

A food waste digester cum biogas plant (40 kg food waste/day) has been developed for treating large quantity of organic waste. The product has an automatic control system for more efficient biogas production and its utilization. About 40 kg food waste/day unit can generate around 7 M3 biogas daily (average biogas was 160-180 L/ Kg food waste, methane content >60%). It has been installed in schools, Regional Cancer Center, Marthoma orphanage in Thiruvananthapuram, CPCRI, Kayamkulam and Kavaratti island in Lakshadweep.

Disposal of municipal solid waste utilising high temperature plasma: The technology has been developed for effective & eco-friendly disposal of municipal solid waste material generated on daily basis and generation of fuel gas containing predominantly CO and H₂ utilising high temperature (>3000°C) Plasma arc. The technology has been licensed to M/s Positronics Innovation Pvt. Ltd., Kolkata for commercialisation.

Biogas Purification & Bottling Technology for vehicular application developed at Indian Institute of Technology, Delhi has the capacity of generate upto 100 m³/day biogas and is in the process of demonstration and commissioning at Bhopal.

Waste Treatment Technology Development

DBT is supporting many demonstration programmes for conversion of waste to energy. The focus is on conversion of both municipal solid waste and municipal liquid waste to bio-oil, bio-CNG and bio- methanol. A demonstration plant has been set up at BPCL, Refinery, Chembur, Mumbai at 1 ton/day. In addition, two other demonstration plants have been set up at GHMC site, Hyderabad and BITS Pilani, Goa. Both these are at 2-5 ton/day. On successful completion of demonstration, these technologies would be scaled up for commercialisation.

New Hybrid Kiln (Novel Bio-toilet Technologies)

New Hybrid Kiln has been developed which incorporates features for natural draft and induced draft kiln, with higher efficiency at less fuel consumption. The patent has already been filed for "New Hybrid Kiln with zig-zag technology". Hybrid kiln reduces the energy consumption and also maintains the required production level throughout the operating season of brick kilns.



DST Waste Management Technologies (WMT) Programme

“Waste Management Technologies (WMT)” programme was initiated in October 2015 to provide innovative technological solutions for challenges around solid waste management, including, hospital waste, plastic waste and e-waste – **19 projects were initiated in the first phase and 18 projects in the second phase.** DST has recently invited Expression of Interest (Eoi) for considering joint and scale up projects under solid waste management. The overwhelming response of investigators was reflected in 780 Eols received by the Department.

Hybrid light weight, high strength and glossy finish, polymeric composites from marble & granite waste stream makes green composites by utilisation of marble



Landfill Reclamation: DST has constituted a scientific advisory committee on the request of the Government of Delhi for the reclamation of a sanitary landfill site. The committee recommended short term, medium term and long-term measures and action plans to the concerned municipal bodies. A comprehensive assessment of available technologies for solid-waste management has also been completed and shared with MoUD to aid in the future deployment of these technologies.

and granite wastes. The hybrid green composites can be used as viable alternatives for timber, synthetic wood and plastics for use in civil infrastructure. To generate awareness and confidence, an Industry Institution Enclave (IIE) 2017 was organised in Coimbatore where hybrid green composites made from marble wastes were showcased. Networking with select promising entrepreneurs and start-ups have also been established for commercial exploitation.





WWW





Digital India





“We want to have one mission and target: Take the Nation Forward, Digitally and Economically”

Shri Narendra Modi, Hon'ble Prime Minister of India

Digital India: Progressive India

DIGITAL India is a flagship programme of the Government of India, with a vision to transform the country into a digitally empowered society and knowledge economy. Ministry of Science and Technology and Ministry of Earth Sciences have been implementing many programmes and activities supporting the Digital India Initiative, which are:

High Performance Computing (HPC)

Ministry of Earth Sciences has augmented its HPC facility by 6.8 Peta Flops (PF) which has been installed at two of its constituent units namely, Indian Institute of Tropical Meteorology (IITM), Pune with 4.0 Peta Flops capacity and National Centre for Medium



The HPC facility ‘Pratyush’ at IITM and ‘MIHIR’ at NCMRWF were dedicated to the nation by Dr. Harsh Vardhan, Minister for Earth Sciences on 8 January 2018 and 30 January 2018, respectively.

Range Weather Forecasting (NCMRWF), Noida with 2.8 Peta Flops capacity. **The HPC facility ‘Pratyush’ at IITM and ‘MIHIR’ at NCMRWF were dedicated to the nation by Dr. Harsh Vardhan, Minister for Earth Sciences on 8 January 2018 and 30 January 2018, respectively.** With this facility, a paradigm shift in weather and climate modeling activity for operational weather forecast has been achieved.

The HPC system will be a national facility for improving weather and climate forecasts and services under the umbrella of the Ministry of Earth Sciences (MoES), Govt. of India. India’s ranking has moved from the 368th position to around the top 30 in the Top 500 list of HPC facilities in the world. India is now placed at the 4th position after Japan, UK and USA for dedicated HPC resources for weather/ climate community.

This facility is part of Ministry’s continuous endeavour to provide world class forecast services to the citizens of India through its various operational and research and development activities. The Ministry of Earth Science has developed several services for societal benefits catering to a variety of sectors of economy by building state-of-the-art systems for multi-hazard risk reduction from cyclones; floods/droughts; heat/cold waves; earthquakes and tsunamis.

National Supercomputing Mission

It is a visionary programme to enable India to leapfrog to the league of world class computing power nations. The NDA Government approved the Supercomputing Mission at a total cost of ₹4500 cr in March 2015. The Mission envisages installing a vast supercomputing grid comprising more than 70 high-performance computing facilities. The Mission also includes development of highly professional High-Performance Computing (HPC) aware human resource for meeting challenges of development of these applications. Supercomputing capability would add a great value to realise the goals of Digital India. The six supercomputing systems in Phase I are to be made operational shortly.

Interdisciplinary Cyber-Physical-Systems (ICPS)

DST has identified Interdisciplinary Cyber Physical Systems (ICPS) as one of the emerging fields, progress in which is expected to have significant impact on health care, urban transportation, water distribution, energy, urban air quality, manufacturing and governance. The complex socio-technical systems, involving interactions between 'cyber' and 'physical' are addressed by CPS technologies. The R&D activities envisioned under this program will provide a great fillip to Indian manufacturing through invention of new products and services, and creation of skilled human resource at all levels (from technicians to researchers, and entrepreneurs). It is also expected to become a key contributor in realizing the vision of a **"Digital India"** and for economic growth.

The ICPS division is working on the development of the National Mission on ICPS (NM-ICPS), CPS and the associated streams, and all aspects of research will be coordinated under the umbrella of NM-ICPS.

The infographic features a green header with the text "INTERDISCIPLINARY CYBER PHYSICAL SYSTEMS" and the Indian national emblem. Below the header, a central text block states: "DST has launched a new programme 'Interdisciplinary Cyber Physical Systems (ICPS)' to foster and promote R&D in this emerging field of research." To the left of this text is an icon of a cloud containing various digital symbols, with a double-headed vertical arrow below it. At the bottom left is an icon of a modern building. At the bottom right is a blue banner with the text "Interdisciplinary Cyber Physical Systems (ICPS) Division". The footer includes social media handles for Facebook (@IndiaDST) and Twitter (@IndiaDST).

Science and Heritage Research Initiative (SHRI)

The objective of SHRI is to promote the scientific research and intervention to preserve, restore and develop of new material/methods/tools to strengthen Heritage Science in sectors such as textiles, metal works, crafts, ceramics, etc. and diffuse this to artisan clusters. The programme was launched by Hon'ble Minister of S&T on 13th October 2017 during IISF-2017. Around 100 proposals were received under the first call for proposals closed in February 2018.

Indian Heritage in Digital Space (IHDS)

The Indian Digital Heritage (IDH) project is a unique initiative of the DST supporting collaborative projects between researchers in the areas of technology and humanities for the digital documentation and interpretation of tangible and intangible heritage. The project highlights the art, architecture and cultural legacy of the world heritage site of Hampi in Karnataka, the medieval capital of the Vijayanagar dynasty.

As an outcome of the IDH Scheme, a total of 37 generic technologies, 7 prototypes and scaled models have been developed and demonstrated. These technologies are generic in nature and thus can be applied on any monument. Developed technologies broadly relate to Murals, Knowledge bank, Interfaces, Intangible, Memorialization, Design, Crafts, 3D Printing, Features, Resurrection, Ontologies, Representation, 3D Surface, Preservation, Immersion, Reconstruction, Haptic, Walkthrough, Scaling etc. Three Start-up Companies have been spun off from IDH research and technologies.

Networked Programme on Imaging Spectroscopy and Applications (NISA)

Network Programme on Imaging Spectroscopy & Applications (NISA) is a cluster based multidisciplinary networked scheme to promote research on various aspects of Imaging Spectroscopy and Applications (ISA). This scheme is expected to evolve reference standards, protocols, database and research methodologies for adaptation in various fields relevant to society. This networked scheme has 37 projects in seven theme areas (such as geology, agriculture, forestry, water, snow and glacier ice, urban & built-in materials and algorithms). 70 JRFs are working towards their PhDs in this advanced field of Imaging Spectroscopy & Application. Outcome of this project will add new dimension to India's natural resource exploration strategies and resource inventory. The scientific understanding in each thematic area emerging from this networked project will also fill the gaps in present understanding on this subject globally. ISA being the current and futuristic technique, the proposed networked project will certainly pave way for technology development, generating human resource in the country.

New Directed Research Programme on “Quantum Information Science and Technology (QuST)”

Quantum Information Science and Technology (QuST) promises to revolutionise the future computation and communication systems which will ultimately have an immense impact on the Nation and our society. To evolve and finalise the research topics & thrust areas of QuST, two brainstorming meetings were organised, the first one at the Centre for High Energy Physics, IISc, Bangalore and the second one at HRI, Allahabad.

ICPS Division has initiated a new directed research programme on “**Quantum Information Science and Technology (QuST)**” with the following broad objectives:

- Development and demonstration of quantum computers
- Development and demonstration of quantum communication & cryptography
- Development of quantum-enhanced and inspired technology
- Development of advanced mathematical quantum techniques, algorithms and theory of quantum information systems.

The development of a cluster based networked programme under directed research to meet the QuST objectives is going on.

AutoCEPH: A software for 2-D Computerised Cephalometric Analysis

CSIR-CSIO and AIIMS have jointly developed software to carry out 2-Dimensional Lateral and Posterior Anterior (PA) Cephalometric Analysis— AutoCEPH. It can perform 16 standard Lateral, 3 PA analyses and superimpositions. The software can be utilised by orthodontics specialists and cosmetic surgeons for patient diagnosis and treatment planning.

eProMIS: A web enabled Project Management Information System

A web enabled project management information system called **eProMIS** has been designed and developed essentially to keep a track of the funds being distributed geographically and area wise and to effectively manage as well as monitor the extramural research. This system has also enabled paper — less communications through auto-generated emails to Pls, reviewers and task force members. Very recently, this system has been adapted by Department of Science and Technology.

DivyaNayan – Portable Reading Machine for Visually Impaired and Low-literacy Populations

A personal reading machine for visually impaired is a machine that can read any printed and digital books available in Hindi and English. DivyaNayan has been tested with many visually impaired individuals from different age groups, and has gained wide popularity. Due to the increase in demand, many public and private industries are interested in the manufacturing this technology. Currently, pilot production of the developed technology is on and very soon the technology will be available to users.



Car Driving Simulator

This research-based simulator has been developed in association with Faros Simulation Systems Pvt. Ltd., Gurgaon, to evaluate a driver's driving abilities and skills, as well as psychophysical and cognitive driving capacities. The technology serves as a useful tool for multiple stakeholders including transport authorities, and training institutions responsible for evaluating driving traits of the drivers before issuing driving licenses.

Digital Ocean

Digital Ocean being developed by Indian National Centre for Ocean Information Services (INCOIS) is a dynamic framework of a set of applications to efficiently integrate and manage heterogeneous ocean data and to provide advanced visualisation and analysis tools to facilitate improved understanding of oceans in multi-disciplinary approach. In a nutshell, the Digital Ocean is the representation of the ocean that is georeferenced and connected to all diversified digital data archives on ocean parameters (for example, temperature, salinity, oxygen, acidity, etc.). In addition, the Digital Ocean built on the real relief of ocean characterised by abyssal plains, ridges, trenches, continental slopes, continental shelf and coasts, that will help in viewing the evolution of ocean parameters in time and space (in 3D).

The Digital Ocean will be fed by data generated by various programmes using diverse platforms and sensors. The idea of the Digital Ocean is that all data irrespective of source, sensor or platform should be made available for analysis on a single platform so that the analyst can develop better feel for data and improve his understanding on the working of oceans. For example, the temperature of the ocean is usually measured/recorded using different sensors and platforms like bucket thermometers, versatile Argo floats, CTDs, sensors attached to Gliders and moored buoys and satellite based sensors. The alpha version of the application is under progress and the project is expected to be completed by June 2018.

BTISnet Across the Country

The Biotechnology Information System Network (BTISnet) is now spread across the country with around 170 centres. The BTISnet includes 6 Centres of Excellence (CoEs), 12 Distributed Information Centres (DICs), 49 Distributed Information Sub-Centres (DISCs) and 103 Bioinformatics Infrastructure Facilities. The network also consists of one supercomputing facility for Bioinformatics and six interactive graphics facilities. A large number of bioinformatics R&D projects are being supported through this programme. The network supports 6 teaching programmes in M.Sc., M.Tech. and PhD in Bioinformatics and Computational Biology to generate skilled manpower. Further, the BTISnet centres conduct short term trainings and workshops for the benefit of the research community including experimental biologists. The centres also provide Bioinformatics and Computational Biology services to the scientific community.

BABRONE — for Northeast India

An online human resource repository of Biotechnology and Bioinformatics Resources of North East India (BABRONE) has been created and located at College of Veterinary Sciences (AAU), Khanapara, Guwahati (Assam). It is a freely accessible e-learning server developed as a common platform for uploading learning materials, sharing of information and as an online discussion forum at <www.babrone.edu.in>. Details of more than 1300 researchers, faculty and teachers from NER are available there on the portal.

NER-DeLCON

DBT's e-Library Consortia for North Eastern Region (**NER-DeLCON**) was established in the year 2010 through which access is available to more than 900 high impact e-journals. The facility is being offered to 18 selected NER institutions free of cost. It is being extensively used by scientists, faculty and students of these 18 institutions.





Energy For All





First biomass to ethanol plant and its commercialization

Energy For All

ENERGY forms the part of matrix that defines the quality of life. Currently, India's energy requirements are met to a major extent by fossil fuels and to a small extent by hydel, nuclear and renewable sources.

The Ministry of Science Technology is engaged in R&D for economic, efficient and environmentally safe energy generation and management, and has made significant contributions to the energy sector. A host of technologies have been developed pertaining to energy from fossil fuels on one hand and renewable sources on the other.

First Biomass to Ethanol Plant and its commercialization

The Institute of Chemical Technology (ICT), Mumbai has developed India's first home grown technology to convert biomass to ethanol with speed and efficiency. The technology which converts agricultural waste into ethyl alcohol, or bio-ethanol, is superior as the rate of conversion is four times faster than other technologies

currently available in the international market, it produces about 300 litres of ethanol per ton of biomass in 18-20 hours. The country's first Second-Generation (2G) Ethanol plant was inaugurated by Union Minister Dr. Harsh Vardhan at Kashipur in Uttarakhand and subsequently transferred to Bharat Petroleum Corporation Limited (BPCL) and Hindustan Petroleum Corporation Limited (HPCL) to build commercial scale biomass ethanol plants based on the technology. The plants are scheduled to be operational by 2018.

Certification for Coal used in Power Plants



CSIR entered into an MoU with coal supplying companies and power utilities for quality analysis of coal being supplied to power utilities by coal supplying companies. This collaboration will enhance efficiency of use of coal by power sector. The MoU was signed on June 28, 2016 at Anusandhan Bhawan, New Delhi, in the august presence of Union Minister Dr. Harsh Vardhan, Vice President, CSIR, and Mr. Piyush Goyal, Hon'ble Minister of State (IC) of Power, Coal and New and Renewable Energy.



Supercritical CO₂ Brayton Cycle Test Facility at IISc Bangalore

Supercritical Carbon dioxide Brayton cycle Test Loop Facility

Union Minister Dr. Harsh Vardhan, inaugurated the supercritical carbon dioxide brayton cycle test loop facility at IISc, Bengaluru in February 2018.

This lab scale test loop, the first of its kind in India, was developed by a research group at the Interdisciplinary Centre for Energy Research, IISc, as part of the Indo-US consortium SERIIUS. Funding for this endeavour was provided by DST under the Indo-US Joint Clean Energy Research and Development Centre (JCERDC) programme.

The supercritical carbon dioxide based power generation offers a highly efficient and compact alternative to conventional steam-based power plants. This is India's first supercritical-CO₂ Brayton cycle test bed, and perhaps the first ever coupled with a solar heat source. This early stage research could potentially be useful for meeting the future energy needs of the country and reduce the carbon footprint of power generation significantly.

“The availability of advanced technologies will define a future global energy mix that is clean, affordable, and reliable”



India participates in Mission Innovation, a Global Initiative to Double Clean Energy R&D

Mission Innovation (MI) is a global initiative of 22 countries and the European Union to dramatically accelerate global clean energy innovation. As part of the initiative, participating countries have committed to seek to double their government’s clean energy R&D investments over five years, while encouraging greater levels of private sector investment in transformative clean energy technologies. This will accelerate the availability of the advanced technologies that will define a future global energy mix that is clean, affordable, and reliable.

India is a member of the Steering Committee and is also a member of all seven innovation challenges, with DBT coordinating all Mission Innovation activities for India.



Mission Innovation (MI) Smart Grid Challenge

DST organized the MI India Workshop on Smart Grid in May 2017 at IIT-Delhi to identify R&D themes relevant to challenge objectives. A Funding Opportunity Announcement (FOA) was announced in June 2017 earmarking US \$ 5 million for collaborative projects with MI countries at MI Ministerial-2 in Beijing, China.

DST also participated in the International Workshop to identify areas for collaboration. A synthesis document was also prepared detailing spectrum of activities, institutions and research priorities of participating countries.

India conducted the second International MI Smart Grids Workshop on 16-18 November 2017 at IIT Delhi. An exhibition was also conducted in November 2017 to showcase the work under taken by Government bodies as well as Industries.



Participants of Second International Mission Innovation Smart Grids Workshop on 16-18 November 2017

The outcome of the MI international workshop was:

- Release of a country report on MI Smart Grids activities, strategies and vision
- Launch of UI ASSIST India US Collaborative Programs
- Identified R&D tasks to be launched by 2018.



Participants of Clean Energy Workshop at TERI, New Delhi



SEGES PIS showcasing their research at Second International Mission Innovation Smart Grids Wprkshop on 18 November 2017

The first MI-India Workshop on “Clean Energy Materials Innovation Challenge” was organized on 17th August 2017 at TERI University, New Delhi in order to identify country’s research priorities in conformity to the goals of Innovation Challenge for Clean Energy and develop the country status report in this area.

The Department also participated in Mission Innovation’s (MI’s) Clean Energy Materials Innovation Challenge, an International Experts’ workshop at Mexico City in the month of September 2017. The aim of the workshop was to support the Innovation Challenge’s goal of accelerating the exploration, discovery and use of new, high-performance, low-cost clean energy materials by at least ten times.



Solar Power Tree

The solar power tree is an intervention designed and developed for utilizing minimum land to harness maximum solar energy.

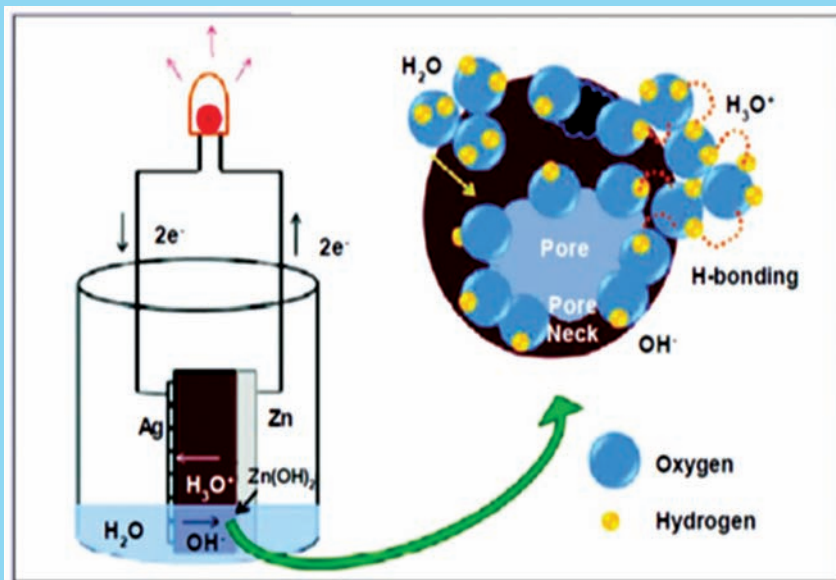
IoT-ready Smart Solar Tree

Two 500 W IoT-ready smart solar trees have been developed and installed by CSIR. The IoT-ready smart solar tree occupies only 0.25 m² of ground space and is a decentralized power generation system which can be scaled and configured according to the location and application. The development is in line with the 'Smart City' Mission of the Government of India.



Fuel Cell Technology d=Development: Towards sustainable energy solutions

Indigenous know-how was developed to make technology components and the process for building Proton Exchange Membrane Fuel Cell (PEMFC) multi-cell stack of desired power output up to 3.0 kW. The fuel cell test facility has been commissioned to provide plenty of useful data for testing and developing indigenous fuel cells at low costs for commercial applications.



Novel hydro-electric cell as a source of Green Energy

Hydroelectric cell has been developed which operates at room temperature, produces no excessive heat and greenhouse gases, and being made of inexpensive precursors, is cheaper than fuel cells.

Lithium Ion Battery: India's First Fabrication Facility by CSIR

India's first Lithium ion battery fabrication facility was established based on indigenous novel materials for making 4.0 V/14 h standard cells at CSIR-CECRI Center, Chennai. The facility is being used to develop technologies related to Li-ion batteries for their possible commercialization.

Eco-friendly and safe Rechargeable Magnesium Battery

A rechargeable magnesium battery with natural graphite was developed, which is suitable for stationary devices like UPS and Inverters. It could be an efficient substitute to the lead-acid battery used commonly at present. The materials used in the electrode are both re-usable and bio-degradable.

Coal dust collecting and briquetting system

A coal dust collecting and briquetting system was developed that controls air pollution in mining and industrial areas, effectively reducing health problem related to air borne dust in mining and industrial areas. A significant number of employees will be engaged in manufacturing and operation of the system in mines and other industrial areas.



Smart Plug

A device specific energy monitoring through smart plug (5/15 Amp) has been developed to monitor and control individual high power consuming electrical appliance through a smartphone.

Smart MeTER

The smart phone integrated Smart MeTER is an 220 V/ 30 Amp AC energy meter that can be installed at the user's premises through a Wi-Fi hotspot. The meter operates on a pay-and-use mode and real time data related to consumption is available through a smart phone.

Solvent free/high solids Thermal insulation coatings

CSIR-IICT has developed an eco-friendly process technologies for platform thermal insulation coatings, effectively reducing surface temperatures. The coatings can be used on inner roofing materials for low cost housing to benefit masses in the rural and urban settings.

Bio-energy: Fueling India's growth

While the government is garnering efforts to make India the clean energy world capital, the Department of Biotechnology (DBT) has flagged clean energy and waste-to-energy as two of its key missions. DBT has recently achieved significant milestones in bio-energy research and scale up from fundamental research to applications, to ensure nimbleness and constant access to the best technologies. It has developed cost effective and efficient ways to convert waste to energy and has set up plants for scaling up the production of energy in different forms.

Capacity-Building in Bio-energy

- **10 post doctoral fellows attracted back to India under the Energy Bio-science Overseas Fellowships**

They are now placed in some of the centres of excellence on bio-energy in the country.

- **Launching Bio-energy awards for cutting-edge research**

India and United States have joined hands to support a fellowship that will allow a group of fellows and interns to pursue cutting edge research in various areas of bio-energy in US institutes of repute. This will help build capacity in clean and environmentally safe energy.

- **Indo-US Joint Clean Energy Research and Development Centre**

DBT is supporting a bio-fuel consortium led by IICT Hyderabad and University of Florida from the US. This programme is being coordinated by DBT along with US Department of Energy under an MoU signed between both countries in November 2010.

- **Mission Innovation Challenge - Affordable Heating and Cooling of Buildings**

DST with CEPT University and Alliance for Energy Efficiency Economy (AEEE) organised a workshop on Affordable Heating and Cooling of Buildings in August 2017 in New Delhi. The objective of the workshop was to create awareness about Innovation Challenge #7 and discuss India's priorities in the area of affordable heating and cooling of buildings and explore possibilities for India's R&D initiatives. DST also participated in International Workshop at Abu Dhabi and made important contribution in all six thematic subareas including storage and physiological studies in which India is taking a lead.

- **Energy demand reduction in the Built Environment**

A joint India and UK research programme has been initiated to help reduce energy demand in UK & India's built stock, with a commitment of £ 3.8 M with matching support from DST to support R&D projects in the area of energy demand reduction in the built environment. Total 22 proposals have been received against the call and four proposals have been initiated.

Materials on Energy Storage (MES)

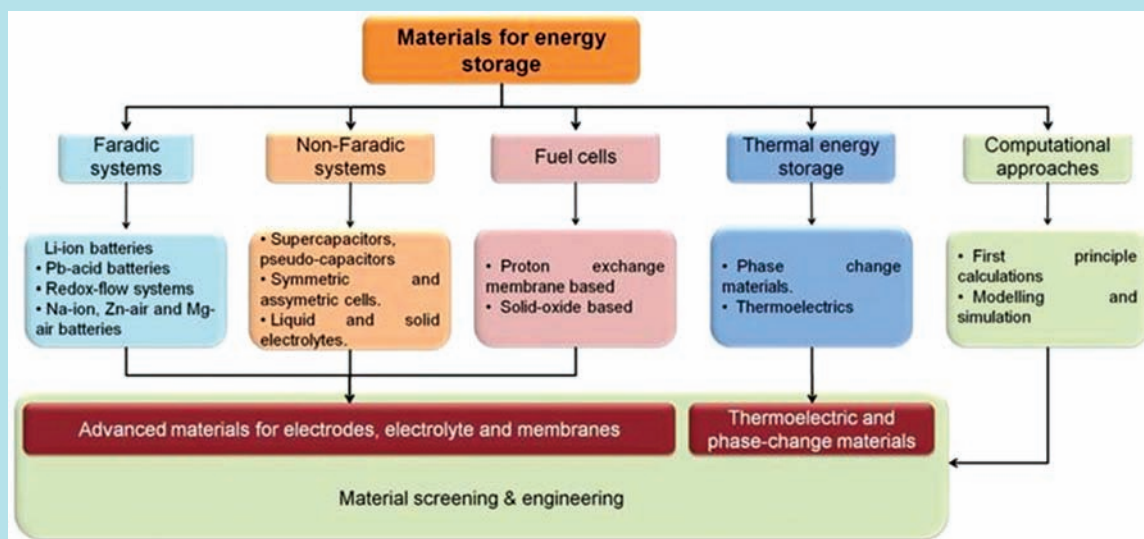
A new programme was launched to support R&D activities aimed at innovative materials for energy storage, and to build energy storage device with enhanced output for multifunctional applications. The prime objective of the initiative is to aim at the efficient use and further increase of

renewable energy and demonstrate its value in terms of flexibility in the energy systems.

130 proposals were received and 18 were approved for funding with a total cost of ₹ 16 crores.

The programme focused on supporting basic, applied research and technology development, improve tools and methodologies needed to understand and predict the characteristics and performance of energy storage materials, components, devices and systems, under different conditions and at different length and time scales.

125 proposals were received and 33 were approved for funding in the year 2016-17.



Research stream classification of materials for energy storage

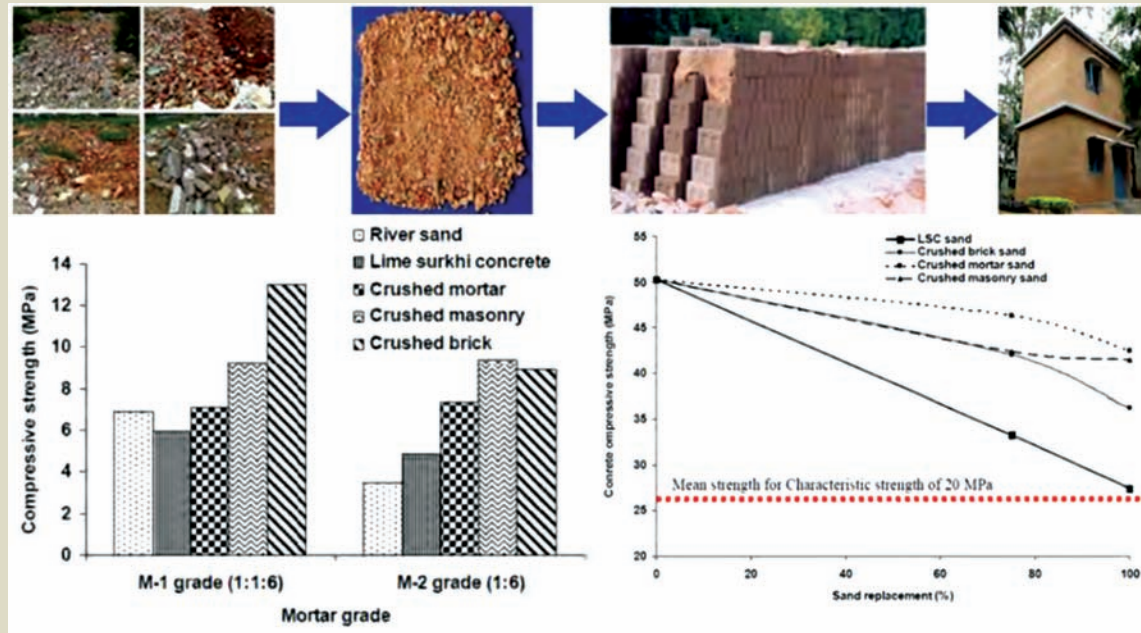
Materials for Energy Conservation and Storage (MECSP)

A theme-based initiative to support research and development for entire spectrum of energy conservation and storage technologies from early stage research to technology breakthroughs in materials, systems and scalable technologies to maximize resource use efficiency was initiated in the year 2016-17. The objective of the initiative was to underpin recognized centres of energy materials research, to encourage

those centres to link with new research groups working in complementary areas and to link centres into a coordinated national network and to create a strengthened energy materials research community that covers the full breadth of energy research areas that is strongly linked both nationally and internationally. A total of 52 proposals are under consideration for support.

Initiative to Promote Habitat Energy Efficiency (I-PHEE)

A new national programme on “Initiative to Promote Habitat Energy Efficiency (I-PHEE)” to improve energy performance of buildings and cities was launched. The programme would support enhancement of knowledge and practice to save energy in design, construction and operation of buildings. Till now, 30 projects have been initiated.



Mission Programme on Methanol and Dimethyl Ether

The Methanol economy holds promise to help India to mitigate its petroleum import cost and at the same time counter the problems associated with global warming due to excess CO₂ emission. An International Seminar on India’s Leap to Methanol Economy— Opportunities and Options for Energy Security’ was held for knowledge sharing and aggregation for chalking out a strategy for preparing a road map on Methanol & DME economy for the country. DST actively contributed in preparation of roadmaps for Methanol DME and Dimethyl ether. A survey report on Production & Utilisation issues of Methanol & DME was finalized. DST initiated research programme on methanol and DME, which evinced great interest and 94 proposals were received out of which 9 have been supported.

Advanced Ultra Super Critical (AUSC) Thermal Power Plant –R&D Phase

A consortium of three government entities, namely Bharat Heavy Electricals Limited (BHEL), Indira Gandhi Centre of Atomic Research (IGCAR) and National Thermal Power Corporation (NTPC) have formulated a R&D project for the development of AUSC technology for thermal power plants of the future. The project envisages reduced coal consumption as well as carbon di-oxide (CO₂) emissions. The project has a time cycle of two and a half years, with an estimated cost of ₹1554 crores. Two proposals have been supported by DST to IGCAR, Kalpakkam-BHEL to develop advanced rotor testing facility and spin test rig for Dadri Plant using indigenous material.

Joint Virtual Centre for Clean Energy

India and UK have collaboratively set up a virtual Joint Clean Energy Centre on Clean Energy focusing on integration of intermittent clean energy with storage for stable power supply at grid as well grid isolated communities at a total investment of £ 10 million. Two research proposals were supported.

Collaboration on National Mission for Electric Mobility

The Department has formalized a collaboration with the Department of Heavy Industry (DHI) on working jointly for implementation of R&D component of DHI's National Mission for Electric Mobility. A Joint Technology Platform for Electric Mobility (TPEM) has been set up in the Department of Science & Technology to implement the programme.

DST & DHI develop an indigenous technology for green vehicles & green India

- Electric and Hybrid Vehicles- On priority for govt.- aiming for the development of complete technology for indigenous manufacturing of electric and hybrid vehicles, aligning with "Make in India" 
- Govt. offering incentives to promote electric vehicles under Faster Adoption and Manufacturing of Hybrid and Electric Vehicles in India (FAME) scheme 
- DHI and DSTs Inter Ministerial Program- Technology Platform for Electric Mobility (TPEM) developing indigenous technology to roll out electric vehicles at affordable prices 
- Solution to hazardous hospital waste disposal - Environment friendly "Plasma Pyrolysis" technology developed with DST's support for safe disposal of biomedical waste. Central Pollution Control Board informed to all the State Pollution Control Boards to adopt the technology. 



Water For All



Water For All

Water and air quality monitoring is one of the most important initiatives of the Government towards scientific social responsibility. DST is supporting the development and application of advanced tools and techniques by leading Indian and US institutions for real time water monitoring. DST and Intel have jointly initiated a research programme titled, “Research Initiative for Real-time River Water and Air Quality Monitoring” to develop low-cost and low-power autonomous wireless sensor technologies for sensing,

communication and analysis of large-scale data collected from autonomous networks of perpetual/ long-lived sensor nodes. The development of these technologies will be followed by integration and deployment for water and air quality monitoring in real-time. This real-time data will significantly strengthen and complement the Missions of national priority like Namami Gange, by serving as critical data feeders for pre- and post-treatment analysis.

DST-Intel Collaborative Research for Real-time River Water and Air Quality monitoring

The project has been initiated as a new joint programme at a cost of ₹ 33 crores on a 50:50 cost sharing basis in Public-Private Partnership (PPP) mode. The project will develop low cost compact smart sensors with on-board power and communication for real-time analysis of water and air quality over large areas.



Improving Water Quality and Reusing Waste water



Water Treatment System at Buja Buja, Nellore District, Andhra Pradesh



Building upon the Thames-Ganga Partnership and recognising the importance of clean and potable water, DST and Research Council of UK, have agreed to launch a new collaborative programme on 'Improving Water Quality and Reusing waste water'. Eight projects focusing on Sensing, Treatment and fate of pollutants have been launched.

Water Technology

Initiative aims to promote R&D activities for providing safe drinking water at affordable cost and in adequate quantity using appropriate Science and Technology interventions evolved through indigenous efforts. Since quality is the main consideration of safe drinking water, processes which imply nano-material and filtration technologies have been focused. The initiative also includes the pilot testing of credible number of products and referencing of selected technologies, to the social context of the application region. During 2014-18, a total of 174 R&D projects, addressing 20 site specific challenges covering around 400 habitats across 23 states were supported.



Water Treatment Facility & Waste Water Treatment Plant at Thirupattur, Vellore, Tamil Nadu

Integrated Water Management intervention in drought affected regions of Marathwada

DST has supported quick deployment and demonstration of a mobile water purification unit developed by CSIR-CSMCRI for producing potable water for drinking. It was demonstrated in Latur, Marathwada region which was facing severe scarcity of drinking water during year 2016 drought period. Based on these interventions, an integrated waste water management system has been developed in Ausa district, in Marathwada Region.

Development of Mobile Water Purification and Desalination Unit on Wheels for Marathwada Region

Latur, Maharashtra

28 May - 4 June, 2016



Deployment of cost effective bio-sand filter technology for promoting community health by addressing incidence of waterborne diseases in select villages of Bihar

Innovative b-sand (JalKalp) water filter technology is being promoted to address arsenic, iron and pathogens in water as an innovative and cost-effective alternative. 204 villages have been approached for sensitisation and awareness building. Sensitisation and awareness building is being carried out through small meetings with village communities. So far 337 meetings involving 5438 males and



4879 females carried out. Sensitization and awareness building is also being carried out in village schools for children. So far 37 sessions in different schools were carried out, involving students of class 5th and above. 688 households adopted the JalKalp water filters and are satisfied with the performance of filter and the quality of filtered water. A safe water storage container has also been designed, produced and distributed to filter users.





Desalination plant operational in three islands of Lakshadweep

Fresh Water-ocean Thermal Energy Conversion

Considering the importance of fresh water for islands, Low Temperature Thermal Desalination (LTTD) plants of 100 m³/day capacities were established in the Kavaratti, Minicoy and Agatti Islands in the Union Territory of Lakshadweep, where cold water is moored from 400 m water depths. Considering socio-economic advantages including health of the islanders, installation of LTTD-based desalination plants in six more islands of India including Amini, Chetlet, Kadamath, Kalpeni, Kiltan and Andrott is now undertaken by National Institute of Ocean Technology (NIOT), Chennai.

Being close to the equator, the sea surface is always fairly warm in Indian waters. The difference in temperature between the sea

surface and at a deeper depth can be utilized to harness energy by running a Rankine cycle based power plant with suitable working fluid. This is called Ocean Thermal Energy Conversion or OTEC. NIOT has taken up the challenge of establishing OTEC powered desalination plant in Kavaratti Island of U.T. Lakshadweep in the near future. Design of a 100 kW open-cycle OTEC-powered LTTD-based desalination plant of 100m³/day with a low differential pressure steam turbine with cold water input of 8.5°C and cold-water pipe of 1m diameter has been also undertaken. A laboratory having the capabilities to simulate various process scenarios for OTEC, desalination and both together, has been established at NIOT.

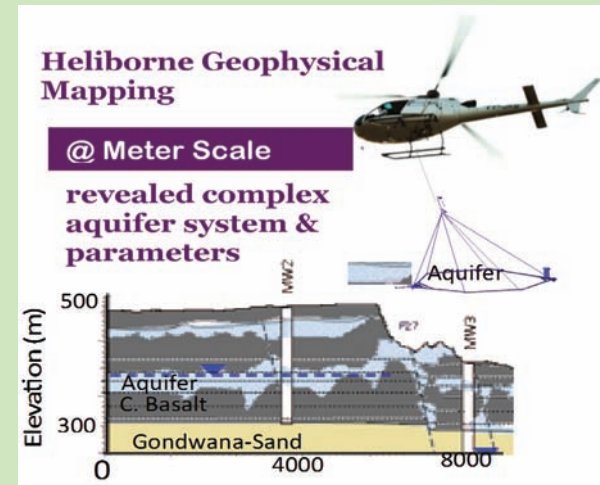
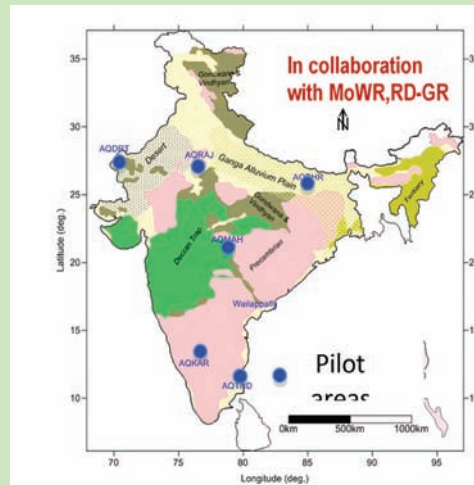
Water for All — Aquifer Mapping of Water-scarce Areas

CSIR-NGRI utilized a robust technology, Helicopter borne Transient Electro Magnetic (HTEM) and Magnetic (HMAG) for delineation in various areas, for delineation of Groundwater aquifers.

Data was provided to Central Groundwater Board for drilling.

International collaborations have been leveraged to develop technologies to provide clean water for various end uses like drinking and agriculture.

The department's support has helped develop green remediation process for textile dyes in wastewaters, developed empowered septic tank as decentralized wastewater treatment system, reduced water scarcity in several areas by constructing wetlands with plant.



India-Europe collaboration on Water4Crops integrate bio-treated wastewater reuse with enhanced water use efficiency to support agriculture

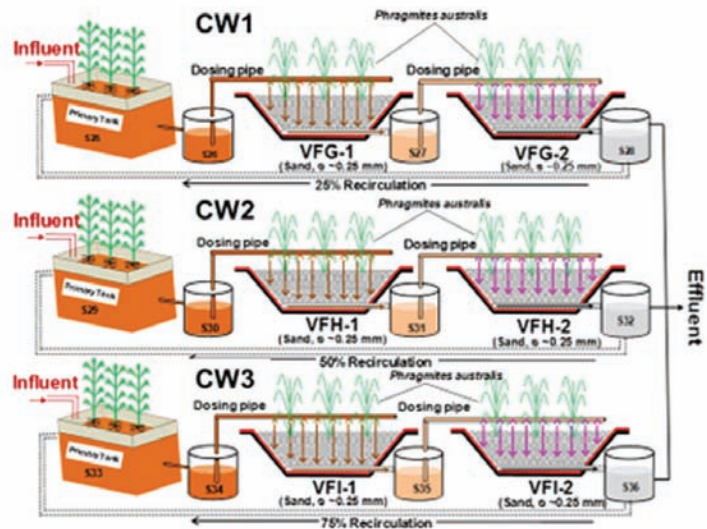


Indian consortium partners have demonstrated the use of constructed wetland. The initiative involved 11 Indian institutes and 21 EU institutes to bring about better management of water, land & crops aimed at a viable, stronger & sustainable green economy at an amount of 19 Million Euros

The European Union and Government of India co-funded project, Integrating Bio-treated Wastewater Reuse with Enhanced Water Use Efficiency to Support the Green Economy in EU and India. It has shown remarkable success in reducing water scarcity and helping safe reuse of wastewater in agriculture. By constructing wetlands with water plant and weed species the chemical oxygen demand in wastewaters have been reduced by 30.92%. Moreover, yield evaluations have shown increased crop yields (14 to 40%) of crops like okra, brinjal and chilly irrigated with treated wastewater as compared to fresh water.

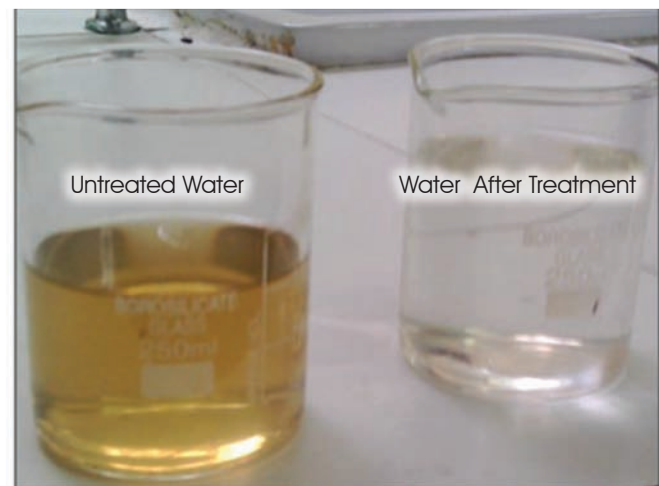
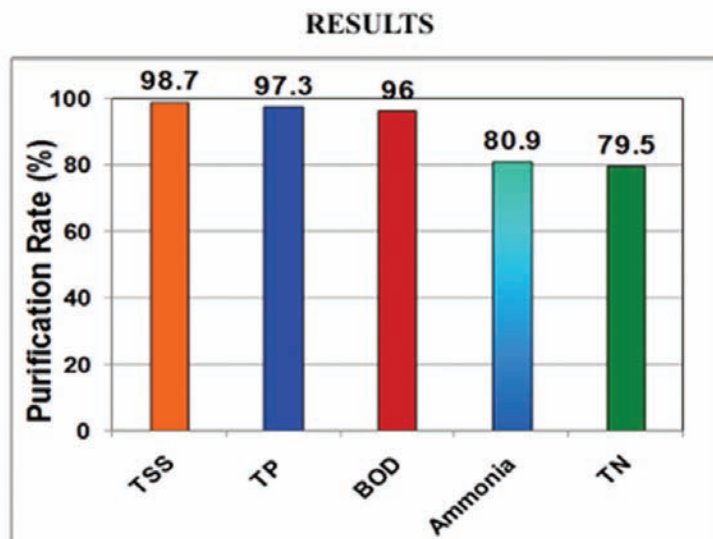
Technology for Treatment of Dairy Wastewater

Constructed Wetland (CW) based wastewater treatment technology has been developed. Different designs of Vertical flow Sub-surface Constructed Wetland (CW) units were operated to assess the most appropriate design which can provide the maximum removal of pollutants such as BOD, TSS, Total Nitrogen, Total Phosphorous, Ammoniacal Nitrogen, Total dissolved solids(TDS) from dairy wastewater. All the CW units showed good removal efficiency of pollutants from dairy wastewater. There was remarkable reduction in the average concentrations of all the pollutants (BOD, TN, NH4-N, TP and TSS) in all the CW units. The present research findings may help in reducing the size of CW units yet providing higher removal of water pollutants from dairy wastewater coming out from dairy premises.



Vertical Sub-surface Flow Constructed Wetland unit 1, 2 and 3

Performance of Vertical Flow Constructed Wetland Unit Treatment of Dairy Wastewater



Technologies Transferred

Mercury — Free UV Lamps for Water Purifiers

Mercury-free plasma (MFP) UV-lamp for water disinfection systems has been developed to provide water free of environmentally and health hazardous mercury. The technology can also be used for sterilization of food, medical equipment, surfaces, ill-skin conditions, air-conditioners and air fresheners for hospitals, etc. The technology has been transferred to two companies — M/s YOUWE (UV) Purifiers, Jaipur and M/s ARKIN Technologies Pvt. Ltd., Pune for its mass production.

Oneer — a Novel Solution for Safe Drinking Water

Oneer is useful for the treatment of drinking water supplies that have microbial contamination to disinfect pathogenic micro-organisms and to provide safe drinking water to communities as per National and International standards. Cost of treated water is less than 1 paisa per litre.



Domestic Iron Removal Filter

A domestic/household type iron removal filter of ~2 L/hr capacity has been developed which is suitable for a family of 4-5 members. The filtration unit can remove iron from groundwater (below the WHO limits 0.3 ppm), foul odour and bad taste. Technology has been transferred to M/s Bargachiya Cluster of Metal Product, Bargachiya, Howrah for mass deployment.

AMRIT — Water Purification Filters using Nanotechnology

The Indian Institute of Technology-Madras has developed energy free, water purification systems for arsenic & iron removal using nanotechnology (AMRIT - Arsenic & other Minerals Removal by Indian Technology). It functions without electricity. This technology has already been commercialised. The group has also developed purification technology for removal of pesticide and other contaminants in water, which is also commercialised. AMRIT water filters installed in 750 locations in West Bengal, Uttar Pradesh, Bihar and Karnataka provide arsenic-free drinking water at a cost of less than 5 paise per litre to nearly 5 lakh people. Ministry of Drinking Water and Sanitation had recommended the replication of the nanotechnology-based purifier in all states where drinking water is contaminated with arsenic.



Environment, Climate Change and Natural Disasters





Environment, Climate Change and Natural Disasters

THE world is facing the biggest environmental challenge our generation has witnessed. Over the past 100 years, we have changed the sensitive energy and ecological balance of our planet by burning fossil fuels and human activities like deforestation. Conserving natural resources is a basic requirement for sustainable development and improving the quality of human life. Climate change has many adverse

consequences like floods, droughts, heat waves, sea level rise and glacier and sea ice melting.

Ministry of Earth Sciences (MoES) and Ministry of Science and Technology are working on many facets of climate change including basic sciences, climate change projections and technology development for climate change mitigation.

System of Air Quality Forecasting and Research (SAFAR)

In view of the emerging challenge of pollution, the MoES has introduced a critical national initiative titled, "System of Air Quality and Weather Forecasting and Research" known as "SAFAR". This has been created with a focus on metropolitan cities (Delhi, Mumbai, Pune and Ahmedabad) to provide location specific information on air quality in near real time and its forecast upto 1-3 days in advance.

SAFAR-Ahmedabad an integrated early warning system of air quality, weather and health System was launched by Dr. Harsh Vardhan, Hon'ble Union Minister for Science & Technology and Earth Sciences along with several state minister's and dignitaries on 12 May 2017 in Ahmedabad.

The current observations and forecasts are disseminated through various user-friendly communication media such as SAFAR-Air (Mobile app for Android and i-phone), SAFAR Toll free no.1800 180 1717, SAFAR-India web portal (<http://safar.tropmet.res.in>), and LED display boards.



Inauguration of the SAFAR-Mumbai

Environment Monitoring and Research

Environment Monitoring and Research Center (EMRC), a division of IMD conducts monitoring and research related to atmospheric constituents that can force change in the climate of the Earth, and may cause depletion of the global ozone layer, and play key roles in air quality from local to global scales. EMRC also provides specific services to Ministry of Environment, Forest & Climate Change and other Government Agencies in the assessment of air pollution impacts. IMD contributes in the field of atmospheric environment to the World Meteorological Organization (WMO) Global Atmosphere Watch (GAW) programme. The National Ozone Centre of IMD is designated as secondary regional ozone centre for Regional Association II (Asia) of World Meteorological Organization. The centre maintains a network of ozone monitoring stations including Maitri and Bharati in Antarctica. The Black Carbon Monitoring Network of 16 stations for measurement of Spectral Aerosol Absorption Coefficient, Equivalent Black Carbon Concentration and bio-mass burning component has been established during 2016.

Climate Change Research

The Centre of Climate Change Research (CCCR) was launched in 2009 with the support of the Ministry of the Earth Sciences, Government of India. At present, the CCCR is part of the Indian Institute of Tropical Meteorology (IITM) located at Pune. The CCCR focuses on development of new climate modeling capabilities to address global and regional issues concerning the science of climate change. The salient achievements made by the Centre are:

E-Nose to Detect Toxic Fumes – Sensors based Innovative Solution for Monitoring Environmental Pollution

Electronic-nose can sniff out volatile organic compounds (VOCs) potentially harmful to human life in a very short time. It measures odour concentration and intensity, besides identifying individual chemicals causing the foul smell. This has been the first attempt in India to develop such a product using odour sensors that make use of intelligent software to identify odorous molecules. The E-nose is being used at Mysore Paper Mills, Karnataka; Tamil Nadu Newsprint and Paper Mill, Karur; and International Paper Private Limited, Andhra Pradesh.

- The IITM Earth System Model (IITM-ESM) - a radiatively balanced global modeling framework for long-term climate investigations was developed indigenously. The IITM-ESM is the first climate model from India to contribute to the Coupled Modeling Inter-comparison Project Phase-6 (CMIP6) experiments and the Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (AR6).
- The centre is the nodal agency for the Coordinated Regional Downscaling Experiment (CORDEX) – an International Project under the World Climate

Research Programme (WCRP), World Meteorological Organization. Under this programme, CCCR has generated an ensemble of high resolution downscaled projections of regional climate and monsoon until 2100 for the IPCC climate scenarios (RCP4.5 and RCP8.5) at CCCR, IITM using a regional climate model (ICTP-RegCM4) at 50 km resolution, by driving the RegCM4 regional model lateral and lower boundary conditions from multiple CMIP5 global atmosphere-ocean coupled models http://cccr.tropmet.res.in/cordex/files/data_on_esgf.jsp].

- Climate Data Portal and Earth System Grid Federation (ESGF) data node (http://cccr.tropmet.res.in/cordex/files/data_on_esgf.jsp) were established for archiving and dissemination of the CORDEX South Asia datasets as well as CMIP6 outputs to users and stakeholders for application studies and impact assessments. The ESGF is an international project that develops and maintains software infrastructure for management, dissemination and analysis of model output and observational data (<https://pcmdi.llnl.gov/projects/esgf-llnl/>).
- High resolution simulations were performed using a variable resolution global atmospheric model with telescopic zooming (grid-size ~35 km) over South Asia for the 20th century (1886-2005) and future projections for the 21st century, following the IPCC scenario RCP4.5. The high-resolution experiments are also being used for detection and attribution of recent decadal changes in monsoon precipitation over India due to natural and anthropogenic forcing.
- Different aspects of monsoon variability, tele-connection mechanisms, climate drivers (ENSO, Modoki, IOD, Ningaloo, etc), long-term trends and

dynamics of precipitation extremes were investigated using atmosphere and ocean observations, reanalysis products and model experiments. This has resulted in important scientific publications with lead authors from CCCR.

- Proxies of past climatic variations over the Indian subcontinent were generated through dendroclimate studies, stable isotope analysis of climate archives (e.g., tree rings, corals, speleothems, etc). Tree ring analysis of *Cedrus deodara* D.Don from Western Himalaya (India) has enabled climate reconstructions during the past few centuries. Monsoon rainfall variations have been reconstructed using analysis of Teak tree rings from Kerala during the past 500 years. In addition, isotopic analysis of speleothems (Cave deposits from Kadappa caves, in Andhra Pradesh) have enabled reconstruction of past rainfall variability during 1200 BC – 300 AD (approx. ~ 1500 years) at annual resolution.
- Several training workshops, summer schools, were organised by CCCR jointly with various national and international partner institutions that includes participants and faculty from India and abroad. The training workshops primarily focused on analysis of observed data, evaluation of model outputs, hands-on training, quantification of uncertainties, bias correcting climate model outputs to drive application models, earth system modelling summer school, Eddy-Covariance techniques for flux measurements and several others.
- A high-end Greenhouse Gas (GHG) measuring laboratory has been established in IITM and near-continuous records of p CO₂ ([CH₄]) are being measured. The GHG data provide insight about the causative mechanisms that control their variability.

- CO₂ and H₂O fluxes are being measured at a deciduous forest in Assam and evergreen forest in Darjeeling and the aqueous environment of the Pichavaram mangrove. Results indicate that the deciduous and evergreen forest ecosystems act as a net sink of CO₂ during the summer-monsoon season. On the other hand, the aqueous Pichavaram mangrove ecosystem appears to act as a source of CO₂ to the atmosphere, apparently driven by anthropogenic activities.
- Detailed studies were conducted to understand the transport pathways of water vapor, NOX, aerosols in the summer monsoon upper troposphere anticyclone were investigated using satellite data and Chemistry Transport Model (CTM) simulations.

Dr. Harsh Vardhan, Hon'ble Union Minister for Ministry of Science & Technology and Ministry of Earth Sciences released a report "Climate Change over India" - an interim report on Foundation Day of Ministry of Earth Sciences in New Delhi on 27 July 2017.

This Interim Report on Climate Change for India prepared by CCCR in the Indian Institute of Tropical Meteorology (IITM), Pune, is intended to provide a brief overview of — (a) Updated assessment of observed climate change over India, (b) Future climate projections over India, (c) Development of the IITM Earth System Model to better understand and quantify climate change and its regional impacts. The three topics, which are among the core research activities of the CCCR at IITM, have been presented as three chapters in the interim report, and an updated report is planned to be submitted early 2019.

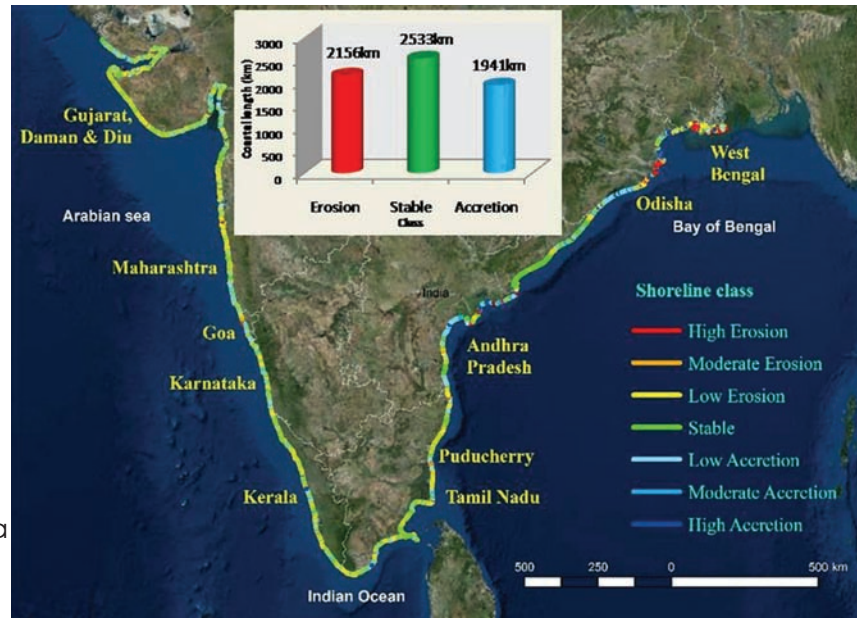


Dr. Harsh Vardhan, Hon'ble Union Minister, Science & Technology and Earth Sciences, releasing the climate change report on 27 July 2017

Monitoring and mapping the shoreline changes along Indian coast

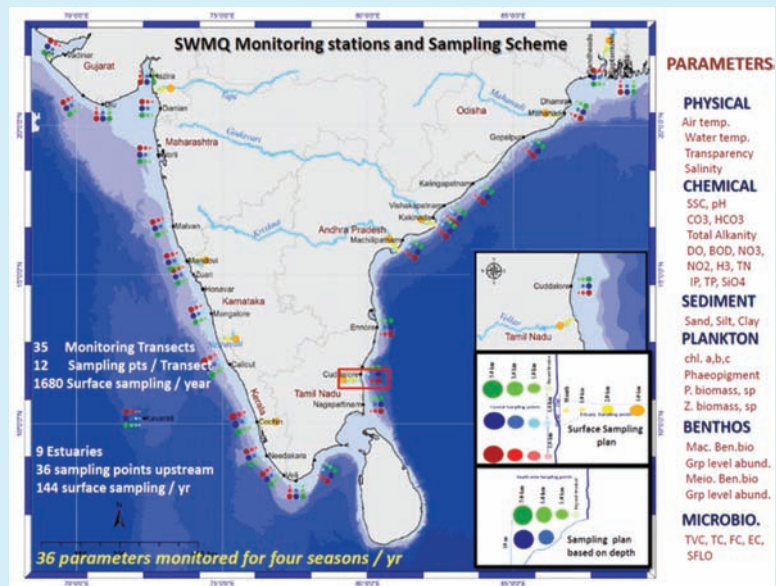
India has more than 7500 km long coastline which undergoes change due to natural and human interventions. Regular monitoring of shoreline and its spatial and temporal trends are required to address the coastal erosion and management related aspects. The shoreline changes, its behavior, erosion, accretion status and related morphological characteristics of Indian coast is being monitored as baseline data using remote sensing, field and mathematical modeling and GIS tools. A GIS based interactive

database was created and 517 maps depicting cumulative shoreline changes for the years 1990-2016 were generated. The shoreline changes vulnerability was classified in 7 classes i.e. 3 each for accretion and erosion and 1 for stable. The analysis of last 26 years data suggests that about 33%, 38% and 29% coast is eroding, accreting and is stable in nature respectively.



Coastal Water Quality

Quality (25 parameters) of coastal water is being monitored by MoES at 22 locations along the Indian coast to assess the health of coastal waters. Sea Water Quality Criteria (SWQC) for heavy metals have been prescribed for limiting the pollution levels to protect the marine organisms and being considered by the Ministry of Environment, Forests and Climate Change for notification in the Environment Protection Act (1985) amended in 1998.





The Union Minister for Science & Technology and Earth Sciences, Dr. Harsh Vardhan and the Minister of State for Environment, Forest and Climate Change (Independent Charge), Mr. Anil Madhav Dave flagging off the Science Express Climate Action Special (SECAS), in New Delhi on February 17, 2017.

Science Express Climate Action Special (SECAS II)

SECAS, intends to contribute towards increasing understanding of the science of climate change, the observed and anticipated impacts, and different possible responses. It is an innovative mobile science exhibition mounted on a 16 coach AC train, which has been custom-built for Department of Science & Technology (DST) by Indian Railways.

The SECAS II is a unique collaborative initiative of Department of Science & Technology (DST), Ministry of Environment, Forest & Climate Change (MoEFCC), Department

of Biotechnology (DBT), Ministry of Railways and Vikram A Sarabhai Community Science Centre (VASCSC).

The exhibition will convey a message about climate change and will also be a good opportunity to generate a dialogue and discussion. The state-of-the-art exhibition on board the SECAS aims to create awareness among various sections of society, on how climate change can be combated through mitigation and adaptation. The exhibition was witnessed by nearly 24.72 lakhs visitors.



Science Express Climate Action Special

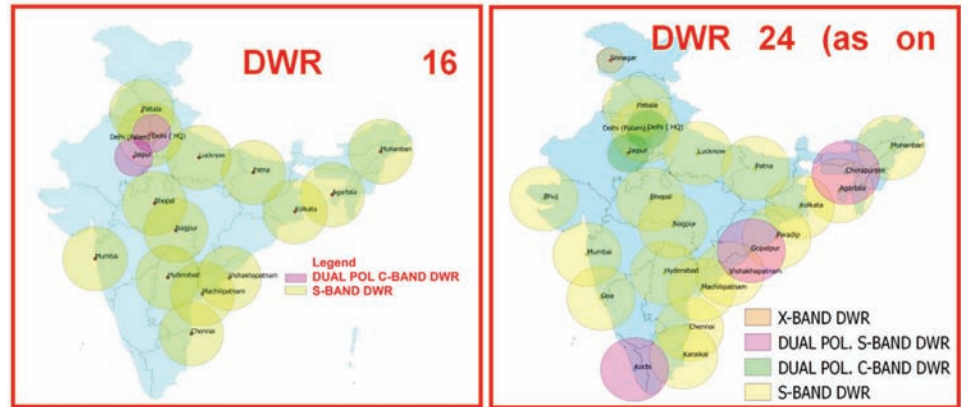
Natural Disasters — Early Warning Systems

The Indian region is frequently affected by a variety of hydro-meteorological disasters such as heavy rains, tropical cyclones, tsunamis, storm surges, severe local storms like thunderstorms, hailstorms, cloudburst, tornadoes, floods, heat and cold waves. There are 13 coastal states/UTs encompassing 84 coastal districts which are affected by tropical cyclones. The states within the periphery of "India Flood Prone Areas" are West Bengal, Odisha, Andhra Pradesh, Kerala, Assam, Bihar, Gujarat, Uttar Pradesh, Haryana and Punjab. Heat waves are more frequent over the Indo-Gangetic plains of India. Northern and

eastern states are affected by cold waves. Thunderstorms are more frequent and intense over east and north-eastern India and severe fog occurs over the Indo-Gangetic plains in the winter season.

India Meteorological Department (IMD) is the National Meteorological Service of the country responsible for monitoring and providing warnings for severe weather phenomena as mentioned above. INCOIS/MoES provides tsunami warnings whenever such occasions arise. IMD issues weather warnings for different temporal ranges and spatial domains. MoES has undertaken many initiatives over the last four years to provide improved multi-hazard early warnings for management of natural disasters.

Over the last four years, IMD had improved the warning services by augmenting an observational network, adopting weather prediction models of higher resolution and improved data assimilation. There has been an enhancement of Doppler Weather Radar network from 16 in 2014 to 24 in 2018. The network of Automatic Weather Stations (AWS) has increased from 675 to 711 in 2018 and the network of Automatic rain-gauges has increased from 1160 to 1350. There is also improvement in use of Satellite data for numerical weather prediction with recent launch of INSAT 3D/3DR satellites. Quantum of satellite data used in weather models has increased exponentially over the last 4 years. Satellite data contributed 90% of the total data used for data assimilation in weather prediction models. In 2014, IMD was using a weather prediction model with 25 km

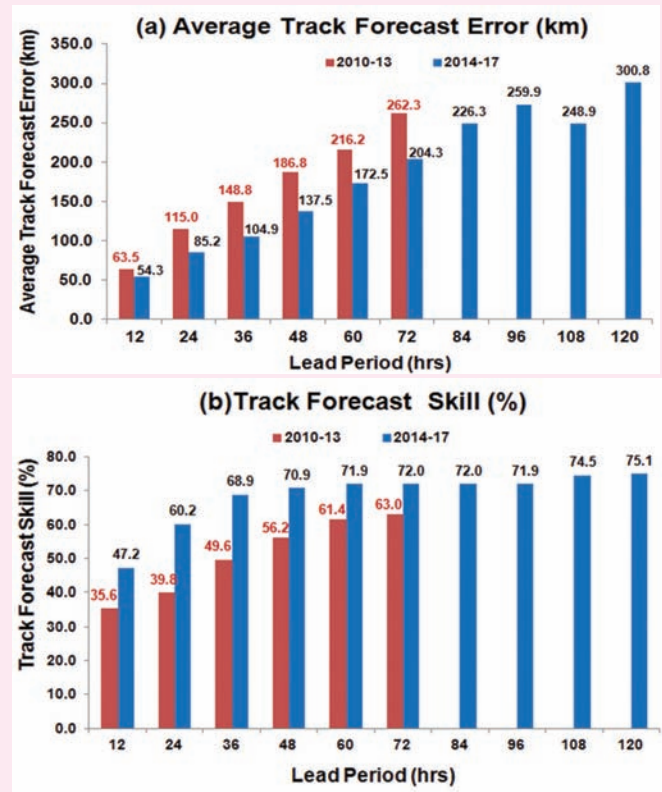
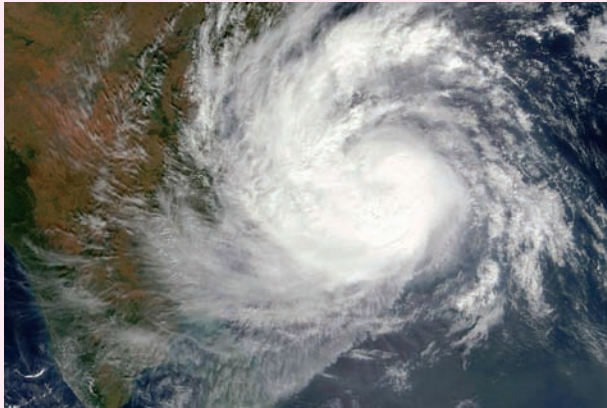


resolution, which has been improved to the resolution of 12 km by 2017. IMD now plans to use this higher version of the model with at least 20 ensembles to generate ensemble forecasts by June 2018 for generating probabilistic forecasts. With this effort, India will have the one of the best weather warning systems in the world.

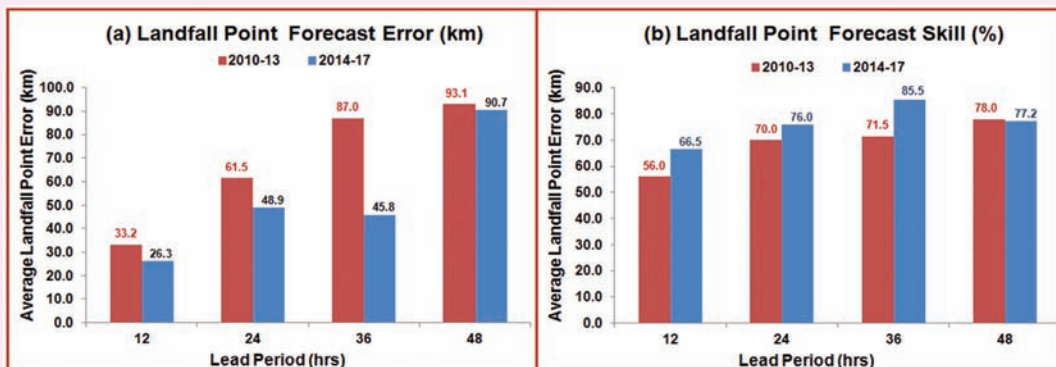


Cyclone warning services

There has been continuous improvement in forecast accuracy with decrease in track and landfall forecast errors and increase in skill over the last 4 years. During 2014-17, the 24, 48 & 72 hours track forecast errors were 85, 137 & 204 km respectively which are 22-26% less than the errors during 2010-13. The track forecast skill during 2014-17 for 24, 48 & 72 hours lead period was 60.2, 70.9 & 72% against 39.8, 56.2 & 63.0% during the period 2010-13.



Comparative analysis of (a) track forecast errors and (b) skill during 2010-13 and 2014-17



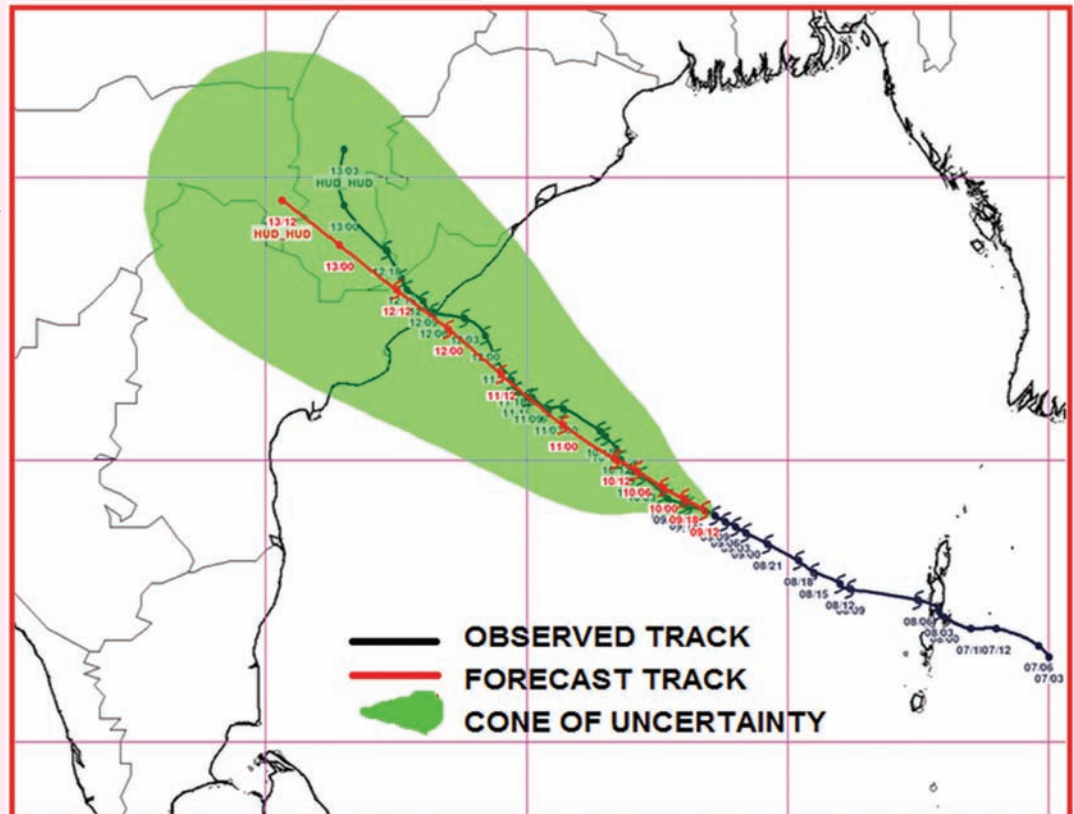
Comparative analysis of landfall point forecast error & skill during 2010-13 and 2014-17

The landfall point error during 2014-17 for 24 lead periods is 48.9 km which is 20% less than the errors during 2010-13. Landfall Point forecast skill during 2014-17 for 24 & 48 hours lead period is 76% & 77% which is about 6-15% greater than the skill during 2010-13 for all lead periods except for 48 hours lead period.

Increase in lead period of forecast increased from 72 to 120 hours for track, intensity and size forecasts. Issue of Probabilistic Genesis forecast was introduced to a lead period of 72 hours from 2014. An example of improved forecast in case of cyclone Hudhud is demonstrated here, indicating negligible error in landfall forecast.

More importantly, there has been a significant reduction in loss of human life and reduction in the cost towards evacuation and payment of ex-gratia to affected population.

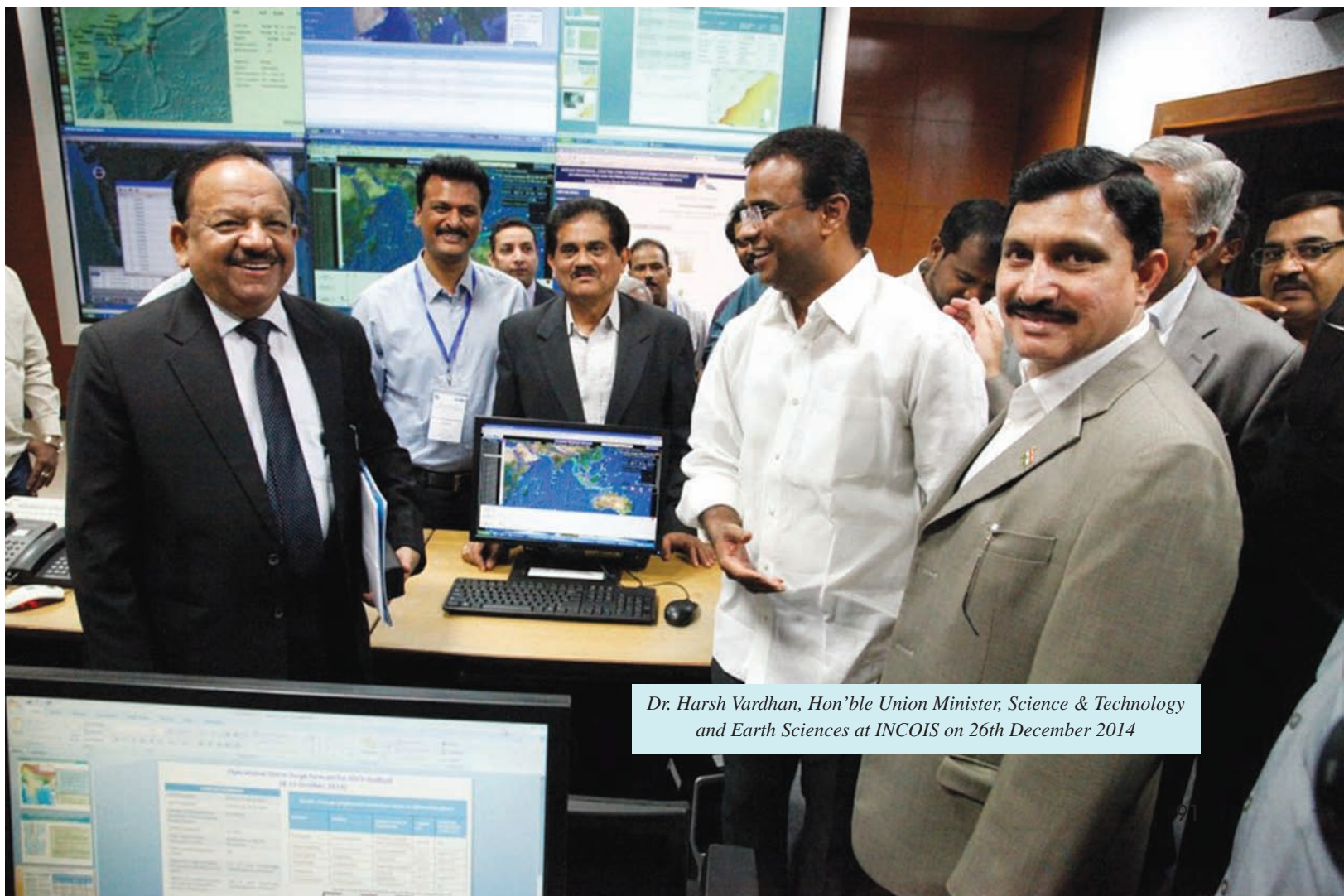
INCOIS/MoES started issuing INCOIS-IMD Joint Bulletins during the occurrences of cyclones in 2013. As part of this, INCOIS disseminates forecasts on the state of the ocean along with the forecasts on marine weather and storm surges in these bulletins. From April 2014 to present, INCOIS issued joint bulletins for 17 cyclone/depression which formed over the northern Indian ocean. INCOIS issued several warnings during the latest cyclone "OCKHI", which passed through the southern coast of India from 28 November 2017 onwards. More than two lakh users in the west-coast were alerted directly by INCOIS about the possibility of rough seas during the passage of cyclone.



Tsunami Early Warning

The Indian Tsunami Early Warning Centre (ITEWC) monitored 143 earthquakes of magnitude ≥ 6.5 during the period April 2014 to March 2018. Out of these, 12 moderate earthquakes occurred in the Indian ocean region. In relation to these earthquakes, ITEWC disseminated the bulletins as per standard operating procedure to its regional (Indian Ocean Countries) and national (India) stake holders through Email, FAX, GTS and SMS. The new Decision Support System (DSS) version 2016 was tested extensively during IOWave16 tsunami mock exercise and made operational in December 2016.

The new DSS is integrated with the necessary metadata layers, latest version of Area of Service (AoS), Earthquake Source Zone (ESZ), CFPs and CFZs. As part of the Tsunami Warning System, INCOIS/MoES has completed mapping the highly vulnerable coastal regions to natural disasters such as tsunami and storm surges using 3D GIS technique for several locations in the east coast of India. A visualization and analysis system for 2D and 3D geospatial data (3DVAS) was developed by INCOIS/MoES. This application integrates all geospatial data pertaining to coastal zone including the outcomes of the 3D-GIS Mapping, which can be effectively used in the events of Tsunami and storm surge events.



Dr. Harsh Vardhan, Hon'ble Union Minister, Science & Technology and Earth Sciences at INCOIS on 26th December 2014

Fog Prediction

There has been a drastic Improvement in the fog monitoring and forecasting systems at IGI Airport (IGIA), New Delhi during Winter of 2014-18 compared to those of 2010-2014 because of successful and effective implementation of three new projects initiated by the Ministry of Earth Sciences as mentioned below:

- (i) Installation of thirteen Indigenous runway-visibility measuring instrument-Drishti
- (ii) Winter fog experiment (WIFEX),
- (iii) Forecast Demonstration Project-Fog in 2014-2018.

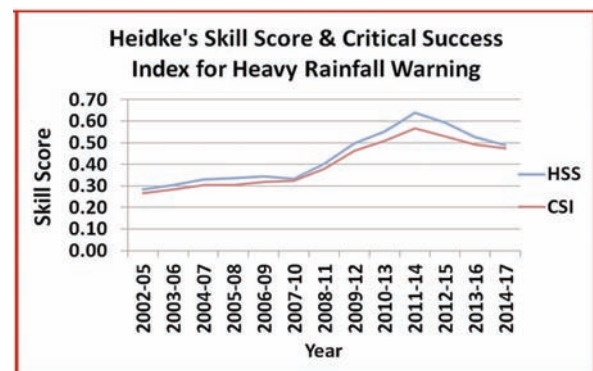
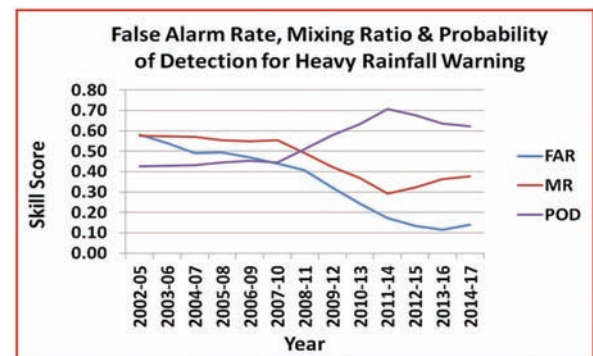
Installation and integration of 13 Indigenous Drishti RVR with their live visibility have improved user outreach and better runway based fog reporting to air traffic control and airlines. Successful and effective implementation of WIFEX in 2015-2018 consecutively for three winters jointly by IITM and IMD with world class observational facilities helped to improve fog prediction. There has been a nominal improvement of fog forecast skill (generic forecast) during the recent 4 years.



Heavy rainfall warning and meteorological support for flood forecasting

To meet specific requirements of flood forecasting by Central Water Commission (CWC), the India Meteorological Department (IMD) provides services for flood warning through Flood Meteorological Offices (FMOs) at 13 locations and the Damodar Valley Corporation (DVC). FMOs provide valuable meteorological support to the CWC for issuing flood warnings in respect of the 43 rivers of India covering 146 river basins. IMD increased lead period to 3 days during 2014-2018 in River Basin/Sub-basin wise Quantitative Precipitation Forecast (QPF) with outlook for subsequent 4 days.

There is significant improvement in heavy rainfall warnings over India during the monsoon season as shown below:



Skill of heavy rainfall warnings

Heat wave warnings

Since 2016, IMD has started hot weather season forecast outlooks for March-May temperatures. A bi-weekly outlook is also issued every Thursday. IMD also issues heat wave alerts and warnings for 5-7 days and outlook for subsequent 7 days with daily updates on heat waves experienced. Since 2016, the 'Heat Action Plan' has been implemented in cities across central India including Ahmedabad, Surat, Nagpur, Akola, Gondia, Chandrapur, Nanded, Jalgaon, Bhubaneswar and Cuttack. It is a comprehensive early warning system and preparedness plan for extreme heat events which has resulted in the number of deaths.



Heat Wave Related Mortality in India since 2015

2015	2422
2016	557
2017	220

Thunderstorm warnings

Thunderstorm and associated lightning is a severe weather event, which can affect public life, aviation and power systems. It is very difficult to predict thunderstorms due to their smaller spatial scale (a few kms) and life time (up to one hour).

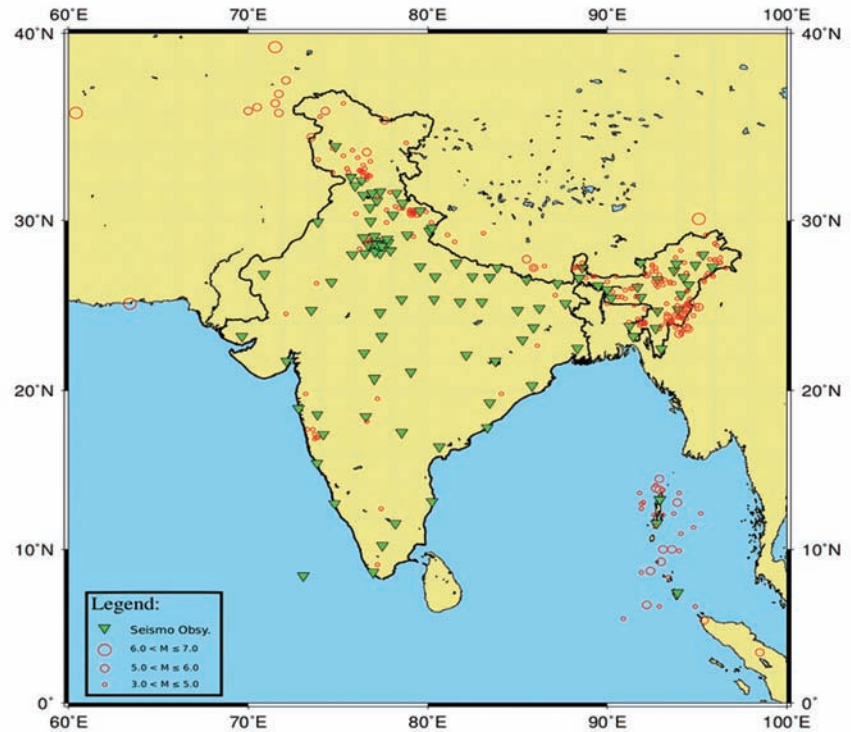
In 2012, IMD introduced Nowcasting (predicting for next 6 hours) for thunderstorms in major cities. By March 2018, 399 stations were covered so far for nowcasting purposes. Nowcast messages are also sent by SMS to registered users.



Real Time Monitoring of Seismic Activity

National Center for Seismology (NCS) is the nodal agency of Government of India, primarily responsible for monitoring seismic activity in and around the country. The operational task of the Center is to quickly estimate earthquake source parameters immediately on occurrence of an earthquake and disseminate the information to all the user agencies including the concerned State and Central Government agencies responsible for carrying out relief and rehabilitation measures. The earthquake information is transmitted to various user agencies including public information channels and media using different modes of communication, including SMS, fax, e-mail and department website. For automatic earthquake parameter dissemination, India Quake, a mobile App was launched for a faster way for communicating earthquake information with no restrictions on the number of recipients.

NCS is maintaining a country-wide National Seismological Network (NSN). In 2014, a decision was taken to upgrade the national seismological network. This includes adding more seismological observatories and upgrading all analog observatories. This has led to increase in observatories from 84 in 2014 to 110 as of today. This number will further increase to 116 by June 2018. We propose to increase to 150 by end of 2019. Un-scrutinized events are the earthquake whose parameters have been estimated automatically by the software using the incoming wave form data from



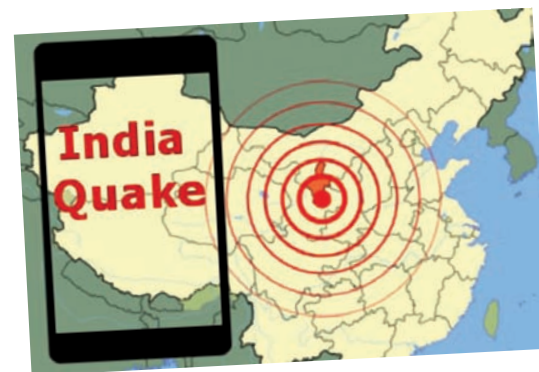
Current seismological observatories in the country along with earthquakes of past 1 year

remote stations. These solutions are scrutinised and confirmed by NCS, which form the category of scrutinised events

Towards mitigating seismic hazard in a few targeted cities lying in seismic zone III, IV and V, a project of seismic microzonation of 30 cities has been approved. Microzonation of these identified cities has been initiated by NCS. In 2016, NCS completed the seismic hazard microzonation of NCT Delhi. Microzonation of a few more cities (Jabalpur, Guwahati, Bengaluru, Kolkata and Sikkim state) has also been completed through MoES sponsored projects.



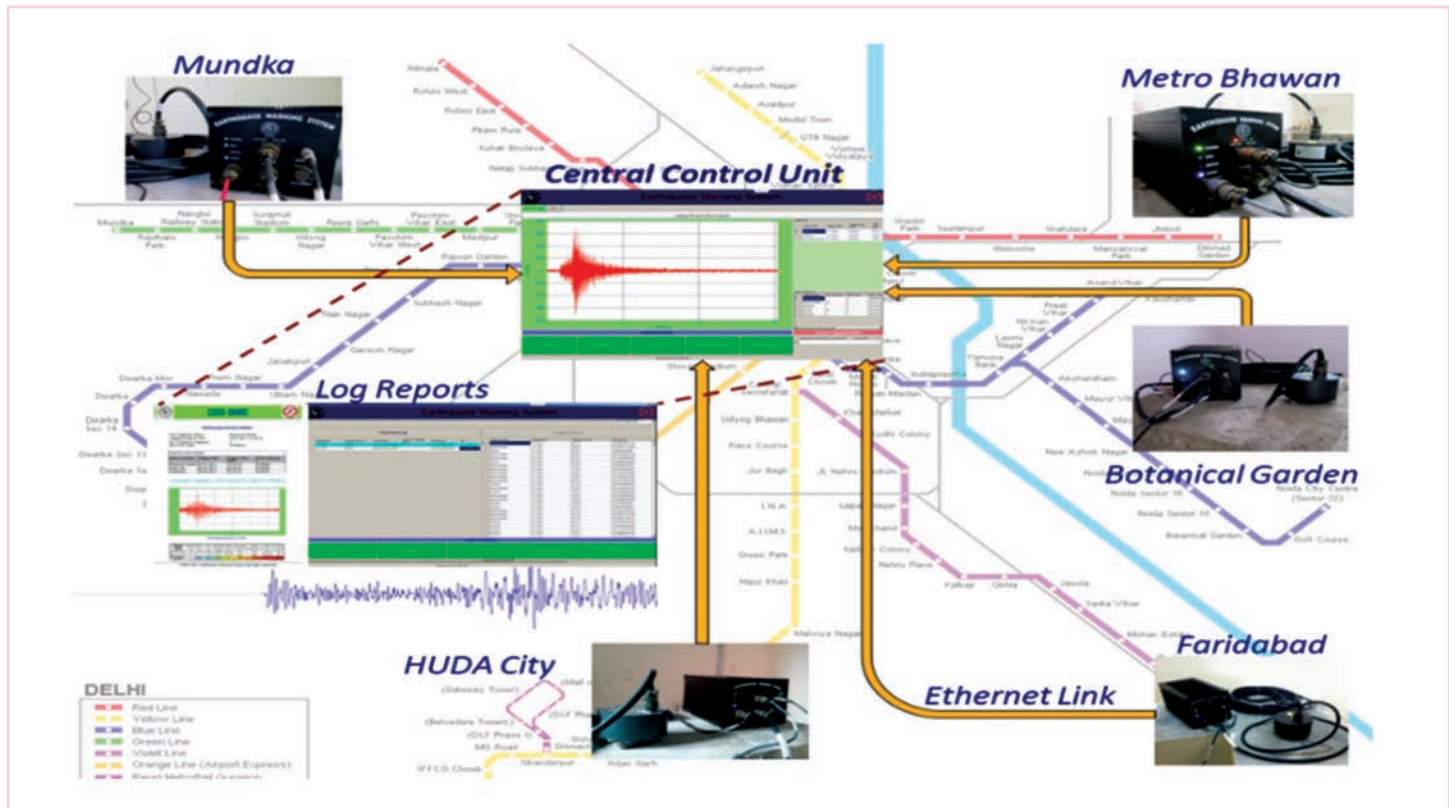
Dr. Harsh Vardhan releasing Mobile App for Earthquake Monitoring



Earthquake Warning System deployed in Delhi

An Earthquake Warning System (EqWS) has been developed and deployed by CSIR-CSIO in Delhi Metro. System comprises five sensors installed at Mundka, Botanical Garden, Huda City Centre, Metro Bhawan and Faridabad.

During early April 2016, the Earthquake Warning System helped stop the Metro services after the tremors hit the national capital. The system sensed and recorded the event and generated SMS to the concerned action points, in real time. The same technology will be tested in Greater Noida Metro line through M/s Siemens.



Blue Economy





Blue Economy

Deep Ocean Mission

THE blue economy encompasses sustainable use of ocean resources for economic growth, improved livelihoods and jobs and health of the ocean ecosystem. It involves programmes for sustainable harnessing of ocean resources, R&D in oceanography, assessment of stock marine resources like minerals, introduction of marine aquaculture, deep sea/long line fishing and biotechnology and development of human resources.

Potential Fishing Zones (PFZ) and Tuna Advisories

- Potential Fishing Zone advisory is a flagship programme of the Indian National Centre for Ocean Information and Services (INCOIS)/MoES which benefits tens of thousands of fishermen and their family.
- Information on regions with fish availability is generated and advisories disseminated in smart map and text form on a daily basis.

- PFZ advisories are reaching more than 4 lakh users every day. However, efforts are on to reach out to all the almost 9.27 lakh fishermen involved in actual fishing, either full or part time.

Sagarvani – Words of Caution

- ‘Sagarvani’ is an integrated Information Dissemination System (IDS) that includes Multi Lingual SMS, Voice Call/ Audio Advisory, Mobile Apps (User/Admin modules), Social Media (Facebook, Twitter, etc.), Email, GTS, Fax, Digital Display Boards, Radio/Television broadcast units, IVRS, Cloud Channels, etc.
- High Wave Alerts and Tsunami early warnings are being disseminated to fisherfolk through ‘Sagarvani’.
- The system also provides access to various stakeholders (NGOs, State Fishery Departments, Disaster Management Authorities, etc.) for further dissemination of ocean information and alerts to the user community.
- The number of users has increased fourfold during the last 4 years.
- Total annual net economic benefits due to the scientific identification of PFZs is estimated to lie in the range of ₹ 34,000 to ₹ 50,000 crore.

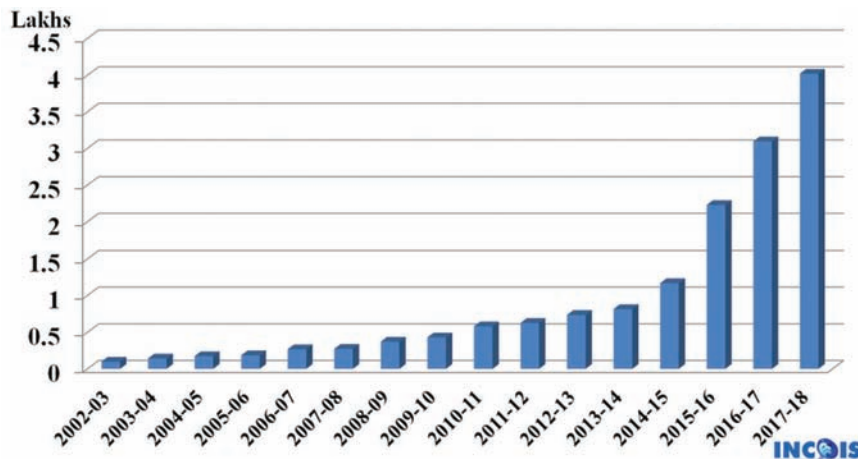
Ocean State Forecasts

- Ocean State Forecasts (forecasts of waves, currents, sea surface temperature, etc.) are provided to a wide spectrum of users which include fishermen, ports and shipping industry, defence, oil and energy exploration agencies, and disaster management authorities.
- OSF services are also being provided to several Indian Ocean rim countries including Sri Lanka and Seychelles under the umbrella of Regional Integrated Multi-Hazard Early Warning System (RIMES) for the Afro-Asian Region.
- Currently, the ocean state forecasts are provided to approximately 16.7 lakh users on a daily basis.

Oil-spill Advisory

- Oil-spill advisories predict the trajectory of the oil-spill.
- Oil-spill off Ennore port due to the collision of two ships on 28 January 2017 at 13.228° N, 80.363° E spilled around 20 tons of HFO oil. The Indian Coast Guard used the oil-spill advisory to plan and execute the clean-up operations.
- Recently Inaugurated Online Oil-Spill Advisory (OOSA) version 2.0 gives a high resolution trajectory prediction (for continuous and instantaneous spills) along the west coast.

Growth of INCOIS PEZ users over the years



Total annual net economic benefits due to the scientific identification of PFZs is estimated to lie in the range of ₹ 34,000 to ₹ 50,000 crore.

The number of users has increased fourfold during the last 4 years.

High Wave Alerts and Tsunami early warnings are being disseminated to fisherfolk through ‘Sagarvani’.

XV NATIONAL MARITIME BOARD MEETING 27 JULY 2016,



Dr. Harsh Vardhan, Hon'ble Minister of Science & Technology and Earth Sciences, dedicating SARAT to the Nation during the XV National Maritime Search and Rescue (NMSAR) Board meeting held at Vigyan Bhavan, New Delhi on 27 July 2016

Search and Rescue Aid Tool

- Search and Rescue Aid Tool (SARAT) developed to track objects/ persons lost at sea.
- Predicted ocean currents and surface winds at the last known location are used to estimate the probabilities of finding the missing object/person in the sea.
- Mobile App also developed for handy use of SARAT. This App can assist with searching of over 64 types of missing 'objects' in the ocean including boats, ships, man-on-board, etc. App is available for download from Google Play Store under the name "SARAT".

Support to Off-shore Industry

INCOIS/MoES regularly provides ocean state information and forecasts for the support of off-shore industries. Recently, based on a request from Oil & Natural Gas Corporation Limited, Eastern Off-shore Asset, Kakinada, INCOIS/MoES conducted a detailed study for their proposed drilling well located off Kakinada (Andhra Pradesh). ONGC has also expressed a desire to support its offshore operational activities by taking the regular ocean state forecasts from INCOIS/MoES.

LIDAR-based platform in Gulf of Kutch



Energy from the Oceans

- Ocean energy harnessed from waves, tidal currents, tidal range and salinity and thermal gradient is a green and renewable energy.
- India has a large coastline and hence a huge potential for ocean energy.
- The National Institute of Ocean Technology (NIOT)/MoES and Ministry of New and Renewable Energy (MNRE) designed and installed a LIDAR-based data collection platform in the Gulf of Kutch and Gulf of Khambhat during 2017 for measuring wind parameters at 20 m elevation from sea level. Subsea structure optimization studies are being undertaken for turbines of 3 MW capacities.
- As part of the floating wave energy system, Backward Bent Ducted Buoy (BBDB) based on oscillating water column principle was developed for port navigation applications and is now available for commercialization.
- For efficient energy harvest from low speed marine currents prevailing in Indian locations, after successful demonstration of a smaller turbine at the Andaman Islands, development of a 5 kW capacity ocean current based hydrokinetic turbine with directly coupled slow-speed permanent magnet synchronous alternator has been undertaken.

Mineral Wealth from the Oceans

- Minerals such as gas hydrates, polymetallic nodules, and polymetallic sulphides are abundant in the Indian EEZ and Indian Ocean. Polymetallic nodules, which are rich in Cobalt, Nickel, and Copper are available at about 5500 m water depth in the Central Indian Ocean Basin. MoES is involved in exploration and harvesting of these resources.
- An area of 75,000 sq km was allotted to India by the United Nations after India conducted an extensive survey of 150,000 sq km of the Central Indian Ocean.
- A crawler-based mining machine with a flexible riser is being developed for mining nodules from 5500 m water depth. A seabed crawler-based mining machine has already been developed and demonstrated at a depth of 500 m.
- A mining machine is now even being developed for 6000 m water depth.
- To test the strength of the soil at those depths an in-situ soil tester has been developed and deployed up to a maximum depth of 5462 m at the polymetallic nodule site in the Central Indian Ocean.
- Remotely Operated Vehicle (ROV) developed to aid the exploration of the deep ocean minerals at 5500 m depth.



Pumping tests during 2017 at 400 m depth off Chennai

Sustainable use of Marine Resources

- Effective bio-remediation technologies developed for tackling waste disposal.
- Biotechnological potential for bio-prospecting of high value products & pharmaceuticals explored.
- National facility for Marine Cyanobacteria (NFMC) in Trichy upgraded with 500 marine cyanobacterial strains.
- 30 marine green algae collected from Indian Ocean & potential microalgae identified & characterized.
- Bio-prospecting, inventorisation, characterization, and value addition explored for novel genes, gene products & compounds.
- Drugs from microbes launched in a unique public private partnership under the Grand Challenge Mission programme on microbial prospecting.
- International Depository Authority at National Center for Cell Science established.



A sea cage deployed at Kothachathram (Andhra Pradesh)

Open Cage Culture

- Large scale fish production through mariculture is essential to cope with the ever increasing demand for fish proteins.
- An open 9 m diameter High Density Polyethylene (HDPE) cage with multipoint mooring was designed and developed for commercially important marine finfishes suitable for Indian sea conditions – deployed and tested in the North Bay (Andaman Island), Olaikuda (Tamil Nadu) and Kothachathram (Andhra Pradesh) representing fully protected, semi-protected and open sea environments, respectively).
- Open sea cage culture technology generate considerable employment opportunities and helps meet the fish food production targets of the nation.
- Innovative concept of rearing post larval fishes in a specially designed nursery cage in open sea also developed.
- Geospatial analysis of Indian seas conducted to estimate the fish farming potential of the country.



Scouring for Marine Living Resources

- Comprehensive database containing about 1,20,000 records of more than 6500 marine species in the Indian Ocean created with details of location, depth, taxonomic classification and hydrographic data.
- Dataset is available at Ocean Biogeographic Information System (OBIS) hosted by IODE/IOC program.
- Digital catalogue on new marine species including species which are described as new to science from the Indian Ocean region has been created and the total record stands at 1104.
- Andaman and Nicobar shelf system has been identified as one of the 'hot spot' for organisms found on the seabed. Around 75 different species of deep sea organisms were recorded. The fauna comprised of deep sea fishes, crustaceans and sharks including chimeras, other invertebrates such as echinoderms, sea pens, sponges, polychaetes, anemones, etc.
- Fifty coral species have been identified in the Palk Bay Coast.

Andaman and Nicobar shelf system has been identified as one of the 'hot spot' for organisms found on the seabed. Around 75 different species of deep sea organisms were recorded. The fauna comprised of deep sea fishes, crustaceans and sharks including chimeras, other invertebrates such as echinoderms, sea pens, sponges, polychaetes, anemones, etc.



Before Implementation



After Implementation

Preventing Erosion — Protecting Shore Lines

Coastlines face severe problems of erosion. Seawalls and groins constructed by the Puducherry government to mitigate the coastal erosion problem, only resulted in shifting the erosion further North.

Based on long-term shoreline change analysis, detailed processed based measurement and numerical modelling a hybrid solution with two submerged reefs and beach nourishment were identified to restore the lost beach along Puducherry. Currently, the beach has already formed south of wedge reef to an extent of 600 m and with the steady progress of the project the city's coastline can soon travel back in time to its sandy past.

Surveillance in Coastal Waters

CSIR-NIO has developed an autonomous robotic system that carries an acoustic transponder and standard oceanographic sensors on its hull to measure water column properties in its upward ascent from the seabed to the sea surface. The development throws open novel applications in environmental monitoring of monsoon processes, and also strategic long-term surveillance in coastal waters.

Products from Fresh Marine Macroalgae

Seaweed farming has been initiated by CSIR-CSMCRI using the seed germplasm maintained by it for production of various chemicals of commercial value through biorefinery model to augment the declining agar production and enable India to emerge as a leading producer as well as supplier of agar/ agarose and agarophytic resources to the global market.