ISSN-0971-8400

YOJANA

DECEMBER 2016 A DEVELOPMENT MONTHLY ₹ 30

Special Issue

Science for Development

Strengthening the S&T Roadmap
Ashutosh Sharma

Defence Applications for Civilian Sector
G. Satheesh Reddy

Atoms in the Service of the Nation
K.N. Vyas & M. Ramanamurthi

Agricultural Technologies: Social Contributions
Sant Kumar and Suresh Pal

Special Article
Space based Platform for Common Man
G. Madhavan Nair

Focus
Enriching the Classroom Process
Rajaram S. Sharma

Making Safe Pregnancy a Social Movement

The Pradhan Mantri Surakshit Matritva Abhiyan (PMSMA) which aims at reducing maternal and infant mortality rates through safe pregnancies and safe deliveries was launched recently. The national programme is slated to provide special free antenatal care to about 3 crore pregnant women across the country in order to detect and prevent high risk pregnancies

The nationwide programme will provide fixed day assured, comprehensive and quality antenatal care to pregnant women on the 9th of every month. Pregnant women can now avail of a special antenatal check-up in their second or third trimesters at Government health facilities provided by gaenocology specialists/ physicians with support from private sector doctors to supplement the efforts of the Government sector. These services including ultrasound, blood and urine tests will be provided in addition to the routine antenatal check-ups at the identified health facility/outreach in both rural and urban areas. One of the aims is to identify and follow-up on high risk pregnancies in order to reduce MMR and IMR.

Women who have not received or dropped out of Antenatal care (ANC) check-ups have been targeted in this programme and a minimum package of investigations and medicines such as IFA and calcium supplements, would be provided to all pregnant women attending the PMSMA clinics.

Flagship Scheme on Entrepreneurship Education

The Pradhan Mantri YUVA Yojana, MSDE's flagship scheme on entrepreneurship education and training was launched recently.

The scheme spans over five years (2016-17 to 2020-21) with a project cost of Rs. 499.94 crore, and will provide entrepreneurship education and training to over 7 lakh students in 5 years through 3050 Institutes. It will also include easy access to information and mentor network, credit, incubator and accelerator and advocacy to create a pathway for the youth.

The Pradhan Mantri YUVA Yojana is an important initiative to scale up entrepreneurship in the country and has national and international best practices of learning in entrepreneurship education.

The institutes under the PM's YUVA Yojana include 2200 Institutes of Higher Learning (colleges, universities, and premier institutes), 300 schools, 500 ITIs and 50 Entrepreneurship Development Centres, through Massive Open Online Courses (MOOCs).

The guidelines for State Engagement under Pradhan Mantri Kaushal Vikas Yojana 2.0 (2016-2020)were also unveiled. The guidelines provide a framework for the State Government's role and processes, the funding support and the scheme's implementation and monitoring mechanism.

MSDE (Ministry of Skill Development And Entrepreneurship) also unveiled the Lab Guidelines towards standardisation of lab equipment across skill development training centres in India. These guidelines specify the number of job roles that can be done in a lab, standard lab layout, and available brands of equipment which should be used. These guidelines will pave a pathway in increasing the employability of trained candidates across States ensuring industry standards.

MSDE announced the institutionalisation of National Entrepreneurship awards for first generation achievers below 30 years, for the very first time. The Entrepreneurship Awards are proposed to be given on 16 January 2017. The young entrepreneur will be awarded in various sectors contributing to the economy of the country.

December 2016 Vol 60

YOJANA

Chief Editor : Deepika Kachhal
Senior Editor : Shyamala M. Iyer
Editor : Manogyan R. Pal
Sub Editor : Vatica Chandra

Joint Director (Production) : V.K. Meena
Cover Design : Gajanan P. Dhope
E-mail (Editorial) : yojanace@gmail.com
E-mail (Circulation) : pdjucir@gmail.com
Website : www.yojana.gov.in
Facebook : https://www.facebook.com/pages/Yojana-Journal

Let noble thoughts come to us from all sides

Rig Veda

CONTENTS

Our Representatives : Ahmedabad: Amita Maru, Bengaluru: Punita, Chennai: A. Elangovan, Guwahati: Anupoma Das, Hyderabad: Vijayakumar Vedagiri, Kolkata: Rama Mandal Mumbai: Umesh Sadashivarao Ujgare: Thiruvananthapuram: Dhanya Sanyal K., Jalandhar: Gagandeep Kaur Devgan, Bhubaneshwar Girish Chander Das.

YOJANA seeks to provide a vibrant platform for discussion on problems of social and economic development of the country through in-depth analysis of these issues in the wider context of government policies. Although **published by the Ministry of Information and Broadcasting**, Yojana is not restricted to expressing the official point of view. Yojana is published in Assamese, Bengali, English, Gujarati, Hindi, Kannada, Malayalam, Marathi, Oriya, Punjabi, Tamil, Telugu and Urdu.

Chief Editor's Office : Room No. 660, Soochna Bhavan, CGO Complex, Lodi Road New Delhi 110 003 Ph: 24362971. Yojana (English): Room No. 647, Soochna Bhavan, C.G.O. Complex, Lodi Road, New Delhi - 110 003. **Business Manager (Hqs.) :** Ph :24367260, 24365609, 24365610

Correspondence address of journals unit for new subscriptions, renewals, enquiries has changed. Please contact : Business Manager (Circulation & Advt.), Publications Division, Ministry of Information & Broadcasting, Room No. 48-53, Soochna Bhavan, CGO Complex, Lodi Road New Delhi 110 003(Ph: 011 24367453).Sales Emporia : Publications Division: *Soochna Bhavan, CGO Complex, Lodhi Road, New Delhi -110003 (Ph 24365610) *Hall No.196, Old Secretariat, Delhi 110054(Ph 23890205) * 701, B Wing, 7th Floor, Kendriya Sadan, Belapur, Navi Mumbai 400614 (Ph 27570686)*8, Esplanade East, Kolkata-700069 (Ph 22488030) *'A' Wing, Rajaji Bhawan, Basant Nagar, Chennai-600090 (Ph 24917673) *Press road, Near Govt. Press, Thiruvananthapuram-695001 (Ph 2330650) *205 II Floor CGO Towers, Kavadiguda, Secundrabad-500080 (Ph 27546312)*1st Floor, 'F' Wing, Kendriya Sadan, Koramangala, Bengaluru-560034 (Ph 25537244) *Bihar State Co-operative Bank Building, Ashoka Rajpath, Patna-800004 (Ph 2683407) *Hall No 1, 2nd floor, Kendriya Bhawan, Sector-H, Aliganj, Lucknow-226024(Ph 3025455) *Ambica Complex, 1st Floor, above UCO Bank, Paldi, Ahmedabad-380007 (Ph 26588669) *KKB Road, New Colony, House No.7, Chenikuthi, Guwahati 781003 (Ph 2665090) *SCO 103, Puda Market, New Bus Stand, Jalandhar. (Ph 2224243)

SUBSCRIPTION : 1 year ₹ 230, 2 years ₹ 430, 3 years ₹ 610. For subscriptions abroad the same rates plus Air Mail charges as prescribed by India Post from time to time, as applicable for concerned countries.

No. of Pages 76

YOJANA

Chief Editor's Desk

Science of Today: Technology of Tomorrow

"Science knows no country, because knowledge belongs to humanity, and is the torch which illuminates the world" Louis Pasteur.

Scientific thought and interest have been at the backbone of mankind's advancements and progress – be it the discovery of fire, the wheel or the power of nuclear fission. Scientific temperament and an inquisitive mind are essential for the people to move forward, as only a scientific mind can enquire into situations and seek solutions. If Newton had not questioned the falling down of apple instead of going up, he would not have discovered the power of gravity.

Science however is not only about abstract thoughts but also about it's application in various fields impacting the common man. In science, every discovery is a permanent gain. As Eisntein said, "science of today is the technology of tomorrow". Development is always linked with technology. Particularly in today's knowledge based economies, science and technology are the basic pre requisites for development.

Developments in science and technology are fundamentally altering the way people live, connect and communicate with each other. Scientific inventions like electricity, faster means of transport and weather forecasting systems have made life easier and better for the common man who has light at his disposal to study, travel faster for business and is pre-warned about disasters. Innovations in various sectors are helping young entrepreneurs to upgrade their skills and initiate start ups. India, a food importer at one time, is now not only self sufficient but is also able to export food items thanks to the Green Revolution. Scientific discoveries have helped farmers raise better crops at a faster pace, thus solving the problem of food shortage.

Scientific breakthroughs have revolutionized healthcare by equipping medical practitioners with tools to gather information, make well informed decisions and treat critical diseases. From simple cataract operations to major heart transplants, advancements in medical technologies have contributed to improving quality of human life and increasing life expectancy. Technological advancements have taken education to the doorstep of students in far flung areas. On the one hand digitisation has enabled children in remote areas to access education material through internet, on the other hand invention of newer and interesting tools of teaching have made boring classes and writing on the blackboard a thing of the past. The world has indeed opened up and come closer to such children.

Defence applications are also being adapted to societal development and civilian use. Bullet proof jackets, farming in high altitudes, multi insect repellents, food poison detection kits, etc are some of the outcomes of research and development in defence which are also being put to use in civilian sector. So far as space technology is concerned, India is considered as the leader in area of impacting day to day life through application programmes like tele-education and telemedicine. So is the case with nuclear technology. Hiroshima and Nagasaki had made atomic power one of the most dreaded words in the lexicon. But, thanks to our scientists, the power of the atom is now harnessed and used as nuclear energy for peaceful purposes. Health, agriculture, food preservation, energy are some of the areas hugely benefitted by nuclear innovations.

Science and technology have proved to be a boon to human life. A nation which does not promote scientific thinking lags behind the race for development. Science for development is the slogan for the future. ❑

Strengthening the S&T Roadmap

Ashutosh Sharma

Right from catalyzing rural industrialization in Jodhpur district in Rajasthan to fostering global collaborations for mega projects, from percolating science for social benefits to sprucing the innovative ecosystem, the DST leverages research for equity, empowerment and development and has charted a trajectory that will enable India leap-frog across frontiers of development

The Department of Science and Technology, Government of India serves as the nodal agency for all government led initiatives that create and strengthen the science and technology landscape in our country. The specific mandate is to advance science and technology pursuits and develop related human and institutional resources to foster excellence in these fields. The DST accordingly develops policies and implements programmes to serve this important mandate that also delivers science and technology based societal benefits. These transformational changes are enabled through development models, stakeholder engagement, internal connectivity of programmes, and coordination with several other departments within our country and institutions outside through bilateral and multilateral frameworks.

The missions of the Government of India have added impetus to the initiatives of the DST. These include the Make in India, Start up India, Swachh Bharat, and Digital India programmes in particular.

Here's a peek into some major initiatives to meet the goals and the robust roadmap for the way ahead. Right from catalyzing rural industrialization in Jodhpur district in Rajasthan to fostering global collaborations for mega projects, from percolating science for social benefits to sprucing the innovative ecosystem, the DST leverages research for equity, empowerment and development and has charted a trajectory that will enable India leap-frog across frontiers of development.

The DST partners the Department of Electronics and Information Technology (DeitY) to empower national academic and R&D institutions across our country by installing a vast supercomputing grid with more than 70 high-performance computing facilities. This intervention serves the National Supercomputing Mission aimed to take India into the front ranks of Computing and Big-data Analysis. The mission was approved in March 2015 at a total cost of Rs.4500 crore.

The collaboration in Impacting Research Innovation and Technology (IMPRINT) project entails DST's partnership with the Ministry of Human Resource Development (MHRD) to address such major societal and developmental needs as healthcare,

The author is Secretary, Department of Science and Technology, Government of India. He has served on the Governing Boards/ Councils of over 15 prominent scientific institutions in India and has had a broad international experience. His research contributions are highly interdisciplinary, spanning a wide range in which he has published over 300 peer reviewed papers, and filed over 10 patents. He is also recipient of numerous honours and awards.

information and communication technology, energy, sustainable habitat, nano technology, water resources and river systems, advanced materials, security and defence, and environment and climate change related mitigation and adaptation.

A joint R&D initiative with Ministry of Railways focuses on fuel efficiency enhancement and emission control technologies, alternate fuels, fuel conservation in diesel traction etc.

Reversing Braindrain to Brain Gain: An Early Career Research Award (ECRA) has been launched to provide rapid research support to researchers in their early career stages to pursue exciting and innovative research in frontier areas of science and engineering. The award carries a research grant upto Rs.50 lakhs for a period of three years. The National Postdoctoral Fellowship (N-PDF) scheme is aimed to attract and retain young scientists and discourage brain drain in academic/R&D institutions.

Attracting Women to Science: This is achieved through a programme titled KIRAN (Knowledge Involvement in Research Advancement through Nurturing) launched in 2014. This enables gender parity in science through nurturing research careers of women scientists. The programme provides opportunities to women scientists who had a break in their career primarily due to family responsibilities. The programme encourages them to take up research and emerge as an entrepreneur if they so choose to.

Societal benefits delivered: These cover a wide variety of sectors including energy benefits, wealth from waste and optimal extraction and sustainable management of bio resources. Three such examples are presented in the following.

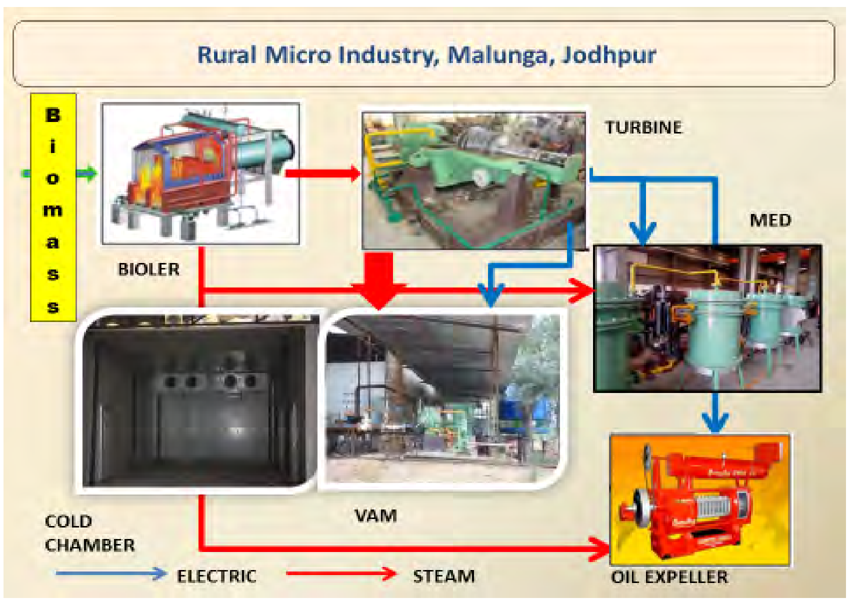
Surya Jyoti lights up homes of poor: In order to capture daylight and concentrate the same inside dark living spaces, a low cost device named Surya Jyoti has been developed and tested. Surya Jyoti is basically a Micro Solar Dome which has a transparent semi-spherical upper dome made of acrylic material that captures sunlight. The light passes through a sun-tube of a thin layer of highly reflective coating on the inner wall of the passage. During daytime, illumination through Surya Jyoti goes upto an equivalent of 15-watt LED lamp. The dome has also been integrated with a photo Voltaic (PV) panel to enable it to provide light up to 4 hours after sunset. The cost of photo voltaic integrated Surya Jyoti is about Rs.1200 and without the photo voltaic panel it works out to Rs.500. The cost is expected to come down drastically after scaling up of the manufacturing process.

Indigenous technology for rural industrialization: For inclusive development of the country, sustainable industrial activities using local resources in the rural areas are extremely important. DST accordingly endeavours to help rural populations through the application of science and technology. One such initiative of the department has culminated in a rural-industry complex in a plot of wasteland at Malunga, a village in Jodhpur district of Rajasthan. Integration of technology in this industry complex has been done in such a manner that it satisfies the local needs by utilization of local resources. It offers sustainable and inclusive development by converting waste to wealth.

North Eastern Centre for Ethno Medical Research**:** DST has established a Ethno Medicinal Research Centre in 2015 with budgetary support of Rs.8.92 crores for 5 years. This Centre will undertake ethno phyto-chemical research on wild herbs available in the North Eastern region with unique medicinal and aromatic properties. The Centre will undertake scientific validation of traditional herbs and products and help improve socio-economic status of local communities and enhance quality-of-life through better livelihood and benefit sharing.

Going Global through Mega Projects: The most important guiding principle for this approach is to leverage India's excellence for mutually reinforcing benefits for high end pursuits on frontiers. These in turn enhance investigation and learning opportunities along with economic benefits through enhanced industry activities.

Thirty Meter Telescope: India's Participation in Thirty Meter Telescope (TMT) project at Mauna Kea, Hawaii, USA was approved by the Government at a total cost of Rs.1299.8 crores in September 2014. The cost would be



met by DST and the Department of Atomic Energy. The other countries participating in the project are USA, Canada, China and Japan. India will contribute towards the construction phase, both in cash and kind. India will benefit scientifically and technologically from participation in this project.

Associate Membership of CERN: The European Organization for Nuclear Research (CERN) is the world's largest nuclear and particle physics laboratory, where scientists and engineers across the globe are probing the fundamental structure of the Universe. Indian scientists have been actively participating and collaborating at CERN on all aspects of science, engineering and computing through joint funding provided by Department of Atomic Energy (DAE) and Department of Science and Technology (DST).

The CERN Council admitted India as Associate Member of CERN in Sept. 2016. As an Associate Member of CERN, India will be a part of the huge scientific and technological endeavor.

Laser Interferometer Gravitational Wave Observatory (LIGO): India has agreed in-principle to set up an advanced gravitational-wave (GW) observatory in the country; that will be the third such observatory across the world. This will be a nationally coordinated project and three lead Indian institutions, Inter-University Centre for Astronomy and Astrophysics (IUCAA), Pune, Institute for Plasma Research (IPR), Gandhinagar and Raja Ramanna Centre for Advanced Technology (RRCAT), Indore will steer this project in collaboration with LIGO laboratories of California Institute of Technology (Caltech) and Massachusetts Institute of Technology (MIT), USA.

Devasthal Optical Telescope: A state-of-the-art world class 3.6 meter Devasthal Optical Telescope was remotely activated jointly by the Prime Minister of India and Prime Minister of Belgium on March 31, 2016. The telescope is installed at Devasthal near Nainital. It is the largest steerable imaging telescope in Asia; a result of scientific collaboration between scientists from Aryabhatta Research Institute of Observational Sciences (ARIES), Nainital, an autonomous institution of DST, and Belgian scientists. The telescope will contribute to observations for frontline scientific research in astronomy and astrophysics.

Collaboration with Italy : Trieste-based Sincrotrone Elettra in Italy opened its two new experimental stations, XRD2 and XPRESS recently in partnership with DST. The two new energy beamlines will research on new materials, pharmaceuticals and biotechnologies.

India-Belgium Aryabhatta Research Institute of Observational Sciences (ARIES) Telescope

Collaboration with Germany: The Facility for Antiproton and Ion Research (FAIR-GmbH) at Darmstadt, Germany, the largest upcoming accelerator facility for basic science research, was formed in October 2010, with India as a founder member. The international facility, which will use high-intensity beams of antiprotons and ions of various species, will assist research in the fields of atomic, nuclear, particle and plasma physics. In India, the project is being implemented jointly by the Department of Science and Technology and the Department of Atomic Energy. Apart from several Indian industries involved in building the advanced FAIR accelerator equipment in the country, Indian scientists are working in 40 different groups spread across several institutions.

The DST has devised integrated approaches to sustain the momentum of these advancements and deliver across all fronts. Immediate, medium and long term goals are well defined as part of a logical framework that includes the following:

Enhance quality and quantity of R&D: The objective is to position India amongst the top 5 countries in scientific research by augmenting the R&D infrastructure, enhance number of active scientists and quality/relevance/impact of research to reverse braindrain for braingain for societal and industrial development and attract youth to study and pursue career in science and technology. The DST will also intensify industry-academia R&D partnerships, to find solutions to national challenges pertaining to energy, water, health, environment, climate and cyber security. There will be new steps to leverage the best of international S&T knowledge and infrastructure by cooperating in the selected areas to gain global competitiveness and support S&T capacity building in least developed countries.

Create a Robust S&T Led Innovation and Start-up Ecosystem**:** DST has developed a national initiative (National Initiative for Developing and Harnessing Innovations- NIDHI) to seamlessly cover the entire innovation chain right from scouting and mentoring to up-scaling the start ups. This will also widen the base of the innovation pyramid by promoting the culture of innovation among students and rural communities with a special emphasis on inclusion, relevance, frugality and grassroot applications.

Technology Development and Deployment entails a special focus on leadership and self-reliance in digital technologies and its applications including supercomputing, cybersecurity, big-data analytics, computational sciences, modelling and simulation, etc. These will improve decision making and governance systems.

Citizen engagement is an important thrust of the DST. This is based on the felt need to create awareness about emerging frontiers and the pervasiveness of science in daily life. The Science Express is a classic initiative that serves this need especially for the benefit of children across the country.

The present snapshot will help understand the spread and depth of integrated approaches that guide the development and implementation of science and technology centred programmes in our country. The DST is aware of the need to further strengthen this landscape to reinforce India's leadership in these areas and continually deliver value added services for the benefit of our country as a whole. ❑

(E-mail: dstsec@nic.in)

DO YOU KNOW?

SURYA-JYOTI

Surya Jyoti (Photo-Voltaic Integrated Micro Solar Dome) is a low cost and energy efficient lamp useful particularly for urban slum or rural areas which don't get electricity supply.

The lamp fuctions by capturing day light and concentrating and saving it inside which can be used during the night time. The device is leak proof, and can work up to four hours continuously after sunset. This device has been developed by the Department of Science & Technology as a part of their Green Energy initiatives.

Voltaic Integrated Micro Solar Dome (MSD)

Surya Jyoti lamps will be used by the 10 million off-grid households in urban and rural spaces that do not have reliable access to electricity. As it can give an illumination equivalent of a 60W incandescent lamp, it will lead to a saving of 1750 million units of energy. It would also lead to an Emission Reduction of about 12.5 million ton of CO_2.

These Surya Jyoti lamps can operate in three modes, day light without any electricity, night time with solar PV and night time with conventional grid after 17 hours of operation. The manufacturing process of the device is labour intensive and is expected to generate huge job opportunities. A monthly production of 6,000 units is expected by December, 2016 which is can go up to 20,000 by March, 2017.

1000 Micro Solar domes are now working in the slums of Delhi, Kolkata, Agartala, Guwahati, Bhopal and Bengaluru. The PV integrated lamps costs about Rs. 1200 and Non-PV integrated lamps cost about Rs. 500,that will be further reduced to Rs. 900 and Rs. 400 respectively, after the scaling up of the manufacturing process. The device has been included as a product for off grid solar lighting applications and is eligible to be subsidised under various rural and urban government schemes. ❑

(Compiled by Vatica Chandra, Sub Editor)
(E-mail: vchandra.iis2014@gmail.com)

Defence Applications for Civilian Sector

G Satheesh Reddy

The new policies of the Government of India are enabling many overseas enterprises to start operations and set up manufacturing units in India with large investments. This is a major driver for development and potential creator of employment

Defence research has, for long, been the arena for transformational technologies that ultimately result in not only empowering a nation with military might, but also pave the way for systems that help in societal development and civilian use. This was demonstrated in Europe and USA during the World Wars I & II. The impetus to development to superior military systems pushed the technology envelope higher during the Wars, and subsequently translated into phenomenal growth of civilian sectors in those countries. Right from aerospace / jet engine technologies that were propelled by wars in the first half of the 20th century to the now ubiquitous internet, defence science has had its imposing footprint in much technological advancement. From the Global Positioning System and a plethora of other communication technologies to canned / irradiated foods in the household, to drones, defence research fosters innovation and engenders development. From an Indian perspective, much needed impetus is being provided by the initiatives of the Government which is creating the right ecosystem for path breaking research leading to defence supremacy and overall development. Defence research, when aligned with the Make in India and Skill Development programmes are bound to speed up the development process and foster an environment of healthy and competitive entrepreneurship in defence research.

Defence and Economic Growth

As per SIPRI database, the total world defence spending is about 1676 billion USD which is in turn about 2.3 per cent of global GDP. US alone spends about 600 billion USD followed by China with about 215 billion USD. India's expenditure on Defence is equivalent to 50 billion USD.

Indian Defence R&D, for many years, operated with a financial outlay of less than 6 per cent of the Indian Defence budget, which compares very modestly to the Defence R&D expenditure of world leaders with USA at 15 per cent, UK 8 per cent, China 15 per cent and Israel at 9 per cent - countries with much larger military budgets.

This demonstrates the impact of Defence science and technologies on the economy of countries. A significant part of economic growth of a country is dependent on the country's ability to produce indigenous defence equipment and systems. Else, major portion of the GDP of the country goes into defence imports.

The author is Scientific Advisor to Raksha Mantri. He led the design and development of Avionics for the country's first ICBM class Agni-5 missile, successfully developed the Medium Range Surface to Air Weapon System (MRSAM) and developed the country's first Guided Bomb bolstering weapons capability of Armed forces. He is the first ever Scientist from India to be conferred with the Silver Medal of Royal Aeronautical Society, UK in their Awards history spanning over 100 years. He is recipient of many prestigious awards.

Globally, cutting edge technologies have always been funded by both public and private institutions for eventual product development for Defence. This in turn, strengthens the industry base and economy. Predominantly most of the technologies developed for Defence have found extensive applications in civilian sector later, thus becoming the backbone of development in those countries.

Whereas in India, defence applications have been dependent on the breakthroughs in civilian technologies for a long time. For unknown reasons, civilian and defence technologies were isolated and insulated rather than complementing one another as is the case globally. In India, from the beginning, development of defence equipment and technologies followed the footsteps of foreign designers/developers. No original ideas and product development were supported and under colonial rule, defence science and technology became a dead horse. Lack of proper research and infrastructure facilities made us dependent on imports to a larger extent.

However, in recent times, India has been making strides towards achieving self-reliance in critical areas. We have attained a stage where there is no dearth of entrepreneurship and policy making initiatives in the country. The increased pace of manufacturing sector is very apparent. Many indigenous industries are competing with foreign counterparts. The day is not far, when, India, once regarded as a country of imports, will transform itself into a country of net exports.

Indigenous Defence Systems production has created a pool of Aerospace industry base to support the future defence technological endeavours of the country. For instance, Akash weapon system induction and production costing about Rs. 20,000 crores alone has provided business to more than 2000 MSMEs and a half a dozen large scale industries, including several CPSUs. Many more weapon systems are lined up for production.

Defence R&D

Since 1958 Defence R&D has grown to be capable of delivering strategic missile systems, Electronic Warfare, Electronics, Naval and complex platforms such as the Light Combat Aircraft.

India is today one of only 5 nations with ICBM capability, one of the 4 countries in the world to have a multi-level strategic deterrence capability, one of only 5 countries of the world to have its own BMD program and underwater missile launch capability, one of only 7 countries to have developed its own Main Battle Tank and an indigenous 4th generation Combat aircraft, one of 6 countries of the world to have developed a nuclear powered submarine, one of select few countries of the world to have its own Electronic warfare and multi Range radar program.

Defence R&D led to the development of Bullet proof jackets, breathing systems, farming in high altitude areas, Dengue, Chikungunya, multi insect repellent, food poison detection kit which have been put to use. In the field of Nuclear Biological and Chemical technologies, a large number of DRDO systems including Reconnaissance vehicles, dosimeters are in use. Bio-digester for human waste management primarily developed glaciers have found its potential in the civilian sectors and have become a significant part of Swachch Bharat movement.

However, focus is to be placed on futuristic technologies for India to become a future world leader. From nurturing and working on denied technologies, we need to leapfrog in capability and lead in relevant areas. Establishing focused research centres in the specific technologies at R&D centres and academic institutes with state of the art infrastructure is the first step in that direction. Innovations at Small and Medium Scale industries should be encouraged and supported. The country needs to have innovative manufacturing institutes with public and private partnership. Also, these technologies must be devised for ultimate exports to earn valuable foreign exchange for the country. Bio-sensors, Photonics, NEMS, MEMS, high energy materials, futuristic power supplies, stealth technologies, advanced materials, high power computing are few such identified priority areas.

Futuristic R&D is only possible by engaging the scientific manpower appropriately. The mere augmentation of research manpower will heed no results until a research conducive ecosystem is evolved and put in place.

Defence Technologies - Benefits

Research in defence science bolsters the might of a nation, leading to development on the military and economic spheres as well. Also, many spin-offs from research in defence science have transformed lives of people. The Floor Reaction Orthosis (FRO) calipers and the Raju-Kalam stent are examples that stand out, having sprung from research in advanced composites. Bio-medical devices, implants, diagnostic products for infection imaging, indigenous X-ray Industrial Tomography System, Radiation Protection Products, Rapid Quantification and Detection Techniques for Pesticides in

Fruits and Vegetables and technology for dengue control are all spinoffs from defence research in our country.

Though the barriers in military and civilian R&D have not come down, much benefit is gained by both sectors leading to national development. To leverage the positives in defence science for overall development, policies should be tailored to capitalize on the knowledge, capability and capacity in the defence innovation sector. Sustained investments in defence science and technology will lead to greater economic benefits as the public and private enterprises work in cohesion to achieve the common goal of development.

Skill Development Initiatives

The basic strength of an organisation lies in its human resources, more so in the defence sector, where domain knowledge is highly specific. Universities and institutes need to plan programmes with curriculum related to the defence science and technologies. It is essential to design the curriculum with subjects related to the defence and incorporate them in the syllabus of leading institutes in the country to nurture the knowledge base and skill sets. This makes the researchers at the entry level to step in with requisite skills for defence science.

Science in general, and defence science in particular, is collaborative and competitive on the global scale. The walls of institutions, nations, agencies, universities and organizations are slowly making way to multidisciplinary teams that join together to solve common problems. When resources and ideas are shared, risks are spread across all the stakeholders. This will put an end to impediments and hasten development. This is the need of the hour.

Bright Future ahead

Till now we have been concentrating on many of the technologies which are denied to us. Now, we should identify the futuristic technologies for the next 10-20years and take a lead in the R&D of these technologies. Many focused research centres in the specific technologies at R&D centres and academic institutes like IIT Madras, IIT Mumbai, Jadavpur University have been established. State of the art infrastructure need to be established at these centres and funded. Innovations at Small and Medium Scale industries are being encouraged and supported. The country needs to have innovative manufacturing institutes with public and private partnership. Most importantly, these technologies must be devised for ultimate exports to earn valuable foreign exchange for the country.

India is transforming itself from biggest importer of defence products and equipment to a major exporter. However, a few points need to be taken into cognizance vis-à-vis research in defence science:

(a) The defence sector is technologically intensive. Changes take place at a rapid pace, and with shifting goalposts dictated by perceived and apparent threats.

(b) R&D in defence science is to a large extent carried out by Government agencies / establishments, with little R&D in the non-Governmental sector

R&D institutes should focus more on basic and translational Research and the public sector units needs to be roped in for development and subsequent production, playing a vital role as lead integrators. The private sector also needs to invest in R&D in specified areas and produce the sub-systems and systems. This will enable such industries to transform their capabilities to the level of lead integrators.

Today, the private sector has already started playing a major role. In last 10 years, private industries have graduated from mere component producers to a challenging role of developing the state-of-the-art sub systems and systems. It is pertinent to note that more than 70 per cent of the supplies for Akash missile system are coming from a conglomerate of private industries. It is evident that the private industry is going through a major transformation to handle greater challenges.

The new policies of the Government of India are enabling many overseas enterprises to start operations and set up manufacturing units in India with large investments. This is a major driver for development and potential creator of employment. The response to 'Make in India' call is overwhelming. The manufacturing sector, thus far neglected has been energized and invigorated.

The future augurs well for Indian Defence Science and Technology. ❑

(E-mail:satorm@gov.in)

India-UK Tech Summit: Showcasing India's Scientific and Technological Prowess

The India-UK Tech Summit was jointly inaugurated by the Prime Minister of India and the Prime Minister of United Kingdom, Theresa May, on 7th November, 2016, The focus sectors at the Summit were Advanced Manufacturing & Robotics; Life Sciences & Healthcare and Smart Cities. The other tracks of the Summit will be Higher Education, Design, Intellectual Property, Innovation and Entrepreneurship. The Summit marked the high point commemorating 2016 as the 'India-UK Year of Education, Research and Innovation'.

In his inaugural address the Prime Minister called for harrnessing the vast traditional knowledge base in India coupled with modern scientific investigation to provide a holistic approach to preventive healthcare which can help address some of the modern life style diseases. He said that the present India-UK cooperation in science and technology was driven by 'high quality' and 'high impact' research partnerships and in less than two years' time wide ranging collaborations covering basic science to solution science aimed at addressing societal challenges were started under the 'Newton-Bhabha' program. The scientific communities of the two countries were working on new vaccines for infectious diseases, inventing new smart materials, providing solutions for clean energy and climate change mitigation, and improving crop productivity including agriculture and food security said the Prime Minister. India-UK Clean Energy R&D Centre on solar energy with joint investment of 10 million pounds has also been planned. A new Anti-Microbial Resistance initiative with joint investment of 15 million pounds is also being launched. India's partnership with UK in industrial research has led to the Global Innovation & Technology Alliance or GITA platform of CII and Department of Science and Technology along with Innovate-UK supports industry led R&D projects in affordable healthcare, clean technology, manufacturing and ICT. He called for active partnership and collaboration between India and UK in various flagship programmes like Digital India, Jan Dhan Yojana, Make in India, Smart City Mission, and Start up India.

SPECIAL ARTICLE

Space Based Platform for Common Man

G Madhavan Nair

Uniqueness of the Indian space programme is that it is able to use the space based platforms for implementing various applications programs which touches the day-to-day life of the common man

Indian space programme had a 20 year late start compared to developed countries, Inspite of that today it has emerged as one among the six leading space faring nations. Without much of external help India has achieved self-reliance by mastering the technologies for building powerful rockets, satellites for earth observation scientific experiments and communication. These cutting edge of technologies developed indigenously are comparable to those possessed by the developed countries.

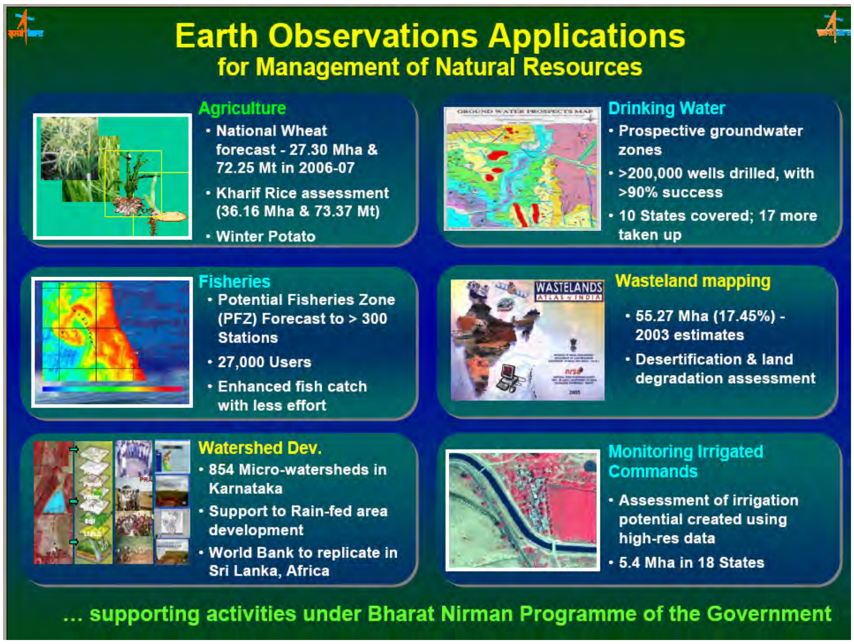
Artificial satellites placed around earth using powerful rockets have revolutionised space research. The ground based observations are blurred by the presence of atmosphere and rockets enabled powerful instruments to be carried above the atmosphere to have a clear view of the celestial bodies. Spacecraft orbited around the earth have provided a platform to observe the universe in great detail and to have a synoptic view of the planet earth These space platforms are the powerful tools helping human kind to expand its fundamental knowledge of the universe and provide services on earth enriching the quality of life of common man.

History of rockets can be traced to 6th century AD when Chinese had an elementary version used as part of fireworks. But later in1782 Tipu Sultan in India deployed rockets as a weapon to fight with the British Army in Srirangapattinam. From there it found its way to Europe. Early 20th century has seen the development of rocket systems in a more professional way in Russia and America. Oberth in USA and Tsiolkovsky in erstwhile USSR had evolved the scientific principles of rocket engines and propellants.

It was the demands of war machinery that had driven the development of rocket systems to a level of perfection. The V2 rockets developed by Germans were a nightmare for the allied forces. After the world war the rocket technologists from Germany were grabbed by the USA on one side and the USSR on the other. The greed for military supremacy had led to fierce competition between the superpowers Several powerful rocket

---

The author is former Chairman of the Indian Space Research Organization (ISRO) and past President, International Academy of Astronautics (IAA), Paris. He has been conferred both Padma Vibhushan and Padma Bhushan. He was responsible for implementation of India's first mission to moon Chandrayaan. He had implemented application programs such as tele-education, telemedicine and disaster management support systems and village resource centre. He is a specialist in Rocket systems and has made significant contribution to the development of satellite launch vehicles starting from SLV3 to GSLV He was the chief architect of India's work horse launcher PSLV. He had initiated number of new missions such as semi cryogenic engines recoverable and reusable launch vehicles Indian regional navigation system and manned missions.



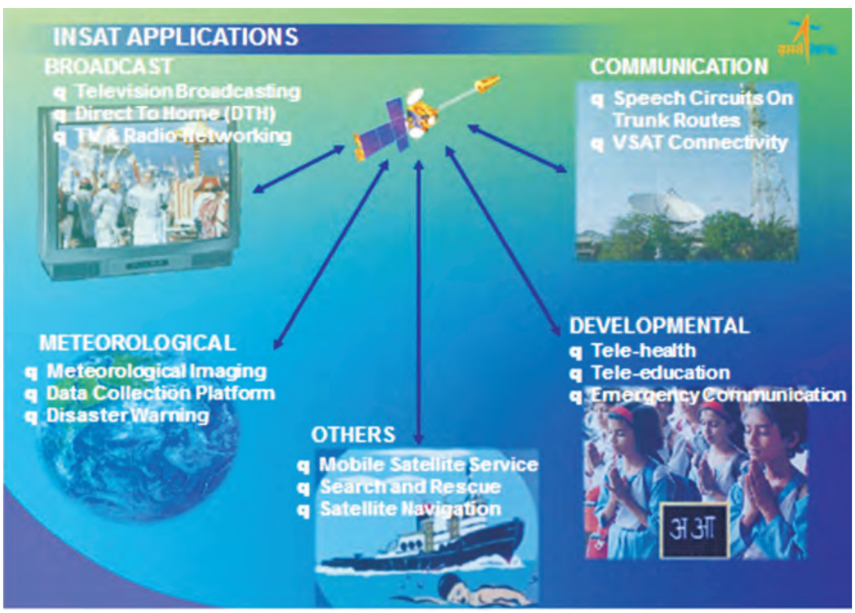
systems were developed as part of the missile systems. A man-made object can be placed as an artificial satellite around earth was demonstrated by Russia with the launch of Sputnik on 4th Oct 1957. This was soon followed by USA through the launch of Gemini capsule. Manned missions around the earth and later the landing of man on the moon were major developments.

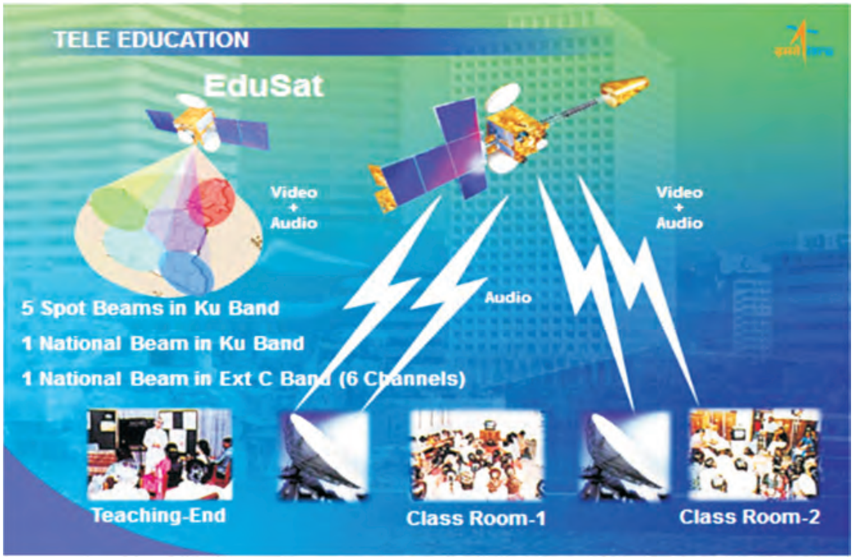
In the developed countries the missile systems developed were re-configured to place the satellites around the earth or send probes to the outermost regions of solar system. These satellites carrying sophisticated instruments became powerful tools for exploring outer space. Europe and China followed soon. Japan with its cooperation with USA also embarked on similar developments.

Whereas India is the only country which embarked on development of space programme in a civilian domain. The visionary scientist Dr. Vikram Sarabhai had not only seen the potential of space technology but also the application of such advanced technology for the benefit of common man. In late sixties he chalked out a vision for space programme in the country which has become the Bible for Indian Space Research organisation.

Indian space program started with the launch of a rocket from the beaches of Thumbain 1963 carrying a payload to study the winds in the upper atmosphere and ionosphere. From there we have come along way. Dr Srabhai had seen the urgent need to develop Rockets for space exploration and set up the Space Science and Technology Centre (SSTC) att Thumba. later this became Vikram Sarabhai Space Centre (VSSC) which is the lead centre for development of satellite launch vehicles The SLV 3 was the first launcher which placed a 50 kg Rohini Satellite into earths orbit in july1980. This marked the entry of India into the Space club consisting of Russia USA China Europe and Japan From there we have come a along way, today we have the PSLV the work horse launcher of India and GSLV capable of placing 2.5 tonne class of spacecrafts into Geo transfer orbit.

Simultaneously development of spacecrafts were taken up at ISRO satellite Centre (ISAC) Bangalureu. Arybhata and Bhaskarawere the first two satellites developed for establishing our competence in space craft technology These 500kg satellite were launched from then USSR Parallaly realisation of communication satelites (iNSAT I Series) was taken up with a US firm Ford Aeros [ace and launched from USA These satellites ushered in new revolution in telecommunication. ISRO took the initiative of integrating three services in the same satellite ie Telephony TV broadcasting and earth observation for Meteorology. Main trunk routes for telephony were connected through INSAT 1





satellites, It relayed TV programs to nearly 1000 terrestrial repeaters for Doordarshan. The Cloud cover movement and cyclone tracking enabled accurate prediction of weather events. Further development in satellites saw the operationisation of of geostationary satellites for national level communication reaching even the emote areas.

Uniqueness of the Indian space programme is that it is able to use the space based platforms for implementing various applications programs which touches the day- to-day life of the common man. The synoptic view of planet earth in high resolution multi spectral images has opened up new avenues for assessing natural resources, and are extensively used for management of natural resources like land water forest fisheries etc. Also these images help in weather prediction, climate change studies and assessment of damages due to floods earthquake and tsunami Some of the application programmes based on Earth Observation sateliеs like IRS, Resourcesat Cartosat Ocean sat ect has become routine operations at National level.

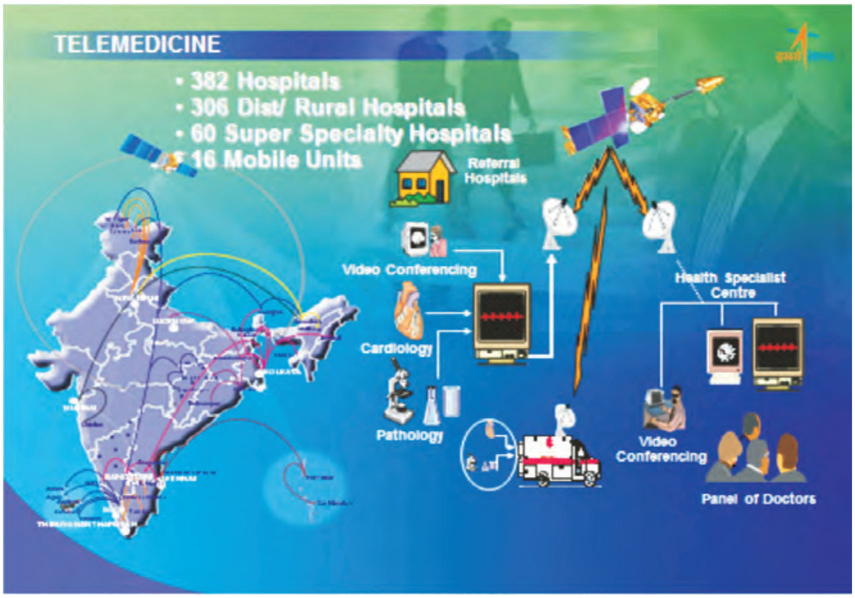
By mapping of cultivated areas and monitoring crop growth helps in providing early warning of pest attack, and drought condition. These warnings help farmers in taking corrective actions and in fertiliser movements and data for crop insurers Based on the inputs like cropping pattern area under cultivation and health of the plants a forecast of potential crop yield is made several weeks in advance This input is very much needed for managing grain procurement and marketing.

India is the only country which embarked on development of space programme in a civilian domain. The visionary scientist Dr. Vikram Sarabhai had not only seen the potential of space technology but also the application of such advanced technology for the benefit of common man. In late sixties he chalked out a vision for space programme in the country which has become the Bible for Indian Space Research organisation.

Forest coverage is an important asset for the nation. Periodic monitoring provides an opportunity to detect damages caused to environment by human intervention or calamities like forest fire. Assessment of quality of water in ponds lakes and dams help in better water management. A pilot project namely the Rajiv Gandhi drinking water mission initiated by ISRO is unique. Using satellite images and ground truth potential zones are identified for water targeting Using this information digging of borewells were taken up in states like Rajasthan and Madhya Pradesh. The results indicate that the number of wells yielding water had gone up to 70per cent compared to 30per cent without such data. Savings on account of non yielding wells per year exceeds thousands of Crores.

Identification of potential fishing Zone is yet another activity helping thousands of Fishermen. By analysing the colour of the ocean, surface temperature and wind conditions from the Oceans at, it is possible to identify areas in the sea where the fish school will assemble Such data is communicated to fishing villages through satellites, With this input fishermen could directly sail to such region directly The yield per catch quite often is more than double and there is considerable saving in time and fuel. Such systems are operationalised in coastal areas of Gujarat Kerala and Andhra Pradesh.

Watershed development is yet another area of remote sensing application. Major part of villages are around small or large water bodies Taking six districts of Karnataka as example with the help of satellite data mapping of the entire region around a water body is carried out. The suitability of the land whether it is for agriculture social fioresty etc. is assessed and advices given to farmers on most optimum use of land along with advices for cropping pattern Rain water harvesting water management avoiding wastages to had helped the villagers to improve the returns from land and water, A review after three years had shown that average income level had doubled by such practices Monitoring of agriculture in areas under irrigation schemes, making alignments for roads, power lines and land utilisation for urban development are some of the areas benefiting from satellite data.



Dr. Vikram Sarabhai the founding father of space program in the country saw the benefit of providing connectivity to every nook and corner this vast country spanning nearly 3.29 million square Km. stretching almost 3000Km along the length and breadth. No other means can provide seamless connectivity to such a large area. In his vision evolved during late 60s building and operationalizing geostationary communication satellites was an important element. Using his contacts with NASA he chalked out a program for bringing an operational satellite over India and conduct socially relevant experiment in two thousand remote villages in Central India. Program called SITE (Satellite Instructional Television Experiment) was intended for beaming socially relevant television programs to remote villages aiming at educating the villages on health hygiene and good agricultural practices. The program lasted for nearly one year and was acclaimed as one of the most successful program for social upliftment by UN.

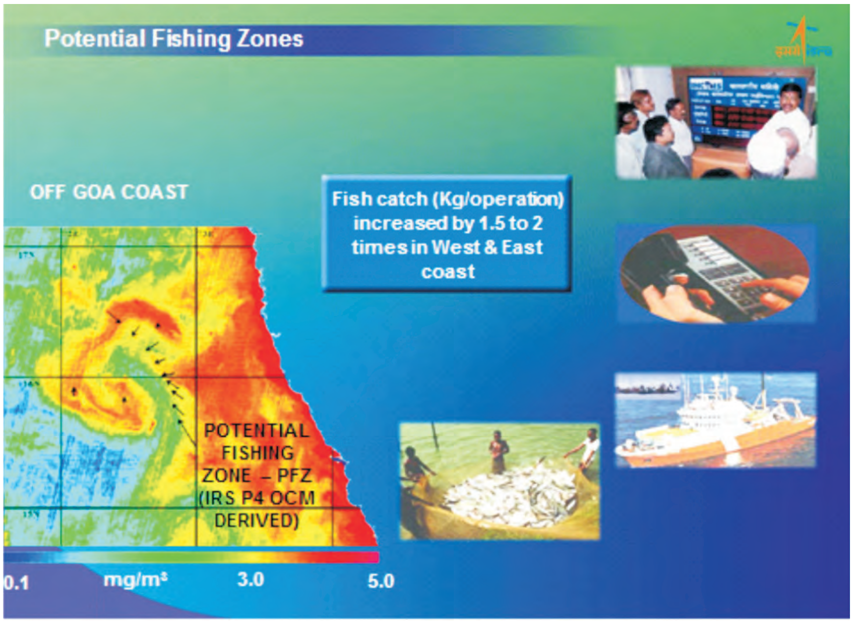
Communication through the geostationary satellites is the most effective one in reaching out to remote and far flung places in India. The direct to home (DTH) television services have revolutionised the entertainment scenario Hundreds of television programmes are relayed through the satellite and can be received using a small roof top dish at any part of the country. Much needed emergency communication to remote and inaccessible places is ensured through the satellites which is a boon to disaster management. The satellite remote connectivity is effectively utilised to take expert classrooms to remote villages through tele-education program.

India is considered as a leader in the area of application of space technology to solve problems on Earth. The societal applications undertaken by India, such as tele-medicine, tele-education and the concept of village resource centre are unique.

Through telemedicine project ISRO had demonstrated how much needed high quality medical service can be taken to the door step of remote villagers The superspeciality hospitals are located in metros and if a villager has to seek the advice of as Pecialist he has to travel hundreds of K meter and spend a few days. Using telemedicine system the patient information is sent to the specialist via the satellite. After studding the data the specialist doctor conducts a tele conference with the patient and provides a prescription or advise for further follow up Such services are provided by major speciality hospitals taking healthcare to the doorsteps of the villagers Today about 382 hospitals in rural and semi-urban areas are connected to about 60 super-specialty hospitals in metros with 16 mobile vans in the tele-medicine network. More than three lakh patients are getting benefited from the tele-medicine facility and are availing medical treatment annually. Such services are being provided by Base hospitals of defense services to the remote field stations.

The SITE experiment provided valuable inputs as to how the satellite could be effectively used for education. There is always the shortage of expert teachers. This can be overcome by telecasting a lecture to hundreds of schools or colleges. The students at the receiving end can be given an opportunity to interact with the teacher through teleconference. Such schemes are used by various states for primary and secondary schools and for teachers training. Further IITs and IIMs are using this for sharing their expert lectures with other sister institutions. Thus remote inaccessible places are enabled to receive benefits of expert teachers, ISRO launched a satellite dedicated exclusively for the purpose of education called EDUSAT in the year 2004. EDUSAT is mainly intended to meet the demand for an interactive satellite based distance education system for the country Today about 60,000 classrooms are connected in the EDUSAT network providing primary, secondary and university education to a large number of students in rural and semi-urban areas.

It is in the area of Disaster management space systems have made a major impact. Incase of floods or earthquakes the earth observation



satellites provide instantaneous assessment of damages and inputs for mitigation measures. In case of cyclones or heavy weather incidents the INSAT satellite based system has become the mainstay. The cloud pictures and movements clearly identify such events and early warning can be issued. The cyclone formation in the bay of Bengal or Arabian see can be detected few days in advance and by tracking the movement of the core the land impact point and time can be predicted well in advance . This information is passed on to the district authorities through the satellite enabled early warning system which helps them to evacuate the region and avoid loss of life. Net result is that loss of life is reduced to very low level compared several thousands before availability of satellite data. When all other means of communication fails the satellite communication is the only way to reach out to flood or cyclone affected regions.

A pilot project of village resource center (VRC) was tried out integrating earth observation and communication capabilities. All local features like land and water resources cadastral map statistics of village household etc are sent via satellite to the VRC computer and the villagers will be able to access the data for better planning. Connected to Agriculture experts and revenue authorities the user can obtain expert advice. and transact business with service providers In addition the Center doubles up as a telemedicine node or a tele education centre. This single window system was proven to be a success in about 475 VRCs on an experimental mode in more than 21 states and union territories.

There is a heavy dependence on the US GPS for the navigation system To overcome the single point dependency ISRO has developed its own navigation system (IRNS) providing accurate position and timing signals over Indian region and its neighborhood. This is a unique system using a constellation of seven satellites in Geo stationary orbit. Defence services will benefit immensely out of this. Defence services also make use of satellite communication and earth observation data for their day to day needs.

INSAT satellites also have transponders to relay distress signals from boats ships or aircrafts when they are in danger helping search and rescue operations. In order to supplement satellite data ground observation from thousands of automated weather stations deployed on land and oceans are are widly used. Real time data on surface temperature wind humidity radiation and soil moisture are collected and relayed through geostationary satellites Communication network through satellites provide uninterrupted services in business community especially the ATMs and stock exchanges.

While ISRO had implemented programs benefiting the day to day life of common man it has not forgotten its commitments to gain knowledge on fundamental questions of how and why of our universe. That is what led us to mission to moon and Mars. Our spacecraft Chandrayan and Mars orbiter had been orbited and provided extremely useful data. Especially confirming presence of water on the moon for the first time and huge deposits of Heluim three which are path breaking findings.

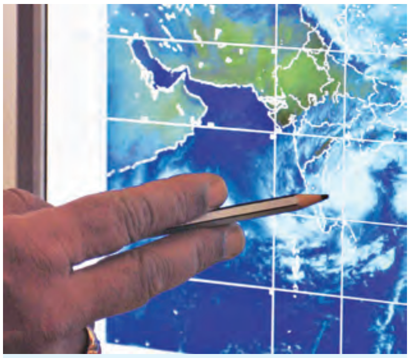
The spin-off from space technologies is seen in many areas. Medical diagnosis, observation, synthesis of complex molecules etc has been enabled through technological breakthroughs in space. In India medical application of composite and special materials for heart valve heart assist pump stent callipers for polio affected patients are few examples.

ISRO had truly lived up to the vision of Dr Sarabhai in mastering the complex technologies of Rockets and spacecraft. It has also made innovative applications touching the lives of people A survey conducted by an independent agency had brought out that the direct and indirect benefits far exceed the investment made by Govt. in Indian space programs. India is world leader in application of space technology for improving the quality of life of common man. ❑

(E-mail: gmnairg@gmail.com)

Earth System Science for Public Safety

M Rajeevan



The Ministry will be also investing on basic research, infrastructure and human resources developing and further strengthening international collaboration. The Ministry is committed to excel in providing weather, climate, ocean, coastal and seismological services and to be a global leader in providing these services

Earth System Science deals with all the five components of the Earth System, viz., Atmosphere, Hydrosphere, Cryosphere, Lithosphere and Biosphere and the complex interactions among the components. The Ministry of Earth Sciences was established in 2006 by bringing all the agencies specializing in weather and climate services (India Meteorological Department, Indian Institute of Tropical Meteorology and National Centre for Medium Range Weather Forecasting) and ocean developmental activities (Department of Ocean Development) under one umbrella. MoES holistically addresses all the aspects relating to the Earth System Processes for providing weather, climate, Ocean, coastal, hydrological and seismological services.

The Vision of the Ministry is to excel as a knowledge and technology enterprise in the Earth System Science for Public Safety and Socio-economic benefits to the Nation. The mission is to provide services for weather, climate, ocean and coastal state, hydrology, seismology, and natural hazards; to explore and exploit marine living and non-living resources in a sustainable way and to explore the three polar-regions (Arctic, Antarctic and Himalayas).

Major Achievements

Over the past decade, the quality of weather, climate, ocean and seismological services provided by the ministry has substantially improved due to systematic efforts to augment atmospheric, coastal and ocean observations and survey, geophysical observations and polar research, develop adequate modelling strategy, conduct cutting edge research and promote investment in human resources development. The services provided by the ministry are being effectively used by different agencies and state governments for saving human lives and minimizing damages due to natural disasters.

The major achievements made by the ministry during the past 10 years in general are illustrated below:

Quality of weather and climate services has improved over the last decade. This was possible due to augmentation of observational network, research efforts in weather and climate modelling and specialized training of scientists. The atmospheric observational network, including Doppler Weather Radar network was augmented to strengthen data assimilation efforts and to improve weather forecasts.

The author is Secretary, Ministry of Earth Sciences, He contributed significantly for developing many application tools and prediction models for societal applications like long-range monsoon prediction models, gridded climate data sets and many other climate application products for regional climate services. He has published more than 100 peer reviewed research papers.

Tsunami Early Warning Centre

Under a new Monsoon Mission, which was launched in 2012, two dynamical prediction systems have been made operational based on the United States of America's National Centers for Environmental Prediction (NCEP)'s Global Forecast System (GFS) and Climate Forecast System (CFS) models and the UK Met office's Unified Model (UM) for short to medium range (upto 10 days), extended range (up to 20 days) and seasonal forecasts. In addition, an ensemble prediction systems based on atmospheric models also have been implemented for generating probabilistic forecasts. In addition, the first version of an Earth System Model (ESM) based on the CFS model with reasonably good fidelity in simulating the present climate and its variability was developed by scientists at the Centre for Climate Change Research, Indian Institute of Tropical Meteorology, Pune. The ESM will be the first climate model from India to contribute to the forthcoming sixth Intergovernmental Panel on Climate Change (IPCC) assessment of climate change process.

One of the important meteorological services being provided by the India Meteorological Department is the Agro-meteorological advisories for farmers. This system has been expanded from State level advisories from 25 state units in 2006 to district level advisories disseminated through 130 Agromet Field Units (AMFUs) in 2009. At present around 2.54 crores farmers are directly benefitted by this service earning a profit of more than Rs.40,000crores.

Noteworthy improvement was made in track and intensity forecast of the tropical cyclones (the 24 hour forecast error in track prediction was reduced from 141 km to 97 km and Landfall error from 99 km to 56 km between 2006 and 2015). Accurate forecasts of the recent cyclones, Phailin and HudhHud saved thousands of human lives. Noticeable improvements also have been achieved in skills for heavy rainfall Forecasts. Regional Climate Services (climate information and monitoring, climate data services and climate prediction) have been set up at IMD Pune and for the first time, seasonal outlook for temperatures for the Hot Weather Season (April-June) was introduced in 2016. Air pollution monitoring and forecasting network was established at Delhi, Mumbai and Pune to monitor air quality and generate air quality forecasts. A state-of-the-art High Altitude Cloud Physics Observatory was established at Mahabaleshwarnear Pune for

MoES Research Vessel Sagar Nidhi deploying ocean buoy

High performance computing system Aditya at IITM Pune

Scientific Activities in Antarctica

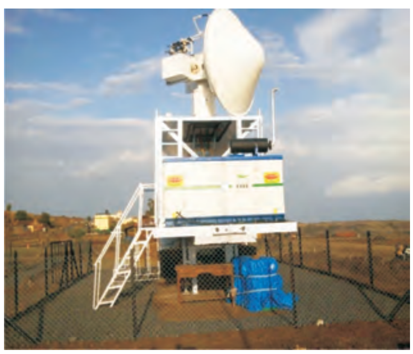
aerosol and cloud observations. Aircraft and surface based multi-year observations were carried out to study the complex interaction between aerosol and clouds and precipitation enhancement process.

Significant progress has been made in establishing a large ocean observing network for the Indian Ocean during the past 10 years. As of now, 51 moored buoys are commissioned for providing continuous met-ocean data in real time since 2010. In addition, 28 Coastal moorings for measurements of coastal currents and 10 High Frequency Radars were also installed. There are now 134 ARGO floats in the Indian Ocean to measure profiles of ocean temperature and salinity. Systematic efforts were also made to develop high resolution ocean regional models with advanced data assimilation methods. Routine forecasts of waves, tides and ocean general circulation parameters are issued to various stakeholders on a daily basis. Advisories on Potential Fisheries Zones (PFZ) based on satellite data on sea surface temperature (SST) and Chlorophyll content in the sea water are produced and disseminated through 558 fishing related centers. At present, an estimated 2.75 lakh users makeuse of the PFZ advisories. A study by the National Centre for Applied Economic Research (NCAER) has shown that the fishermen are benefitting by Rs 3000 crores every year. A state-of-the-art Tsunami early warning system for the Indian Ocean Rim countries was established at the Indian National Centre for Ocean Information Services [INCOIS], an autonomous organization of the Ministry based in Hyderabad. It has been designated as Regional Tsunami Service Provider (RTSP) by IOC/ UNESCO with the responsibility for providing tsunami advisories to Indian Ocean rim countries.

Other achievements include implementation of Storm Surge Prediction system for the Indian coasts and development of high resolution Ocean regional models with advanced ocean data assimilation system for ocean state forecasts. Excellent research work has been carried out on biogeochemistry of the Indian Ocean and Marine living resources.

On developing relevant ocean technologies, significant contribution was made by scientists at the National Institute for Ocean Technology (NIOT), Chennai. Important achievements by the scientists at NIOT are (a) installation of desalination plants in three islands of Lakshadweep and at North Chennai Thermal Power Station using a novel process based on low temperature thermal technology or providing fresh water;(b) An Autonomous coring system (ACS) for ground truth validation of gas hydrate occurrence; and (c) a Remotely Operable Vehicle (ROV) rated for 6000m water depth for survey and exploration. An Open Sea cage culture technique for farming fish in open seas also has been demonstrated off the Andhra Pradesh coast.

Ministry along with other institutions made detailed survey and mapping of an area of about 1.6 million sqkm of Exclusive Economic Zone (EEZ). Another major achievement was the survey and exploration, environmental impact assessment, and technology development for exploration of polymetallic nodules (PMN) in the central Indian Ocean.



New atmospheric observations for improvement of weather forecasts


New Ocean Observations and Ocean Technology

Antarctica, Arctic, Southern Indian Ocean and the Himalayas were further explored for scientific studies. A new research station 'Bharati' - a state-of-the-art facility was commissioned at Larsemann Hills, Antartica in March 2012. Six expeditions were launched and multi-disciplinary data were generated in the Southern Ocean from 2007 to 2016 in collaboration with other national and international institutions. Research studies were carried out on understanding of variability of cryosphere using remote sensed data. An Expedition to the South Pole was carried out in 2010 by a team of multi-institutional scientists for the first time. A research station-Himansh- was established in Himalayas with several monitoring systems to support field survey and laboratory studies in Himalayas.

A National Centre for Seismology (NCS) was established at New Delhi to provide added thrust to seismological research in the country. With 23 upgraded seismic observatories, 21 additional stations, and dedicated networks in North East India and Delhi, NCS now has 84 national observatories with real time data. A major programme on "Scientific deep drilling in the Koynaintra-plate seismic zone" was launched to set up deep borehole observatory to unveil the sources governing seismicity in stable continental region.

Establishment of High Performance Computing System with 1.2 Petaflop speed was completed to meet the modelling requirements of the Ministry. This is now the second fastest computing system in the country. For human resources development, efforts were made to strengthen training activity of operational Meteorology at IMD, setting up a Centre for Advanced Training in Earth System Science and Climate at IITM Pune and setting up of an International Training Centre for Operational Oceanography (ITCOocean) at INCOIS, Hyderabad.

Monitoring Himalayan Glaciers

Vision for 2030

There is a considerable scope for further accelerating the current initiatives to enable the country become a world leader in providing high quality services in the field of earth sciences, and provide for greater economic and societal benefits to the country. MOES also would like to be a leader in providing the services in Earth Sciences to developing countries in Asia and Africa. Accordingly a vision document has been prepared for next 15 years (up to 2030) by critically analyzing the achievements made during the past years, and taking into account the strength and weakness of our on-going scientific programmes, opportunities for future and possible threats.

To further improve accuracy of weather forecasts, observational network has to be augmented more. Ideally, an atmospheric observational network at 25x25km grid and upper air observations at 100x100 km, complimented by Multi-platform satellite and air-craft based profiler observations, Doppler Radars, Wind profilers, Radiometers, Lightning detectors, and LIDARs are required. Since users, especially farmers require weather forecasts at block level, an advanced weather prediction system with high resolution (12 km) global model will be implemented. The present district level advisories for farmers will be extended to block level and will be disseminated through 660 district centers by 2019. With global warming, natural disasters are expected to increase in frequency. Therefore, ministry should have a strategy to predict these natural disasters more accurately with ample lead time for effective disaster management and saving lives of people. This will involve a new modelling and observational strategy for probabilistic forecasts including establishment of

Ensemble Probabilistic Forecasts for Severe Weather events

research testbeds. A separate program for prediction of severe weather and climate events is therefore envisaged. To meet the requirements of climate change assessments, the Centre for Climate Change Research has been developing an advanced Earth System Model for developing regional climate change scenarios. Other future scientific initiatives envisaged are strengthening of climate services, development of research testbeds and process studies, Urban Meteorology, and studies of regional hydrological cycle including development of flood warning systems.

For strengthening the on-going ocean services, the present ocean observing system should be sustained and expanded by including robotic observing systems. It is also planned to develop advanced high resolution ocean modelling system for predicting the variability of the the Indian Ocean. The present ocean services should be extended to cater to the needs of different regions. In view of the importance of coastal processes, a Centre of excellence for coastal research is envisaged. Other projects being planned are to develop beach tourism specific forecast products and ocean Biogeographic information system and census of marine life.

The Ministry is planning to expand its activities on ocean survey and exploration, with a view to support the Blue Economy initiative of the Government of India, This will mainly involve conducting bathymetric, geophysical and geological surveys of Exclusive Economic Zone, as well as continental shelf and high seas for exploration of mineral and energy resources. Exploration of deep sea non-living resources including poly-metallic nodules, poly-metallicsulphides and cobalt enriched crust is also an important agenda of our future activities. We are developing tailor-made technologies to support the initiatives of Blue Economy. This involves innovating, developing and demonstrating world class technologies for exploration and harnessing ocean resources- Energy, Water and Minerals, and developing and deploying technologies for exploring and sustainable utilization of marine resources including off-shore cage cultures. It is also planned to develop a Centre of Excellence for Deep Sea Research to pursue research on deep sea exploration.

Another major mandate of the ministry is to explore the polar regions of Antarctica, the Arctic and the Himalayas for monitoring and predicting variability of the fragile global cryosphere system. The ministry envisages to further strengthen scientific activities including observations at these three poles. This will involve procurement of a polar research vessel and replacement of Maitri research station. Ministry will also beconducting research on understanding the crustal structure, deformation, and rupture, mountain dynamics, critical zone studies, paleo magnetism, and earthquake precursors over high risk zones of the country, and conducting scientific experiments by deep drilling to understand geological phenomena related to interior of earth and promote borehole geophysical research.

Ministry has been providing excellent services in multi-hazard early warnings for disaster risk management. It is now planning to strengthen the services by developing a decision support system for (a) Tropical cyclones and associated damages over the Indian seas;(b) Severe weather (heavy rainfall, urban floods, Fog, Air pollution emergencies, Heat and Cold waves); and (c) location specific nowcasts of thunderstorms, lightning, wind storms and flashfloods. In addition, Ministry will develop a state-of-the-art Hydrological Information System and Flood Warning Support for all the major river basins of the country. The present Tsunami and Storm Surge Early warning decision support system will be further augmented and strengthened. Other major projects Ministry will be initiating is (a) develop a Coastal Mission for an integrated coastal multi-hazard warning and dissemination system for addressing multi-hazards and related services, and (b) develop a DSS for Earthquakes by augmenting the seismological network optimally over the country and neighborhood so that Earthquakes of magnitude 2.5 and above are detected with improved accuracy of location and dissemination of the Earthquake details within 5 minutes of occurrence.

The ministry will be also investing on basic research, infrastructure and human resources developing and further strengthening international collaboration. The ministry is committed to excel in providing weather, climate, ocean, coastal and seismological services and to be a global leader in providing these services. ❑

(E-mail: secretary@moes.gov.in)

Atoms in the Service of the Nation

K N Vyas & M Ramanamurthi

Nuclear power generation has demonstrated excellent performance in almost all aspects viz. operational and safety records, capacity utilisation, carbon footprint and quantity of waste generation. Issues pertaining to proliferation and waste storage are currently well within the realm of being managed and with the advent of new generation of reactors, these concerns are going to be further minimised

For the full industrialization of the developing countries, for the continuation of our civilization and its further development, atomic energy is not merely an aid, it is an absolute necessity. The acquisition by man of the knowledge of how to release and use atomic energy must be recognised as the third epoch of human history. ***Homi Jehangir Bhabha***

Science and Technology (S&T) capabilities are fundamental for social and economic progress of a nation.

The great era of scientific discoveries in the early part of the 20^{th} century was born out of a thirst for advancement of human knowledge towards furthering the frontiers in the understanding of nature. This innate urge of man to explore, understand and perhaps conquer the forces of nature gave rise to many paths of discovery in science in a multitude of disciplines. Understanding the nature of matter to the minutest detail was one such curiosity which led to the discovery of atomic structure. That atom consists of a nucleus at the core surrounded by electrons revolving in fixed closed orbits was the work of Rutherford and Bohr. Natural radioactivity and spontaneous disintegration of atoms had already been reported by Becquerel and Rutherford respectively. But with the discovery of neutron in 1932 by Chadwick, the branch of science known as nuclear science definitively took on a momentum of its own.

Einstein had propounded the equivalency of energy and mass and had conjectured that the large amount of energy stored in matter would be eventually harnessed. Artificial radioactivity caused by bombardment of stable nuclei with alpha particles had already been reported by the Curies in 1934. The discovery of nuclear fission accompanied by the liberation of a large amount of energy in 1938 by Otto Hahn and Fritz Strassman in 1938, the prediction of the nuclear chain reaction for creation of a self-sustaining fission process by Leo Szilard, successful demonstration of a self-sustaining nuclear chain reaction by Enrico Fermi and the ultimate construction and the use of a nuclear weapon in 1945 changed the world forever. A new epoch had begun in the history of mankind, characterized by its ability to annihilate itself many times over with these diabolical weapons.

Shri K.N. Vyas is Director, Bhabha Atomic Research Centre, Mumbai. He has worked for design & analysis of nuclear reactor fuels, has been responsible for design & development of a novel fuel for strategic applications and worked extensively in thermal hydraulics and stress analysis of critical reactor core components. Shri Vyas has been conferred several awards, which include Indian Nuclear Society Outstanding Service Award 2011, Homi Bhabha Science and Technology Award 2006, DAE Awards.

Dr. M. Ramanamurthi is currently the Heading the OCES (Orientation Course for Engineering Graduates and Science Post Graduates) Programme Implementation Section of the BARC Training School.. e has been invited to several national and international conferences to speak on the subject of human resource development in the field of nuclear science and technology.

Dr. Homi Bhabha presiding over the first conference on Peaceful Uses of Atomic Energy at Geneva, 1955

An epoch marked by the discovery of a force of nature revealed to man by the pioneering efforts of a dedicated band of Nobel Prize winning scientists, all of whom had nothing more to seek than the unravelling of the mysteries of nature.

Atoms for Peace- A Utopian Landscape

But out of every situation arises a new hope, a new solution. The two world wars in the 20th century had devastated the world with the loss of tens of millions of humans in a barbaric and cruel display of man's inhumanity to man. The horrendous effects of the two nuclear bombs dropped on Japan in 1945 were an eye opener and shocked mankind as no other weapon of mass destruction had ever done before.

Out of these troubled times did emerge hope for the dawn of an era of exploitation of the power of atom for peaceful purposes. 'Atoms for Peace' was an initiative of the US President, Mr. Dwight D. Eisenhower, launched in the 470th Plenary in the United Nations General Assembly in 1953, with none other than Smt. Vijayalakshami Pandit of India being the President of the assembly. The speech was a tipping point for international focus on peaceful uses of atomic energy, promising the use of radioactivity for various peaceful purposes, especially in energy generation for harnessing the power of the atom- 'To find the way by which the miraculous inventiveness of man shall not be dedicated to his death, but consecrated to his life'. The International Atomic Energy Agency (IAEA) was thereafter founded by the UN charter and announced in Geneva in 1955, in a conference chaired by Dr Homi Bhabha, the father of the Indian Atomic Energy Programme. The objectives of IAEA were indeed laudable, aiming to exploit the peaceful uses of atoms for the benefit of all mankind and to prevent nuclear weapons proliferation.

The journey of the Indian Atomic Energy programme began in 1954 with the founding of the Atomic Energy Commission under the leadership of the legendary Dr Homi Jehangir Bhabha- Scientist, Administrator and a visionary par excellence. Much has been achieved in the sphere of the exploitation of the power of the atom for various purposes. We shall dwell on some of these applications in the following pages, to provide a glimpse of the breadth of our programmes aimed at ensuring food security, energy security and national security and in various other medical, social and industrial applications. This would be by no means a complete compendium of all that is possible and achieved in this sphere. Nevertheless, it would certainly serve to underline our motto of the nuclear energy programme of the country- the use of nuclear and radiation technology for providing better quality of life to its citizens.

Radiation- A Double Edged Sword

Radioactivity, the emission of radiation from the atom had been discovered much before the advent of the nuclear fission era, and the controlled applications of these radiations for cancer therapy had already begun in some parts of the world. Well might it be said that the world first came to learn of applications of radiation and radioactivity as a therapeutic and palliative for cancer cure in the early part of the 20th century. In the subsequent decades, nuclear fission made possible the harnessing of nuclear energy for electricity production. However, the peaceful uses of the atom have developed several other large scale applications in agriculture, medicine and industrial sectors. All these applications depend upon the generation of artificial radioisotopes which have uses due to the radioactivity emanating from them. These artificial radioisotopes are created in reactors or particle accelerators by bombardment of stable isotopes leading to a nuclear reaction and subsequent transmutation to form the radioactive isotopes. More than 200 radioisotopes are used on a regular basis for various applications as delineated in the following paragraphs.

Health – Care to Cure

Application of radioisotopes in healthcare has grown into one of the most important peaceful uses of atomic energy. In the present context, a total number of over 6,00,000 patient investigations (including immunoassays), as per statistical data, are carried out annually in India. This relates to a span of over 500 centres across the country that are benefitting from using radio pharmaceuticals. Regarding radiation therapy, there are more than 270 radionuclidic therapy units which are currently operating in 62 cities in India. BARC is working in close co-operation with other constituents of DAE to widen the scope of this technique for the benefit of the common man, with an aim to bring the benefits of these techniques to everyone.

Nuclear Medicine – Diagnosis

Nuclear medicine is a medical specialty that uses trace amounts of radioactive substances (called radio pharmaceuticals) in the diagnosis and treatment of a wide range of diseases and conditions in a safe and painless way. R*adio pharmaceuticals* can be administered by injection, inhalation, or orally and *selectively localized a*nd retained at *sites* of *diseases* and thus allow an image to be obtained of the loci using gamma scintigraphy or to deliver cytotoxic dose of radiation to specific disease sites without adversely affecting the surrounding normal tissues. Nuclear medicine procedures help in identification of abnormalities in organ function even in very early stages of a disease. Nuclear medicine has proven its worth in the diagnosis of diseases such as cancer, neurological disorders (like Alzheimer's and Parkinson's diseases), and cardiovascular disease in their initial stages, permitting earlier initiation of treatment as well as reduced morbidity and mortality.

The most common isotopes for imaging are ^{99m}Tc, ^{123}I, ^{201}Tl, ^{111}In and ^{18}F. Technetium-99m is the most widely used radioisotope in diagnostic nuclear medicine, and it is estimated that over 80 per cent of the nearly 25 million diagnostic nuclear medicine studies carried out annually are done with this single isotope.

The Medical Cyclotron with Positron Emission Tomography (PET) scanning facility set up at Radiation Medicine Centre (RMC) of BARC, routinely produce ^{18}F-labelled FDG molecules for diagnosis of cancer as well as cardiac disorders. During the year 2015, about 133 consignments of PET radiopharmaceuticals such as ^{18}F-FDG, ^{18}F-FLT, ^{18}F-NaF and ^{18}F-FMISO were supplied to various hospitals in and around Mumbai accounting for nearly 240 Ci of ^{18}F radioactivity.

Targeted Radionuclide Therapy

Therapeutic radiopharmaceuticals consisting of a target-specific moiety with a beta-emitting radionuclide designed to deliver therapeutic doses of ionizing radiation to specific diseases sites is one of the rapidly growing fields of nuclear medicine. A number of therapeutic radiopharmaceuticals based on radionuclides such as ^{131}I, ^{177}Lu, ^{32}P, ^{153}Sm and ^{188}Re developed by BARC have been supplied to different nuclear medicine centres. ^{177}Lu-DOTA-TATE is used for the treatment of neuroendocrine cancers, while ^{153}Sm-EDTMP and ^{177}Lu-EDTMP are used for bone pain palliation. At the Thyroid Clinic of RMC, entire gamut of thyroid problems including the complete work up of thyroid cancer is being attended to and treated using ^{131}I. More than 40,000 patients have been provided with the therapeutic treatment using radiopharmaceuticals developed at BARC, in year 2015.

Nuclear medicine procedures help in identification of abnormalities in organ function even in very early stages of a disease. Nuclear medicine has proven its worth in the diagnosis of diseases such as cancer, neurological disorders (like Alzheimer's and Parkinson's diseases), and cardiovascular disease in their initial stages, permitting earlier initiation of treatment as well as reduced morbidity and mortality.

Radiation Therapy

Radiation therapy is a treatment involving the use of high-energy radiation either by using special machines or from radioactive substances. The radiation may be delivered using a machine outside the body, known as external-beam radiation therapy or teletherapy, or alternatively it may come from radioactive material placed in the body near cancer cells, known as internal radiation therapy or brachytherapy. The aim of radiation therapy is to impart specific amounts of the radiation at tumours or parts of the body to destroy the malignant cells.

External Beam Radiotherapy

External beam radiotherapy usually involves using a machine either a ^{60}Co-teletherapy unit or a linear accelerator, which focuses high-energy radiation beams onto the area requiring treatment. External beam radiotherapy can be used to treat Breast Cancer, Bowel Cancer, Head and Neck Cancer and Lung Cancer. A teletherapy machine christened Bhabhatron has been designed by BARC. Bhabhatrons are installed at about 50 cancer hospitals in the country. Compared to any imported telecobalt machines, the indigenous machine is cheaper and superior in features. BARC developed "Imagin" simulator is used for localization of treatment areas and for verification of treatment plans prior to starting treatment.

Brachytherapy

Internal radionuclide therapy is the treatment of disease by placing sealed radioactive sources, at or near the target area on a temporary or permanent basis. Brachytherapy makes it possible to treat a cancer with a larger dose of radiation than can be given with external beam radiation therapy.

In some of the cases, the implants are kept in the body for a specific amount of time ranging from a few minutes to a few days. Iridium-192 is the isotope of choice for temporary implants. For permanent implants, radioactive seeds or implants are placed into the tumour or treatment site, where they remain permanently. The radiation dose emitted from such radiation source reduces over weeks or months to almost zero. Finally, the seeds remain inactive with no lasting impact in the treatment site. Permanent

Civilian Application of Nuclear Energy

brachytherapy is mainly used for the treatment of prostate cancer.

Tiny titanium encapsulated Iodine-125 seeds, developed by BARC have provided a new avenue for the treatment of eye cancers. Presently 3 hospitals are using 'BARC I-125 Ocu-Prosta seeds'. Over 120 patients have been treated so far. "BARC I-125 Ocu-Prosta seeds" are also clinically deployed in a hospital as permanent seed implants for the treatment of prostate cancers. Mould brachytherapy using beta-emitting radionuclides is a viable option to treat superficial skin cancers close to the vital organs. BARC has developed a method for the preparation of ^{32}P sources. After successful preclinical evaluation, ^{32}P sources have been clinically deployed in AIIMS, New Delhi.

Food Security -Supplementing the Food Basket

India has witnessed impressive economic growth in recent years, but the growing population of our country places huge demands on our agricultural resources. The problem is further accentuated by the fact that the agriculture's share in the country's economy is declining, raising the concern of food security. The situation calls for technology-driven sustainable management of natural resources for achieving food, nutritional, environmental and livelihood security to ensure all-inclusive growth in the country. Use of ionizing radiation-based technologies provides safe, hygienic and economically viable solutions to address the issues of agricultural productivity.

Nuclear Agriculture

For the past several decades, ionizing radiation is being employed by BARC to induce mutations in plant breeding, and 42 varieties of different crops have been released to Indian farmers for commercial cultivation in the country. These include new kinds of groundnut, mungbean, blackgram, pigeon pea, soybean, cowpea, mustard, sunflower, and rice, which are endowed with one or more improved and desirable attributes such as higher yield, earliness, large seedsize, along with resistance to biotic and abiotic stresses. Mutation in rice and wheat is also being carried out to improve yield and disease resistance. Besides, micropropagation protocols involving rapid multiplication of stock plant material to produce a large number of progeny plants have been developed for furnishing improved varieties of banana, sugarcane, grape, pineapple, potato, turmeric and ginger.

Food Preservation-Produce and Preserve

Pest infestation is another impediment in food security and safety, as this causes substantial losses of agricultural productivity globally including India. One of the major tragedies of Indian agricultural system is that almost 30 percent of the food produced is lost due to spoilage because of pest attack, contamination and moulds infestation. These are encountered both during harvesting as well as post-harvest handling and storage of the edible and cash crops. Prevention of post-harvest losses can plug the widening gap between food production and demand. Conservation of agricultural produce has, therefore, assumed paramount importance if we have to leverage the increasing yields and feed the growing population to boost Indian economy. The most popular pest control methods, such as use of synthetic pesticides and other protocols are fraught with several problems such as potential health hazards, disturbance of ecology and also development of resistance in the pests against the synthetic pesticides. Radiation processing can provide a viable, effective, and eco-friendly alternative to chemical fumigants and microbial decontamination, as the latter affect human health and environment adversely. There is an utmost need to adopt and integrate the irradiated foods into the country's supply chains and promote the widespread use of this technology to ensure food safety and security. This technique involves exposure of food and agricultural commodities to controlled doses of radiant energy to achieve desirable effects such as disinfestation of insect pests in stored products; disinfestation of quarantine pests to overcome international trade barriers; delay in ripening and senescence in fruits and vegetables; inhibition of sprouting in tubers, bulbs and rhizomes; destruction of microbes responsible for food spoilage; and elimination of parasites and pathogens of public health importance in food. This is the only method of killing bacterial pathogens in raw and frozen food. It can be applied to pre-packaged commodities even under frozen conditions.

It may also be highlighted that radiation brings its effects through direct deposition of energy, and in no way, it makes the product radioactive. Radiation processing of food has been approved by various International and National organizations viz. International Atomic Energy Agency (IAEA), Food and Agricultural Organization (FAO), World Health Organization (WHO), World Trade Organization (WTO), Codex Alimentarius Commission, United States Department of Agriculture (USDA), Food Standards Australia New Zealand (FSANZ), and Food Safety and Standards Authority of India (FSSAI) to ensure 'Food Security & Safety', and overcome 'Technical barrier to International Trade'. Recently, harmonization of food irradiation rules with international regulations has taken place in India through class-wise clearance of irradiated food items by the FSSAI. Irradiation of more than 60 kinds of food, ranging from spices, grains, grain products, fruits, vegetables and meat are being carried out globally. To this end, BARC has developed irradiation technologies for preservation of fruits (litchi, mango, cherries) and vegetables (potato, onion), sea foods, spices (turmeric, chilli) and many of these technologies are available in commercial domain. Fifteen food irradiation facilities are currently operational in India. One of these facilities at Nasik is being regularly used for irradiation of mangoes, onions and potatoes for preservation and increasing their shelf-life and promoting international trade. The volume of irradiated food in India has been steadily increasing. A total of nearly 34,000 tons of produce has been irradiated by the Radiation Processing Plant, Vashi, Navi Mumbai till 2015. Irradiated mango is being exported to the USA since 2007. The knowledge of irradiation technology is also being disseminated to various agricultural universities and institutions.

In summary, it is important to note that the green revolution has undoubtedly increased the availability of food stock manifold over the decades, but challenges of demands in the coming decades warrant further improvement and refinement in these techniques for improved crop yield and quality. The irradiation-based strategies have the potential to bring about a paradigm shift in the agriculture sector and propel our nation towards prosperity.

Energy Security- Nuclear is Clean and Green

Global Warming- A Perilous Precipice

All indicators of climate change and global warming over the last few years point to the unavoidable conclusion that planet Earth is today teetering on the brink of a perilous precipice, caused by global warming and the attendant climate changes taking place on the globe. Carbon Dioxide levels in the atmosphere have reached an unprecedented 400 ppm and the temperature rise of more than 1°C has taken place mostly over the last three decades. This rise has affected the climate significantly and consequences such as increasing sea levels, severe and frequent heat waves, unpredictable rains and storms, etc. are already upon us. The predominant cause of these is the nature of human activity, accelerated at a tremendous pace over the last few decades, inclusive of the increasing loading of the atmosphere with carbon dioxide due to the use of fossil fuels-wood, coal, natural gas and oil.

Nuclear Energy Goals-The Way Ahead

Over time, it is becoming increasingly evident that nuclear energy provides a solution to the vexing but real problem of global warming, being endowed with the lowest carbon footprint amongst all energy producing sources-including the renewable sources such as solar, hydro and wind power.

Being a rapidly growing economy with international obligations to curtail carbon emissions, India today needs to rapidly ramp up power production using nuclear energy. With 21 operating plants and 12 plants in the pipeline, we are poised a period of enhanced growth in this sector. The atomic energy sector is projected to make a significant contribution to energy security and climate mitigation over the next few decades.

Being a rapidly growing economy with international obligations to curtail carbon emissions, India today needs to rapidly ramp up power production using nuclear energy. With 21 operating plants and 12 plants in the pipeline, we are poised a period of enhanced growth in this sector. The atomic energy sector is projected to make a significant contribution to energy security and climate mitigation over the next few decades.

Societal Applications- Towards the Common Good

Sludge Hygenisation- From Waste to Wealth

Large amount of sewage sludge is generated in India on a daily basis. The sludge is laden with infectious microorganisms and improper disposal of the sludge can result in the spread of diseases thereby becoming a public health hazard. At the same time, it also has essential micro and macro nutrients, especially organic carbon, useful for soil and crop production. Radiation Technology has been used to hygienise the sludge to protect public health and environment and in addition, manufacture the manure with desirable qualities for use in the farming sector. Ahmedabad Municipal Corporation (AMC) has taken the lead to set up the first plant in India to treat 100 tons/day sludge and produce manure using a fully automatic process. Irradiation facilities such as these can be set up to treat whole city sludge at a single central location using a fully automatic process. The technology has high potential in contributing towards meeting the objectives of the Swachh Bharat Mission.

Hydrogel- Healing the Wounded

Hydrogel, a thin transparent sheet of gel is an excellent medical tool particularly useful as burn and injury dressings. It is prepared by cross linking molecules of hydrophilic polymers like PVA either chemically or by Gamma/ Electron Beam irradiation. A 3D network of gel like structure is formed which holds large quantities of water. Gamma irradiation achieves gel formation and sterilization in one step.

Hydrogel provides moist environment and a cooling effect on the wound due to a regulated oxygen supply to the wound through a sterile cover. It adheres firmly yet gently to the healthy surface but does not adhere to wet wound surface resulting in painless dressing. Being transparent, the progress of the wound healing can be easily observed. Raw Materials required for manufacture are low cost and locally available. The process was developed by BARC scientists and technology has been transferred for commercial production. It's an import substitute product and now available at a low cost in the Indian market.

Water- The Elixir of Life

Water is becoming a scarce commodity largely due to the increasing demands on this resource from domestic, agricultural and industrial sectors. Isotope hydrology techniques enable accurate tracing and measurement of the extent of new and renewable underground water resources at various locations. It also provides information about the origin, age and distribution of groundwater, as well as the interconnections between ground and surface water and aquifer recharge systems. The technique is also used for monitoring surface water resources for leakages through dams and irrigation channels, the dynamics of lakes and reservoirs, flow rates, river discharges and sedimentation rates etc. The data obtained is used towards resource planning and sustainable management of these water sources.

Our scientists have developed low cost and user friendly kits for measurement of contaminants in water. These kits are being used for the detection of contaminants like fluorine in groundwater and chromium in water of river Ganga. Technologists of BARC have also developed a membrane for filtration for the removal of bacterial contamination and for desalination of brackish water as well as sea water. All these technologies for water purification have been transferred to Indian industries and serve a large section of the society providing low cost solutions.

Industrial Applications – Support to the Manufacturing Sector

A host of applications are in use and serving the industrial and manufacturing sector as aids and tools towards implementation of good manufacturing practices. Following is a briefly listed overview of a few such important applications.

Radiation Sterlisation of Medical Products

Products such as syringes, cotton wool, burn dressings, surgical gloves, heart valves, bandages, plastic and rubber sheets and surgical instruments, powders, ointments and solutions and biological preparations such as bone, nerve, skin, etc, used in tissue grafts.

Radiography

Radioisotopes which emit gamma rays are more portable than x-ray machines, and may give higher-energy radiation, which can be used to check welds of new gas and oil pipeline systems, with the radioactive source being placed inside the pipe and the film outside the welds. Other forms of radiography (neutron radiography/ autoradiography), based on different principles, can be used to gauge the thickness and density of materials or locate components that are not visible by other means.

A Glimpse into the Future

It has been our objective to communicate to the readers the breadth of applications of nuclear technology straddling almost all walks of life, leading to economic and societal benefits to the nation. These are the benefits which shall continue to be leveraged for a considerable period in the foreseeable future, as they are almost irreplaceable in the type and range of applications. Nuclear power generation is, of course one of the important segments, currently contributing significantly to the energy basket worldwide. Scepticism on this front has been unfortunately dogging the industry, leading to closure of this extremely carbon friendly energy source and a shift to renewable power sources – solar, hydro, wind and geothermal. Unfortunately, not only are their carbon footprints higher than that of nuclear energy, their somewhat unpredictable nature and low efficiencies may be unable to meet the base load requirements in many countries aggressively pushing ahead with these renewable sources. This is leading to the increase in the use of natural gas, with an even higher carbon footprint, despite the issue of global warming and climate change looming large upon the horizon. In such a scenario, it is imperative that the world should take a dispassionate view and avoid reducing the role of nuclear energy in the energy basket. Nuclear power generation has demonstrated excellent performance in almost all aspects viz. operational and safety records, capacity utilisation, carbon footprint and quantity of waste generation. Issues pertaining to proliferation and waste storage are currently well within the realm of being managed and with the advent of new generation of reactors, these concerns are going to be further minimised.

Readings

1. Making of the Atomic Bomb, Richard Rhodes, Simon & Schuster, 1986.
2. The case of optimism on climate change, Al Gore, TED Talk, 2016.
3. Averting the climate crisis, Al Gore, TED Talk, 2006.
4. Biology & Medicine: Excitement of Research and Deployment of its Outcome–The Twain Do Meet in BARC, Krishna B. Sainis, BARC Newsletter, Page vii, Sept-Oct 2013.
5. Industrial Applications of Radioisotopes, IANCAS Bulletin, Vol 16, June 2001.
6. Isotopes Application in Agriculture, IANCAS Bulletin, Vol VI, No. 4, November 2007.
7. Radiation Technology for Sewage Sludge Hygienisation, Lalit Varshney, BARC Newsletter, Page 41, No-Dec 2012.
8. The Liberation of the Environment, Jesse H. Ausubel, Internet Resource
9. Agriculture and Food Security, SIRD, BARC Publication, 2013.
10. The many uses of Nuclear Technology, World Nuclear Association Website, Updated March 2014
11. How fear of nuclear power is hurting the environment, Micahel Shellenberger, TED Talk, September 2016.
12. Peaceful Uses of Nuclear Energy: Meeting Societal Needs, Dr. Mohamed El Baradei, IAEA, 15th Annual Conference of the Indian Nuclear Society (INSAC-2004), Mumbai, India. ❑

(E-mail: director@barc.gov.in
mmurthi@barc.gov.in)

Agricultural Technologies: Social Contributions

Sant Kumar and Suresh Pal

....agricultural science in India has not only made significant economic and social contributions in the past, it was reorienting the programs to sustain these benefits in future also

Millions of people derive their livelihood security from agriculture in India, and it directly provides employment to nearly 52 per cent of total workforce. However, agriculture contributes only 14 per cent to India's gross domestic product (GDP). Despite falling share of agriculture in the national GDP, this sector remains important as it ensures food security for over one billion population of the country and provides raw materials to agro-based industries. Agricultural growth has also direct and decisive impact on reduction of rural poverty in the country.

The concerted efforts of farmers, scientists, and policy makers have made Indian agriculture a pride. Agricultural production has considerably increased during past 50 years (1965-2015) after the introduction of new agricultural technology in the mid-sixties. During 2014-15, India produced 252 million tonnes of foodgrains, 26 Mt of oilseeds, 17Mt of pulses, 257 Mt of fruits and vegetables, and 146 Mt of milk. The role of the National Agricultural Research System (NARS) has been pivotal to this immense growth in agricultural production. But now, Indian agriculture faces new challenges of sustainability in terms of sustaining factor productivity, increasing profitability, and building resilience to climate change, besides attaining significant increase in the production of pulses and oilseeds for self-sufficiency.

Sustaining growth in total factor productivity requires efforts to maintain flow of technology to farmers. The production loss in perishable products indicates weak linkages (both forward and backward), and emerging climate change points towards the proper management of resources like land and water to meet the food-security goals. Addressing these problems and emerging challenges and providing durable solutions is a technology and policy challenge. This is also essential to sustain benefits of agricultural technology in terms of economic and social welfare.

Research System and Intensity of Investment

Agricultural research system in India is being managed under a three tier system, viz. (i) Indian Council of Agricultural Research (ICAR) at apex level, (ii) State Agricultural Universities at state level, and (iii) private sector at

Suresh Pal is presently Director at ICAR-National Institute of Agricultural Economics and Policy Research (NIAP), New Delhi. He also holds charge of Member (Official), Commission for Agricultural Costs and Prices, Govt. of India. He has made significant contributions to research and teaching in the area of agricultural development and policy.

Sant Kumar is currently Principal Scientist at the ICAR-National Institute of Agricultural Economics and Policy Research, New Delhi. He has made contributions in agricultural economics and policy research on important theme of impact of agricultural R&D, and research priority in agriculture. He has published 30 research papers in national journals, in addition to book chapters, and policy papers.

both at sector and commodity level. Apart from these, there are some institutions in central Departments of Agriculture, Council of Scientific and Industrial Research (CSIR), Ministry of Science and Technology, Ministry of Commerce and Industry, etc. ICAR has a network of more than one hundred institutes spread across the country. These institutes are organized on commodity or resources pattern and few have multi-commodity and resource structure. SAUs are expanding presently more than seventy in number. One of the major institutional links between ICAR institutes and SAUs is the All-India Coordinated Research Project (AICRP). These coordinated projects working on the principle of inter-are disciplinary and inter- institutional collaborations. The first AICRP on maize was started in 1957, and the ICAR had 79 AICRPs during 2015-16, involving several disciplines and commodities, viz. soils, water, crops, horticulture, livestock, fisheries, agricultural engineering, home science, education, etc. The AICRPs on crops have defined operational area based on ecological conditions. This set up enables AICRPs to effectively utilize natural resources and man and material to solve problems at various levels in a coordinated manner according to predetermined priorities and strategies.

Research Investment

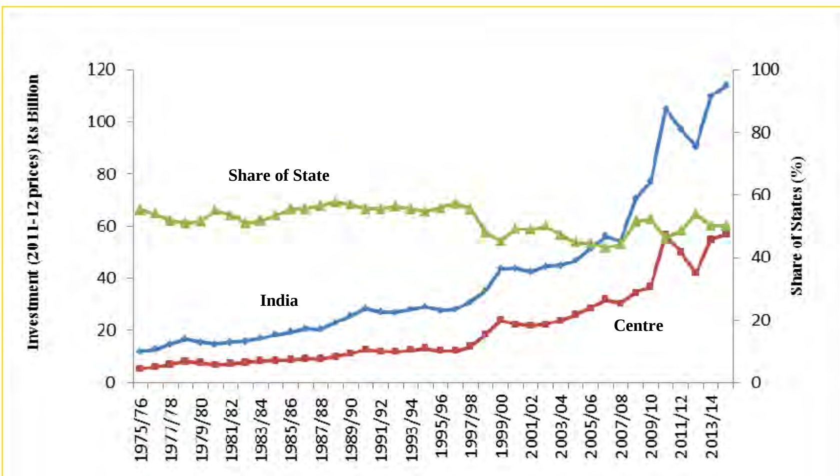
In India, agricultural research system is mainly under the public domain and the government has played a major role in developing agricultural R&D system. The Government has consistently provided funds for research in all fields of science including agriculture. The total government expenditure for agricultural research and education (R&E) increased in real terms (2011-12 prices) from Rs 11.9 billion in 1975/76 to Rs 113.8 billion in 2014-15 –-a ten-fold increase in past forty years (Figure 1). There is an increasing trend in spending on agricultural R&E by both Centre and States. Analysis has shown that the share of states in total R&E has fallen from 58 per cent in 1988-89 to 43 per cent in 2006-07, and in 2014-15 the share is about 50 per cent. However, a large proportion of central funds are transferred to SAUs through development grants and other activities like frontline extension. Local R&D institutions have failed to emerge as major players and supporters of agricultural R&D in India. The central sector has always been pressing for obtaining incremental resources. State systems either do not bother or lack of capacity in arguing their case for additional funding. This issue of under funding needs immediate attention of policy makers.

Another way to look at level of public spending for agricultural R&E is to compute research investment intensity which is the ratio of research expenditure to agricultural gross domestic product (AgGDP). This ratio was 0.57 during the TE 2008-09, against the level of 0.40 during 1990s. This level of research investment intensity is comparable with 0.6 percent overall average for the developing world (Beintema and Stads, 2010). However, the agricultural R&D intensity is generally recommended as 1.0 percent for developing countries. Thus, there is a clear case of under investment in agricultural R&E in India. However, with the size of agricultural research system and actual expenditure along with emerging complex challenges and opportunities, reasonable increase in public spending will be in offing.

Contributions of Agricultural R&D

Agricultural research and development (R&D) has potential to offer long-term solutions to the problems of agriculture sector. The scientific progress in agriculture have helped in development of new technologies having added potential and provided options to derive the same or even higher benefits at lower cost per unit of output. These contributions have been most impressive in India and the historical rate of returns to the public investment has been in excess of 50 percent. Most of these benefits have accrued through improvement in crop and animal productivity. Developments in pre-and post-harvest management technologies have facilitated reduction in losses and helped in increasing the availability and value addition (Alam *et al*., 2002). Reduction of production losses and adding value to the produce is a direct contribution towards increasing total availability, lowering cost of production, and contributing to the national economy. Although the technology alone is not capable to provide complete

Figure 1: Public expenditure on agricultural research and education in India



solution for managing the problems of agriculture, but it is capable of offering better durable solutions. Hence, the role of agricultural research and development (R&D) is critical in managing problems and challenges facing agriculture, particularly in India.

In order to illustrate the contributions of agricultural R&D, the case of varietal development in rice is discussed here. This is because rice is a major crop of India and most of technological developments evolve around plant varieties. Moreover crop variety is one of the usable technologies and better indicator to assess the contributions of R&D. Rice crop is studied as this is one of the major crops covering large cultivated area, and receiving greater attention of the research system facing numerous constraints. The data presented in Table 1 show upward trend in number of varieties developed by the Indian rice breeders. During the 1970s, 127 varieties were released, which reached to 223 in the 1980s--almost doubling the breeding productivity. The number of released varieties increased 257 in 1990s, and further rose to 301 during 2001-2012.

Besides increase in the number of varieties bred, rice breeding programme also witnessed some qualitative changes over time. The share of varieties with fine quality (long slender) grain increased from 29 per cent in 1970s to 36 per cent in 1990s, and the share has however declined to 28 per cent during 2001-2012 but with notable contribution in terms of basmati varieties like Pusa 1121 and Pusa 1509, there is a significant increase in number of varieties developed for marginal production environments, as well as those tolerant to biotic stresses. These varietal developments contributed to marked reduction in yield variability even in rainfed areas of eastern India. Hybrid rice varieties have also been bred and have evinced yield advantage of 15-20 per cent. Thus, maintaining high and stable yields with fine grain quality is a major gift of rice breeding programme. The focus has also been on breeding short to medium duration varieties, which constituted about half of the total varieties released during 1980s and 1990s, have reached close to 80 per cent during 2001-2012, owing to high variability in monsoon rainfall, increased cost of irrigation water, and awareness to take one more catch or cash crop to earn extra profit from per unit of land.

Similar developments of breeding programmes have also been observed in other crops, for example, maize, and wheat. In maize, besides increase in yield, efforts have been made to develop high protein maize hybrids to meet the rising demand for feed and fodder. In case of wheat, during more than 100 years period, a total number of 381 varieties were developed

Table 3: Trends in Rice Variety Development

Rice Variety Features	1971-1980	1981-1990	1991-2000	2001-2012
Total number of varieties developed	127	223	257	301
Percentage of varieties with fine grain quality [a]	29.1	34.9	36.5	28.1
Percentage of varieties tolerant to diseases	50.4	67.2	51.0	52.3
Percentage of varieties tolerant to insect-pests	10.2	25.1	20.2	33.1
Percentage of varieties developed for marginal areas [b]	41.7	50.6	46.0	33.5
Percentage of short to medium duration varieties [c]	74.8	53.8	52.5	79.2

Note: data from Pal *et al.* (2005) and http://drdpat.bih.nic.in/ Downloads/ Rice-Varieties-1996-2012.pdf

[a] Long slender grain type, [b] Rainfed upland and low land, deep water, saline and alkaline ecosystems

[c] 50 per cent flowering in less than 100 days

Table 2: Contribution of Agricultural Research to major crops in India

Particulars	Paddy	Wheat	Gram	R&M	Cotton
Share of TFP in output growth (per cent)	24.5	58.9	26.1	10.1	31.6
Share of research in TFP growth (per cent)	55.7	40.1	42.2	88.6	83.6
Research contribution in production growth (percentage points)	0.32	0.83	0.07	0.40	0.82
Production in 2005-06 (Mt)	133.47	71.27	5.8	7.72	19.19
Research contribution in production (lakh tonne)	4.23	5.90	0.039	0.31	1.58
Price: 2005-06 (Rs/q)	570	1080	1435	1715	3570
Research contribution to selected crops (in crore Rs)	241.0	636.8	5.6	53.2	562.4

Source: Chand *et al.* (2011)

(1905-2010). Of these, 136 varieties are having rust resistance traits. Besides, more than 215 varieties of wheat have been developed keeping quality traits like grain nutrition, glutenin content, and pasta quality. In recent years, bio-fortified wheat varieties rich in micro-nutrients have been released and will benefit to large poor masses to live healthy life.

Besides, research in horticultural crops making available disease-free planting materials by tissue culture and other modern technology and contributing to rapid adoption of thus improved varieties and higher crop yields. The resource conservation technologies are reducing water use by 5 to 30 per cent in the rice-wheat system. The development of livestock technologies have increased milk and meat yields and reduced mortality rates in animals.

Economic benefits

Adoption of improved technology on farmers' field leads to higher crop yields which in turn lead to higher production. The analysis has shown added production of 4.23 lakh tonnes of paddy, and 5.90 lakh tonnes of wheat (Table 2) was achieved due to adoption of improved technology alone during 1975-2005. In value terms, this additional production is estimated to be 241 crores and 636.8 crores, respectively. The additional output not only increased total crop production, but this helped in ensuring food security of over one billion of population of India, and achieving cent-percent self-sufficiency in crops like rice, maize, wheat. However, self-sufficiency for oilseeds and pulses is still lagging behind and need more efforts and urgent attention.

Reduced cost of production

The concept of total factor productivity (TFP) in economics literature is commonly used to signify role of research. The estimates of TFP refer increase in output due to technological and knowledge-based factors other than physical inputs used in production process. Figures in Table 2 show that research and knowledge inputs have contributed to increased output growth in majority of crops during 1975-2005. Wheat crop has been most benefited followed by cotton, gram and paddy. Data further reveal that research and technology led growth has helped decline in real cost of production (at 2005-06 prices) in the range of 1.0-2.3 per cent per annum in the case of cereals, gram, cotton and rapeseed and mustard. This has helped in keeping the prices of cereals low for consumers and benefiting the producers also through a decline in real cost of production. Thus, the estimated actual economic benefits from research far exceed the investment and therefore justify higher investments by the Government.

Table 3. Estimated marginal product and internal rate of return to research investment in India

Crop	Marginal product value, Rs	Internal rate of return, per cent
Rice	2.02	29
Wheat	4.03	38
Maize	1.85	28
Jowar	4.28	39
Bajra	2.29	31
Gram	2.84	34
Pigeon pea	12.82	57
Groundnut	0.71	18
Rapeseed & mustard	0.89	20
Cotton	4.15	39

Source: Chand *et al.* (2011)

Returns to Research Investment

Research investment in agricultural research has been a 'win-win' option as it is the largest contributor to total factor productivity (TFP) in agriculture, which in turn reduces rural poverty significantly (Chand *et al.*, 2011, Fan *et al.*, 1999). Analysis revealed that additional investment of rupee one in research generated more than Re one on an average in all the crops, except groundnut and rapeseed & mustard during the period 1975-2005 (Table 3). Highest marginal value product of research investment was obtained in pigeon pea where additional investment of one rupee generated additional output worth Rs 12.82. For most of other crops, the additional benefits range from two to four rupees with increase of investment by one rupee.

Another way to look at the potentiality of investment is the internal rate of return (IRR) which provides the idea of potential profitability and quick recovery of investment. Data in Table 3 revealed that the overall IRR to public investment in agriculture turned out to be 29 per cent for rice, 38 per cent for wheat, 28 per cent for maize, 57 per cent for pigeon pea, and 39 per cent for cotton during the period 1975-2005. These returns have been consistent with those estimated by other studies for a shorter period after the green revolution. The results suggest that further investments on research in agriculture will generate significant returns and lead to development of agriculture in the country.

Sustaining the Research Benefits

Indian agriculture has stood the test of time, despite facing constraints on resources to the competing goals and programmes. This was possible through development and dissemination of technology. The economic benefits realised in the past are comparable to country and other benefits in terms of reduction in rural poverty and promoting environmental sustainability. Efforts are also made to make the system more responsive and effective in meeting specified goals and objectives. This entails scrutiny of limited resources on regular basis and their allocation to potential areas/activities to yield better results. Prioritization, monitoring and evaluation (PME) is a useful tool to take stock of research activities/processes in the regime of declining funding for agricultural research and the need for stronger accountability. This new management tool was applied in the system for better targetting of research, and rational allocation of available research resources. This was considered more important in the situation of large system and complexity of research objectives. Now PME is regular feature in the research system to better understand the research complexities and establish the links between agricultural technology, rural livelihoods and national development priorities. Biophysical and social scientists and research managers work together to build the system more responsive within existing conditions. Another major thrust has been on research partnership between various institutions, which often involves working with private agencies and farmers. Such partnerships help optimize resource use, develop synergies and pursue a demand-driven technology agenda. In areas of mutual interest, public institutes work with private companies for commercialization of technology and benefits are shared in the framework developed for management of intellectual property rights. Thus, agricultural science in India has not only made significant economic and social contributions in the past, it was reorienting the programs to sustain these benefits in future also. This however will need allocating more resources for research and also fostering linkages between other stakeholders and development agencies to accelerate dissemination of technology.

References

Alam, A., K. Gopakumar G. Kalloo (2002) *Report of the ICAR Sub-group on Post-harvest management under the aegis of ICAR*. Indian Council of Agricultural Research, New Delhi.

Beintema, N. and G. J. Stads (2010) *Public agricultural R&D investments and capacities in developing countries: Recent evidence for 2000 and beyond*. Background Note for the Global Conference on Agricultural Research for Development, Montpellier, France, March 28–31.

Chand, R. P. Kumar and S. Kumar (2011) *Total factor productivity and contribution of research investment to agricultural growth in India*, Policy Paper 25, National Centre for Agricultural Economics and Policy Research, New Delhi.

Fan, S., P. Hazell and S. Thorat (1999) Linkage between government spending, growth and poverty in rural India. *Research Report 110*, IFPRI, Washington, D.C.

Ghosh, S. P. (1991) *Agro-climatic Zone-specific Research: Indian Perspective under NARP.* Indian Council of Agricultural Research, New Delhi.

ICAR (2016) *ICAR/DARE Annual Report 2015-16*. Indian Council of Agricultural Research, New Delhi.

Jha, D. and S. Kumar (2006) *Research Resource Allocation in Indian Agriculture*. Policy Paper 23, National Centre for Agricultural Economics and Policy Research, New Delhi.

Pal, S., P. Mathur and A.K. Jha (2005) Impact of agricultural research in India: Is it decelerating? *Policy Brief 22*, National Centre for Agricultural Economics and Policy Research, New Delhi. ❑

(E-mail: director.niap@icar.gov.in sant.kumar@icar.gov.in)

Enriching the Classroom Process

Rajaram S Sharma

Science and technology can serve the classroom, the teacher and the student with its content, influence the methods of teaching and learning, provide the means to infuse into and enrich classroom processes and provide a canvas to explore science and technology. The wide variety of science and technology applications available all around us can provide unlimited possibilities for interaction and exploration

Science and Technology, not so long ago could be distinguished from various pursuits of life as a distinct activity. We celebrated people who dedicated themselves to the pursuit of science. The fruits of this pursuit was also immediately visible and its value to the improvement of the quality of life recognised.

Several distinguished thinkers have examined the practice of science as a distinct activity and gleaned many a feature, comparing it with other pursuits of knowledge creation and appreciation. This characterisation of the pursuit of science has shown it to be superior to other forms of exploration and the validity of its findings shown to be more reliable. This also has led to educators attempting an abstraction of the processes followed in science and its codification as the scientific method.

Runaway developments in science and technology over the recent few decades however, have turned the rather simplistic notions of a scientific method, into a fuzzier landscape. While on the one hand, there is hardly a pursuit of humankind which remains uninfluenced by the products of science and technology, on the other, the variety of applications, techniques, processes and methods adopted by the 'scientist' has made them difficult to codify. Similar principles guide the pursuit of science across different disciplines and applications, but there may no more be one clearly definable way in which scientists can be said to practise their trade.

These two developments have great implications for teaching and learning. In the not so distant a past, it became fashionable, and perhaps rightly so, to treat science as a distinct subject and to treat it as a compulsory part of the curriculum in schools. It must be noted that schooling is not treated merely as a preparation for the world of work. Hence, the teaching of science was not to develop scientists, engineers and technicians. What then justified this status granted to science as a subject of study.

As noted earlier, the products of science and technology have become so omnipresent and influential in our lives that living without a minimum understanding of science and technology has become almost impossible. How would you conceive of a person unaware of electricity or even human physiology, for instance, to be able to negotiate life. A typical person would come in contact with hundreds, if not thousands of

The author heads the Central Institute of Educational Technology of the NCERT. He leads initiatives in exploring appropriate applications of ICT in education, including radio, television, audio, video, web and interactive multimedia applications. In a career in education, spanning over three decades, he has been an educator, trainer and researcher, and helping school systems explore appropriate ICT to reach out and bridge divides.

Science Education: Opening up newer possibilities

products and processes of science and technology in a typical day – beginning from the humble toothbrush and paste to the newspaper, to the daily commute to the food, to entertainment to the mattress he or she would retire onto, not to mention the omnipresent mobile devices, which every finger itches to reach out to. At the same time, it would neither be possible, nor desirable to conceive of school teaching and learning as a means to make children aware of all the products of science and technology.

Development of rational thinking, abilities to deal with information, problem solving and a host of other abilities are integral parts of the practice of science and hence the teaching of science. Further, children equipped with these abilities would be better able to negotiate life itself, even if they did not end up as scientists or technologists in adult life. Hence the teaching of science can be construed as a significant investment in preparing citizens for the modern world.

Science and Technology has had the uncanny ability, sooner or later, to show up its darker sides. One can argue, as is popularly done, that the inherent badness does not lie in science and technology itself. But the fact remains, that science and technology holds the potential to cause, sometimes irreversible, damage and destruction. It provides an ever so convenient handle to the wicked and the greedy to lead humankind to rue the consequences or at times suffer it.

While science and technology has become an integral part of the definition of development itself, given its negative sides, it makes us circumspect and diffident to jump to embrace it. Environmental degradation, pharmaceutical backtracks, weapons of mass destruction, extinction of other living beings, shortages of food and water appear to be directly emerging from untempered pursuits of science and technology. The very models of development pursued with great belief and vigour have soon shown up to be headed in the opposite way. Is a tempered approach possible? Will it be a solution? Can science and technology itself be assigned that responsibility?

Modern day products of technology have added a few entirely newer dimensions to the possibilities in the classroom. Emerging out of the pursuits of information and communication technologies, they hold the potential to extend the classroom beyond its walls, in fact doing away with the walls.

It is our fond hope that it is not only desirable, but possible.

We have tried to glean out a few distinct purposes we expect the teaching and learning of science and technology to serve:

- One, to bring in to the classroom the wonders it has unravelled. The wonders of nature and the way they were prised out never cease to amaze, provoke the curious and prompt many more questions to probe. Passing on this inheritance to the young minds is surely an investment in the continuance of the pursuit of science. In the amazement, perhaps lies the possibility of respecting the earth and its bounty, including humankind and exploiting it only that much, leaving behind as much of its pristine glory as possible.
- Two, a training in the tools of the trade, be it measurement, working with instruments, designing experiments and solving problems. This practise equips the mind to manage, troubleshoot or simply use the products of science and technology.
- Three, a training in the method of science is also a training in a world view – a belief in cause and effect that can be systematically pursued and found; a healthy doubting of the findings leading to further investigations, fine tuning and in effect placing knowledge on ever firmer grounds; a willingness to accommodate newer facts and to modify or even abandon existing views. While being an adequate testimony of its reliability, it also contributes to the shedding of ignorance and superstition delivering the weak and disempowered out of their miseries.

Taken together, they constitute a compelling set of reasons for adapting science and technology as an integral part of the schooling process. Modern day products of technology have added a few entirely newer dimensions to the possibilities in the classroom. Emerging out of the pursuits of information and communication technologies, they hold the potential to extend the classroom beyond its walls, in fact doing away with the walls.

Access to information was, not so long ago, confined to the printed text. Libraries of books have nurtured many a generation. The process however was intensive, time consuming and added an element of chance to the discovery of existing facts and figures; in effect delaying many a discovery. The rapid growth of science and technology owes a lot to universal, on the tap, access to information.

The world wide web today hosts not only the world of the printed text, but also data, visualisations, and glimpses into the phenomena themselves through video and other media representations. The possibilities of rapid communication have helped establish exchange of information, sharing of equipment and resources, pooling of capabilities and in essence a spirit of working together. For the classroom this opens out doors.

Much is written about the various media and multimedia devices that can be used in the classroom and what one can do with them. Teaching has been claimed to be revolutionised by adding colour to the otherwise monochrome blackboard. Research has, however, not justfied this claim. Rather than improving student learning, it appears to have contributed regressively. Reducing the teaching learning process to a show and tell, it has eroded the agency of the teacher as someone who could have guided students towards learning. It has encouraged facts of science to masquerade as science, coming in the way of students engaging with the richer practice of science. Information and communication technologies can go much beyond such trivial applications. They can fundamentally transform classrooms, realising the dream of schooling – developing faculties and abilities of students.

How can science and technology transform the class and how should the classroom transform itself to benefit from these possibilities?

No more need the teacher be restricted by the knowledge her textbook encapsulates. Her ability to represent the information in graphical ways, supporting it with media rich representations will make her communication richer. Not only the teacher of science, but also the teacher of social science or languages or even the arts can benefit immensely from a computer connected to the web and a projection device readily available to her in the classroom. But this presupposes that the teacher and her students actively engage with the information. Searching, selecting, reflecting and in other ways making this newer information ones own is required.

Embracing science and technology provides newer possibilities to the classroom. Opening up the classroom to the wonders of nature, the products and processes of science and technology, bringing in the wide world outside into the classroom can create opportunities for a much richer fare of information.

Add to this the possibilities of interactivity and students can be involved in the exploration of 'what if' of knowledge. Imagine a graph displayed and each question asked about it answered by actually tweaking or even dropping a variable. A wide variety of data-rich applications across different subjects are available and can be infused into learning. Interactive simulations, online maps and globes, data and its representations, interactive dictionaries and thesauruses, can be creatively used to enhance student capabilities and interest. Particularly in science and mathematics, the possibility of plugging in measuring devices into the computer, providing real data inputs, can create exciting possibilities. Doing science is within the reach of every classroom.

This, of course, is in addition to what could have been possible through conventional equipment and resources – laboratories. The possibilities of information and communication technologies can extend the lab, provide access where none existed and provide it in a form which is more readily accessible and manipulable by the student.

Ready access to data and information opens out newer avenues to the enterprising teacher. Exploring light, for instance, need not be constrained by the syllabus anymore. Short of observing rainbows on Planet Venus, it is only the teacher's imagination, desire and ability to hunt down the resource that restricts the possibilities. If information exists or can be constructed from present day knowledge, it can be deployed in the classroom.

A typical classroom believes in the same pieces of information being transmitted to all students. It also believes in a transmission from the teacher to the student. Dismantling these two constructs can open up still newer possibilities. Engaging students, singly or in groups to explore different aspects of a topic or even different topics can expand time and space in the classroom. What was essentially a limitation of the print medium, restricting how much could be written into a textbook need not anymore restrict what and how much can be learnt in the classroom.

Yet another artefact of schooling is the age-wise stratification of students. Larger schools even create multiple sections within the same age group. This denies students the opportunity to seek out role models and learn from them, cooperate with each other and in essence learn to live together. Project activities, which break away from these artificial confines can catalyse and accelerate learning enormously. The infusion of technology makes this enormously possible.

Teachers become limited by their own fund of information and access to resources. Connecting to other teachers, and even experts in the field helps overcome this deficit. Connecting to laboratories and students performing experiments with equipment and processes not available in a classroom also becomes eminently possible.

Embracing science and technology provides newer possibilities to the classroom. Opening up the classroom to the wonders of nature, the products and processes of science and technology, bringing in the wide world outside into the classroom can create opportunities for a much richer fare of information. An enterprising teacher can literally create magic in her class. This holds the potential to conserve curiosity, add to it the power of questioning and dogged pursuits of problems, appreciate the travails of fellow citizens and attempt innovative solutions, and in general enable students to participate as young scientists and technologists, bringing in their fresh perspectives unhindered by the diffidence of older minds.

Science and technology can serve the classroom, the teacher and the student with its content, influence the methods of teaching and learning, provide the means to infuse into and enrich classroom processes and provide a canvas to explore science and technology. The wide variety of science and technology applications available all around us can provide unlimited possibilities for interaction and exploration.

The student supported by this window to the world, perhaps will be motivated to learn deeper. They would be able to choose from a much wider set of careers and pursuits. They would be better equipped to handle the problems more rigourously, more surely. The teaching of science and technology can hold the key to developing a citizen, better adapted to live a life immersed in science and technology. ❑

(E-mail:rajaramsharma@gmail.com)

YOJANA WEB- EXCLUSIVES

Yojana publishes articles on various topics in its 'Web-Exclusives' column for the benefit of its readers on the website of Yojana : www.yojana.gov.in. Announcements about the articles under the Web-Exclusives section are carried in the Yojana magazine of the month.

We are carrying the following article under the Web-Exclusives section of Yojana for December 2016.

- Scientific Policies and Sustainable Development
  P. Srivatsa

Please send in your comments and suggestions to us on ***yojanace@gmail.com***

Technology for the Medical Table

Hariharan
Archana Sood

Advancements in medical technology have allowed physicians to better diagnose and treat their patients since the beginning of the professional practice of medicine. Thanks to the continuous development of technology in the medical field, countless lives have been saved and the overall quality of life continues to improve over time

Science is the systematic way of acquiring knowledge through observation and experimentation, whereas technology is the practical application of science. Science and technology has brought a revolution in Healthcare and provided breakthroughs in information gathering, research, treatments, and communications. It has given medical providers new tools to work with and fresh ways to practice medicine. Scientific research has already helped to improve treatment for numerous diseases and serious health conditions. Research enables healthcare professionals to gain all the necessary information to make well informed decisions with regards to which methods of treatment to use to improve the efficacy with minimum morbidity.

Technology is used to design products that improve the quality of human life. Modern technology has changed the structure and organization of the entire medical field. As technology improves every day, new developments are constantly infiltrating our lives. Whether it's the way you shop, how you communicate with friends, the job you do, or the way you travel, technology is transforming the way we behave. The term can either be applied generally or to specific areas: examples include "medical technology", or "state-of-the-art technology.". Without doubt, medical technology is indispensable to people's health and improved quality of life. *Technology is constantly evolving and is particularly important in the healthcare sector enabling physicians to provide the optimum care thus allowing best possible recovery.* Technological breakthroughs are revolutionizing the way healthcare is being delivered. It also contributes in a great way to the economy. There are many benefits that innovative technology brings to the table when it comes to healthcare.

The use of science and technology for the improvement of the health of mankind is not a recent development. There are evidences that cavemen used flints to amputate limbs. Medical science was fairly advanced and the diagnosis and treatment of various diseases were carried out in India from time immemorial. Many surgical concepts and instruments are described

Dr. Hariharan has been working as a medical professional for the past 35 years and also contributed to field of public health as a consultant. His experiences include directing the Sehyog, a project on Juvenile de-addiction, and coordinating the "Drinking and Driving Intervention Project" in partnership with Delhi Legal Service Authority. He was also the Chief Executive, Indian Alcohol Policy Alliance- a global partner of Global Alcohol Policy Alliance (GAPA), U.K. and affiliated with FORUT Norway.
Dr. Archana Sood, MBBS DNB is working as Head of Deptt. Biochemistry, ESIC Dental College and Hospital, Rohini, Delhi and has an experience of more than 20 years of teaching as well as managing clinical Laboratories. She is also Technical assessor appointed by NABL, Ministry of Science and Technology responsible for accrediting various clinical Laboratories all over the country as per international standards.

in the ancient surgical text, Susruta Samhita, believed to have been written 3000 years ago by the ayurvedic scholar, Susruta (Park 2005). The development of the concepts of hygiene, antisepsis, anesthesia and vaccines, and the invention of microscopes and x-rays transformed the practices of medicine in the 19th century and paved the way for a greater impact of science and technology on the medical field. Further, discoveries of causative agents, establishment of the germ theory and modes of transmission of diseases, and development of vaccines, antitoxins and disinfectants also provided a firm foundation for preventive medicine in the later half of the 19th century. The post-war years of the 20th century is said to be one of the best periods in the history of medicine with advances in surgical techniques, significant innovations in drug manufacturing and development of new ideas about the nature of diseases. Over the years, the scope of medicine has broadened to include prevention of disease, promotion of health and improvement in the quality of life of the people, in addition to the traditional goal of treatment of sickness. Further, various studies in the early 1980s have shown that health outcomes are related not only to advances in medicine but also to improvement in diet, housing, water supply, sanitation and environment. Medical advances combined with social strategies have helped contain major health problems across the world.

Medical technology is a broad field where innovation plays a crucial role in healthcare.. Areas like biotechnology, pharmaceuticals, information technology, the development of medical devices and equipment, and more have all made significant contributions to improving the health of people all around the world. From "small" innovations like adhesive bandages and ankle braces, to larger, more complex technologies like CT, MRI machines, Cardiac stents, prosthetic limbs, artificial organs, and robotic technology has undoubtedly made an incredible impact on medicine.

The healthcare industry due to these development of brilliant innovations, has resulted in healthcare practitioners inquisitiveness to find ways to improve their practice – from better diagnosis, surgical procedures, and improved patient care.

I T and Medicine

Information technology has made significant contributions in the medical industry. With the increased use of electronic medical records (EMR), tele-health services, and mobile technologies like tablets and smart phones. Physicians and patients are both seeing the Medical technology to connecting patients and doctors thousands of miles away through telecommunications. It is not uncommon in today's world for patients to hold video conferences with physicians to save time and money normally spent on traveling to another geographic location or send health information instantaneously to any specialist or doctor in the world.

With more and more hospitals and doctors using mobile devices on the job, it has been quite easy within seconds to access to any type of information – from drug information, research and studies, patient history or records and the ability to effortlessly carry these mobile device with them throughout the day. Applications that aid in identifying potential health threats and examining digital information like x-rays and CT scans also contribute to the benefits that information technology brings to medicine.

The risks and benefits of technology in healthcare, with particular focus on electronic health records (EHRs), the availability of health information online, and how technology affects relationships within the healthcare setting. the benefits of technology in health care outweigh the risks; however, it is necessary that proper measures are taken to ensure accuracy, validity, confidentiality, and privacy of health data and health information are successfully implemented. **Telemedicine** is the use of telecommunication and information technology to provide clinical health care from a distance. It helps eliminate distance barriers and can improve access to medical services that would often not be consistently available in distant rural communities. It is also used to save lives in critical care and emergency situations.

Although there were distant precursors to telemedicine, it is essentially a product of 20th century telecommunication and information technologies. These technologies permit communications between patient and medical staff with both convenience and fidelity, as well as the transmission of medical, imaging and health informatics data from one site to another.

Early forms of telemedicine achieved with telephone and radio have been supplemented with videotelephony, advanced diagnostic methods supported by distributed client/server applications, and additionally with telemedical devices to support in-home care.

Medical Equipment Technology

Improving quality of life is one of the main benefits of integrating new innovations into medicine. Medical technologies like minimally-invasive surgeries, better monitoring systems, and more comfortable scanning equipment are allowing patients to spend less time in recovery and more time enjoying a healthy life.

Technology and Medical Research

Medical scientists and physicians are constantly conducting research and testing new procedures to help prevent, diagnose, and cure diseases as well as developing new drugs and medicines that can lessen symptoms or treat ailments.

Through the use of technology in medical research, scientists have been able to examine diseases on a cellular level and produce antibodies against them. These vaccines against life-threatening diseases like small pox, polio, MMR, and more has eradicated, prevent the spread of disease and save thousands of lives all around the globe. In fact, the World Health Organization estimates that vaccines save about 3 million lives per year, and prevent millions of others from contracting deadly viruses and diseases.

Medical Technology and The Law

As technology in the world of healthcare continues to evolve, rules and regulations concerning its use must be established and adjusted to adapt to the new methods of administering care.

The biggest impacts technology has had on healthcare are

The Internet

Using the Internet for research and upgrading the knowledge of newer innovations and technologies by the medical professionals regarding medical issues and also by patients about their diseases means not only looking up symptoms, but exploring treatments and medicines on the web. While it is never a good idea to skip out on the doctor completely, the Internet has made patients more empowered to make decisions about what to do next.

Healthcare facilities and social media

It is easy to see how public clinics, doctor clinic, and even research facilities can take advantage of social media tools to reach wider populations. And there is evidence that they are going above and beyond.

Healthcare facilities, particularly hospitals, are using social media to establish contact with patients, answer questions about practices, launch public awareness campaigns, and perform community outreach. Some sophisticated sites even offer instant chats with nurses and doctors about medical issues and reminders for people to get regularly needed tests and vaccines.

Less suffering and quality treatment

Let's not forget the most obvious way technology has changed healthcare by providing new machines, medicines, and treatments that save lives and improve the chance of recovery for billions. Not only do sophisticated medical practices help patients heal directly; new technology has also improved research so experts can make healthcare even more effective.

Better patient care and efficiency

IT has made patient care safer and more reliable than before. Nurses and doctors use hand-held computers to record a patient's medical history and check that they are administering the correct treatment. Results of lab tests, records of vital signs, and medicine orders are all electronically put into a main database that can be referred to later. And as more institutions are adopting electronic health records, patients have easier access to their own information so they too can understand what is being done to them.

These electronic databases are also consolidating large amounts of information that are used for medical research. With vast patient history, scientists can better study trends and causes of ailments. This means more breakthroughs to come.

Faster outreach Doctors and specialists.

With the touch of a smartphone doctors can access thousands of pages of medical textbooks. They can also use online medical databases to easily look up case studies and check out detailed patient history. Technology has also enabled doctors to use e-mail, texts, videos, and conference facilities to consult colleagues from all over the world. This practice, known as telemedicine, is especially useful for doctors and patients in rural and under-developed areas. Without moving patients, doctors can consult experts from all over the world to diagnose, treat, and research conditions without needing access to a sophisticated hospital. Telemedicine was used effectively today to access healthcare in the remotest area in our country.

Online databases which accurately predict medical trends

By analyzing health information that users search for online, search engines such as Google have been able to accurately predict medical trends such as flu outbreaks.:

"Of course, not every person who searches for "flu" is actually sick, but a pattern emerges when all the flu-related search queries are added together. We compared our query counts with traditional flu surveillance systems and found that many search queries tend to be popular exactly when flu season is happening. By counting how often we see these search queries, we can estimate how much flu is circulating in different countries and regions around the world."

This breakthrough will help medical experts respond to outbreaks quickly as well as take preventative measures. And as more and more people use the web to search for their own medical problems, these internet giants will have even more information to apply to scientific studies.

Technological innovations in the healthcare industry continue to provide physicians with new ways to improve the quality of care delivered to their patients and improve the state of global healthcare. Through technology's integration with areas like disease prevention, surgical procedures, better access to information, and medical telecommunications, the medical industry and patients around the world continue to benefit.

Advancements in medical technology have allowed physicians to better diagnose and treat their patients since the beginning of the professional practice of medicine. Thanks to the continuous development of technology in the medical field, countless lives have been saved and the overall quality of life continues to improve over time. ❑

*(E-mail:hariharandr56@gmail.com
archanasood65@yahoo.com)*

PERSONALIZED MEDICINE

PRECISION MEDICINE

High-end Diagnostics for Healthcare

Ira Bhatnagar

We are moving in a new era of scientific advancements in healthcare through precision medicine/ personalized medicine. Medical devices that are minimally invasive, accurate, durable, user-friendly and low cost can now be utilized to improve diagnostics, prevention and therapeutic monitoring. As a result of these technological advances, medical diagnostics and therapeutics can be more finely tuned to better meet the needs of individual patients

Major advancements in science and technology have allowed healthcare decisions to become increasingly granular over time. We still have a long way to go in understanding why different individuals experience disease or respond to treatment differently. Thus the clinicians are left with no choice but to follow a less than optimal approach towards prescribing drugs and other treatment options. Such an approach may sometimes lead to patient dissatisfaction, adverse drug responses and drug interactions and poor adherence to treatment regimens.

"Personalized medicine" may be thought of as the tailoring of medical treatment to the individual characteristics, needs and preferences of a patient during all stages of care, including prevention, diagnosis, treatment and follow-up. The goal of personalized medicine is to streamline clinical decision making by distinguishing in advance those patients who are most likely to benefit from a given treatment from those who will incur cost and suffer side effects without gaining benefit.

Genetic diagnostics:

Personal genomics is the branch of genomics concerned with the sequencing and analysis of the genome of an individual. The genotyping stage employs different techniques, including single-nucleotide polymorphism (SNP) analysis chips (typically 0.02 per cent of the genome), or partial or full genome sequencing. Once the genotypes are known, the individual's genotype can be compared with the published literature to determine likelihood of trait expression and disease risk.

It plays a major role in determining disease risk for common diseases, genetic predisposition towards a disease (relative risk or odds ratio) as well as genetic versus environmental contributions to disease (penetrance) and thus may help you to determine how to alter your environment and behavior to avoid the disease. On the other hand, it also aids in delineating familial traits, diseases and relationships, thus helping to understand the fate of known family diseases (breast cancers, colorectal cancer, lysosome storage diseases, etc.). Pharmacogenomics and Pharmacogenetics determine drug susceptibility which is an important aspect for the efficacy and adverse effects of common drugs.

Microfluidic systems:

Despite the fact that ample of diagnostic tests exist, need still

The author is senior scientist at the Center for Cellular and Molecular Biology (CCMB), Hyderabad for more than a decade. A microbiologist by degree, she has experience ranging from cellular and molecular techniques, handling viruses while working in BSL-3 lab, nanotherapy and fabricating nano drug delivery vehicles. Her research revolves around targeted drug delivery and scaffold fabrication towards bone tissue engineering.

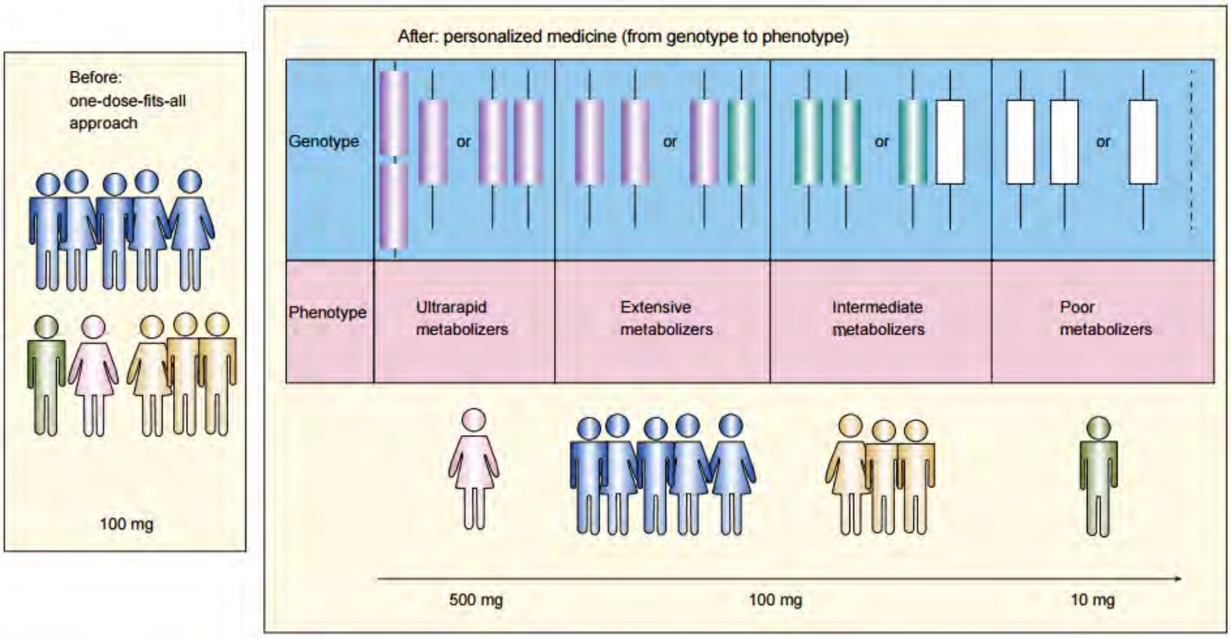


Fig. 1.Representation of the trial-and-error or one-dose-fits-all approach versus personalized medicine. The left panel shows a situation in which everyone gets the same dose of a drug, regardless of genotype. The right panel shows a personalized medicine approach in which the dose of the drug is selected based upon genotypical, and therefore phenotypical, variability of the metabolizing enzyme. (Adopted from Xie, H., Frueh, F.W., (2005). Pharmacogenomics steps toward personalized medicine. Personalized Medicine, 2(4), 333.)

remains for a more user-friendly, sensitive, prompt and specific system to enable diagnosis at patient's convenience. Point-of-care (POC) testing may be one such approach with potential to effect a paradigm shift from curative to predictive, personalized and preemptive medicine. POC testing promotes a transference away from traditional diagnostic tests in the clinical laboratory setting to near-patient settings that enables the physicians with timely diagnostic information which in turn aids in instant medical attention regarding diagnosis and treatment. POC diagnostics includes glucose monitoring, blood chemistry and electrolyte analysis, pregnancy and fertility testing, drug and alcohol load, cardiac markers, cholesterol, hemoglobin/hemostasis, urine chemistry and tumor marker apart from HIV testing, drugs of abuse and molecular diagnostics for infections.

Microfluidics is recently being considered an enabling technology for POC diagnostic devices. Recent developments in microfluidics technology have enabled applications related to lab-on-a-chip or micro total analysis systems. The major advantage of microfluidics lies in the fact that it allows for the manipulation of small volumes of liquids in microfabricated channels and, in some cases, the ability to perform all analytical steps, including sample pretreatment, reaction, separation and detection, on a microchip in an effective and automatic format.

Stem cell Therapy:

Despite promising developments in the therapeutic strategies for the treatment of patients with various degenerative diseases, the regeneration of injured and diseased tissues has always remained a significant challenge. The traditional methods of organ or tissue replacements include xenografts, allografts or autograft based therapies. However, they are associated with certain limitations which have encouraged physicians and scientists to look for newer approaches. Over the past decade, advances in cell biology and material science have evinced increasing interest in the field of tissue engineering and regenerative medicine to replace the traditional system of treatment for improvement of the quality of life.

Stem cell therapy is one such approach where patients' own cells are transformed into model for studying disease and developing potential treatment to negate the chances of rejection. Reprogramming of adult cells has been employed to obtain induced pluripotent stem cells [iPSCs]. The iPSCs are derived directly from adult tissues, which eliminate the need for embryos and can be made in a patient specific manner, paving the way for advanced personalized medicine.

Gene therapy:

Based on the genetic makeup, personalized medicine may be

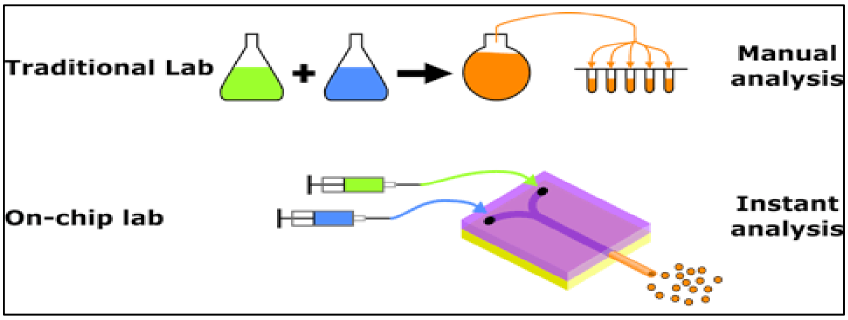


Fig. 3. Comparison between traditional and microfluidic diagnostics. Redrawn from: Brivio, M., Verboom, W., 7 Reinhoudt, D. N. (2006). Miniaturized continuous flow reaction vessels: influence on chemical reactions. Lab on a chip, 6, p.239.

worked out. The genetic basis of complex diseases and related intermediate traits are unique in Indians. Epigenetic regulation of key pathways may explain this variability and provide opportunities for alleviation of future risks of metabolic syndrome. For example, allelic variants of a particular gene are found to be associated with increased risk of malaria and even the infection severity. Based on the information of the genetic makeup of an individual, personalized gene therapy may be employed to reduce the chances of infection and disease progression.

DNA chips:

Genes play an important role in nearly every disease. In the future, every newborn could get his entire genome sequenced on a tiny chip. With this information, doctors could easily look up each person's genetic predisposition to various diseases and could tailor their medical advice. This technology would help doctors better prevent, diagnose, and treat diseases based on each person's genetic profile. It would also make it easier for pharmaceutical companies to develop personalized drugs for diseases like depression and breast cancer. Drugs for anti-depression, for example, currently only work in about half the patients. With personalized gene chips, doctors would know in advance which drugs would work (and not work) for each patient.

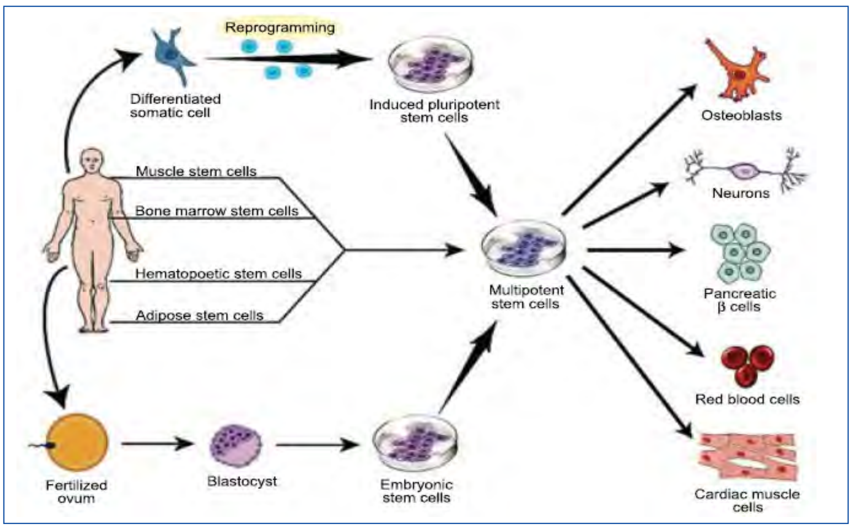


Fig. 4.Isolation and differentiation of stem cells for tissue engineering and regenerative medicine. Multipotent stem cells can be obtained directly from various human tissues. Pluripotent stem cells (iPSCs) are derived from the inner cell mass of the blastocyst (embryonic stem cells) or by reprogramming the cells. Multipotent stem cells can be differentiated into different cell types. Adapted From: Allison C, Bean, Rocky S and Nanotechnology in Tissue Engineering and Regenerative Medicine, Micro and Nanotechnologies in Engineering Stem Cells and Tissues, First Edition, John Wiley & Sons, Inc 2013.

Concluding Perspective:

Although tissue engineering along with nano technologyis capable of addressing the current problems in stem cell therapy, there are several issues that need to be resolved. Fabrication of functional, histo-compatible nano-structures and problems associated with mass transfer effect are still major challenges. Existing clinical technologies, regulation from public health agencies, patents on reagents and technology components, competition in the market, reimbursement of diagnostic devices and acceptance by medical personnel are few of the concerns for the implementation of POC diagnostics and concept of personalized medicine. Moreover, owing to upcoming advances in the healthcare industry, there will be a need for the development of inexpensive and easy-to-use medical devices and information-sharing tools that provide timely health status information at the POC.

We are moving in a new era of scientific advancements in healthcare through precision medicine/ personalized medicine. Medical devices that are minimally invasive, accurate, durable, user-friendly and low cost can now be utilized to improve diagnostics, prevention and therapeutic monitoring. As a result of these technological advances, medical diagnostics and therapeutics can be more finely tuned to better meet the needs of individual patients. ❑

(E-mail: ira@ccmb.res.in)

Science and Technology in Sustainable Development

Sudipto Chatterjee

We are now in a geological epoch called 'anthropocene' where humanity is driving possibly an irreversible global change to some of earth's basic processes. Science has to contribute to meeting these global changes of water shortages, climate change impacts because of like extreme weather events, ocean acidification, sea level rise and loss of ecosystem services

This article comes at a time when the joys of festivities got marred with deteriorating air quality of the country and capital, possibly at an all time low. The metaphor has been of a gas chamber with low temperature and stagnant winds, refusing to dilute the noxious pollutants. The age old health prescription of morning walks is now forbidden; we must stay indoors with our air conditioners on. Threats thus loom large, in the event of our inability to secure ourselves a clean and healthy environment, challenging our ambitious programmes on Swaccha Bharat, breathable air, clean flowing waters in our rivers and streams, healthy terrestrial and aquatic ecosystems.

Science and Technology have to meet a new set of challenges, meet the ever increasing demands and expectations of the inhabitants of this country and the world. Science progresses not for the progress of Science *per se* but for progress of well being of which environment protection and sustainable development is an integral part. Dr Abdul Kalam, the Citizen's President, had a vision for India 2020. TIFAC (Technology Information Forecasting and Assessment Council), Government of India, took up the vision to catapult India to a developed nation. The learning experiences, articulated a new Vision 2035 for India. Comparing with a horse's gait, Vision 2035 retrospected different sectors in India and categorized them to 'Galloping', 'Cantering', 'Trotting' and 'Walking'. Telecommunications, Nuclear, Missile , Life Sciences were categorized as 'Galloping' with India's launching capabilities of polar and geosynchronous satellites and India's enhanced abilities in predictions of weather and climate. The country was found to 'Canter' with respect to chemical processes, as the country is a net importer of chemicals, India 'trotted' in Food and Agriculture sector as India manages to contribute 10.3 per cent of total exports *in-spite* of wastage of one third of its products. India 'Walks' in terms of inadequate waterways and healthcare infrastructure which is inimical for the country's population (Technology Vision 2035).

It is very natural, that we look forward to Science and Technology for remediation to meet these non- ending stream of challenges. Availability of potable water for

The author is Associate Professor, Dept. of Natural Resources, TERI University and has been working for conservation of forests and biodiversity since past 22 years. He worked as Biodiversity and Protected Areas Management Specialist in Sikkim Biodiversity Conservation and Forest Management Project, Govt. of Sikkim, He served as Team Member, Biodiversity, in the Technical Facilitation Organization for the Sustainable Ecosystem and Land Management Country Partnership Project at the Indian Council of Forestry Research and Education, Govt. of India.

Table 1.

Area	Issues	Technology Status/ Requirement	
		Technology expected by 2025	Technology expected by 2035
Urban Environment	Municipal Solid Waste management	Plasma technology Proper designing of collection segregation, transportation and compacting system. Development of more efficient biological processes	Treatment of waste at source
	Electronic Waste	Cost effective recovery of precious metal	Technology to reuse 100 per cent waste
	Biomedical Waste	Re-designing of biomedical equipment to facilitate segregation and reuse	
	Sustainable buildings	Space conditioning technology Software for designing of buildings	Research and development for mobile building (modular and portable structure technology)
Industrial Environment	Industrial waste water	Low cost treatment at source to make it a resource material	No generation of waste, all to be recycled
	Industrial solid waste	Immobilization technology (biological and chemical for leachable solid waste)	
	Oil contamination	Remediation through nano material for bio and non bio components.	
Agricultural Environment	Agricultural waste	Research and Development in biomass boilers/ gasification using rice and straw husk waste with high silicon content Various pathways for conversion of cellulosic biomass in combustible (liquid fuel) form.	
	Contamination of food/ drinking water chain	Research on faster biodegradation of pesticides. Lowering/shortening half life of pesticides Development of paste/disease resistant crop varieties Biological disruption of pest cycle.	Development of cereals/crop variety with nitrogen fixation properties.
Green House Gas Mitigation and Air Pollution	Clean Energy Technology	Using Thorium for power generation Carbon capture by using algae from flowgas.	

Table 1. Cont.

Area	Issues	Technology Status/ Requirement	
		Technology expected by 2025	Technology expected by 2035
	Vehicular pollution	Development of high power to weight ratio. Storage batteries with fast recharge and long life time	
	Agricultural practices	High yielding paddy variety for dry land cultivation	
Natural Resource Management	Water conservation		
	Soil conservation and Reclamation	Cultivation technology in problem soils (acid, saline and salt effected) Development of crop varieties (including genetic engineering) resistant to high pH values	
	Forestry		
	Sustainable use of Biodiversity and traditional knowledge		

Source: Technology Vision 2035 Programme.

rural India and decimation of urban water bodies disrupting hydrological flows remains a concern. Ensuring quality air in cities by managing the pollutants at source questions both, the soundness of technology and inadequacy in implementation of our policies. Vision 2035 has called for a targeted research on advanced clean coal technologies, alternate fuel based transportation , real time dense spatial quality monitoring, real time aquifer monitoring, instant potable water quality testing, *insitu* water purification in pipelines. Self healing pipelines remain an imagination. We still do not have clues to diseases like SARS, H1N1, Swine Flu.

On the energy front we have set a target of 1000 GW of power generation, 50 per cent of which is sourced through renewable resources. For reducing dependence on fossil fuels and emission free energy generation, scientific research needs to be targeted towards, alternative sources of energy, algae, nuclear fusion, fast breeder reactors for thorium, advanced fossil fuel extraction technologies, hydrogen energy, bio-refineries, wireless power transmission, green and net zero buildings. Advanced fossil fuel extraction techniques, microbial fuel cells and zero energy artificial lighting (eg. Bioluminence) remains a distant reality. Our environment needs safeguards through alternatives to polluting construction materials like sand, artificial lighting by using absorbed energy, bio-mimetic constructions. Solar energy applications would require silicon replacements with grapheme, zinc oxide and organic materials. Mining and processing techniques for traditional metallic materials have to be more environment friendly. Polymers need to be non toxic and biodegradable. Groping with solid waste management we need to advance in science for bio-logical remediation.

A brain storming session at TIFAC prepared a status of technology in relation to urban environment, industrial environment, agriculture environment, Green House Gas (GHG) mitigation and Air pollution and Natural Resource Management in 2025 and the expectations a decade further (Table 1). The vision analyses the present status of technology, the desired destination, the interventions needed and anticipated hurdles.

India, being a megadiversity country, with three of the global biodiversity 'hotspots', six priority G200 Ecoregions of WWF , one of the global eight Vavilovian centres of origin of crop plants, a country with Important and Endemic Bird Areas (IBAs and EBAs), IUCN (International Union for Conservation and Nature) centres of endemism is enriched with 150 years of scientific forestry. While the focus has been for a large time period on inventorization of the rich floral and faunal wealth, the trends now are towards research on robust population dynamics studies and species distribution modeling. Its

Science for Sustainable Development

important that we know the trends in population of our wildlife for species which are Red-listed 'Critically Endangered'. Equally important are the lower group of species, like the invertebrates or planktons which are not flagships or are charismatic to draw global attention. We need to know their diversity and their role in terrestrial and aquatic ecosystems. There have been debates in the recent past on tiger census techniques with a gradual switch over from counting pug marks to occupancy studies, using capture-recapture modeling through usage of camera traps and software PRESENCE and MARK. Biological diversity is enumerated as species diversity, ecosystems diversity and genetic diversity. While we have advanced over the years in documenting species and ecosystem diversity we need to accelerate our pace in research on diversity of genes. With climate change a reality, we need to understand the impacts on vulnerable species and ecosystems. Molecular biology has emerged as a tool towards 'de-extinction' and efforts were made by the government to bring back the locally extinct Cheetah to the wilderness of India. Science will play a stronger role in implementing new approaches to conservation of biodiversity like introducing the Principles of Forest Stewardship and Marine Stewardship Council. Kolbert (2014) calls this the era of Sixth Extinction as the rate at which species are disappearing from the earth is thousand times more than the natural rate of extinction.

Science and Technology had a great responsibility towards the Sustainable Development Goals (SDGs). The Sustainable Goal Targets on thriving lives and livelihoods, sustainable food security, sustainable water security, universal clean energy, healthy and productive ecosystems and governance for sustainable societies follow from the Millennium Development Goals on ending poverty and hunger, universal education, gender equality, health, environmental sustainability and global partnership. The SDGs have to be achieved by 2030. We are now in a geological epoch called 'anthropocene' where humanity is driving possibly an irreversible global change to some of earth's basic processes. Science has to contribute to meeting these global changes of water shortages, climate change impacts because of like extreme weather events , ocean acidification, sea level rise and loss of ecosystem services. Griggs et al, 2013 have emphasized that if the aforementioned sustainable development goals are to be achieved, planetary stability has to be ensured. Rockstrom, 2009, at Stockholm Environment Institute worked out the thresholds and boundaries for global changes. With CO_2 concentration reaching 400 ppm in earth's atmosphere, climate change, biodiversity loss. and nitrogen deposition has crossed boundaries.

The country has many global commitments that would require strong science based interventions. The target of INDC (Intended Nationally Determined Contribution) India has submitted a target to achieve 33-35 per cent reduction in the green house gas emissions along with an additional 2.5-3 billion tonnes of CO_2 by 2030 from forestry sector to UNFCCC (United Nations Framework for Combating Climate Change). Around 2/3rd of this target can be achieved through afforestation on 5 million hectare non-forest land with the expenditure of Rs.600000 million per annum till 2030. T (Sharma, 2016). Scientific research will also play an important role in meeting other international commitments like the CBD (Convention on Biological Diversity), Ramsar Convention (for conservation of wetlands on international significance), UNCCD (United Nations Convention on Combating Desertification), CMS (Convention on Migratory Species), UN Laws of the Seas amongst others.

TERI (The Energy Research Institute) has been organizing the Delhi Sustainable Development Summit since 2001 and in 2016 the World Sustainable Development Summit was organized in New Delhi in October, 2016. Hon President of India, Shri Pranab Mukherjee, cautioned us that we are only trustees and have no right to waste our resources. Rising to the occasion, Department of Science and Technology (DST), Government of India which organizes the biannual National Children's Science Congress (NCSC) has declared 'Science, Technology and Innovation for Sustainable Development' as the theme for the year 2017. Children in the age group

10 -17 years are gearing up to the challenges of Sustainable Development in thematic areas like Natural Resource Management, Food and Agriculture, Energy, Health, Hygiene and Nutrition, Lifestyles and Livelihood, Disaster Management and Traditional Knowledge Systems.

Advancement in Science and Technology comes with its own caveats and solutions which must not be counterproductive. Global apprehensions in Gene therapy , and usage of Genetically Modified Organisms (GMOs) needs to be addressed. This is pertinent in the context of the spate of suicides by Indian farmers using GMOs. Science has to provide adequate evidence through empirical and modeling studies for policy and decision making. A series of Editorials in the Journal *Current Science*, dissects the root causes of factors that impedes growth of Science and Technology in India. Dismal investment in Research and Development to the tune of less than 1 per cent of GDP does not gel with the available scientific manpower. The bureaucracy- scientific community divide, our inability to scale up innovation and plagiarism is now openly discussed. The scientific community has risen to the occasion. However, it is time that we move from technology dependence, technology import and technology adoption to technology reliance. This necessitates a deeper analysis of the technology constraints we are going through and upgrade our skills and capacities. Basic research in the country which is on the rise by 146 per cent needs a transition to viable commercial ventures. Needless to say that our institutions of higher scientific learning are gearing up to prepare our societies to meet these challenges.

Reading:

- Griggs wt.al., 2013. Sustainable development goals for people and planet. Nature. Vol. 495. 305-307.
- Holdren, J.P. (2008). Science and Technology for sustainable well being. Science. Vol. 319 424-434.
- Kolbert E. (2014). Henry Holt and Company LLC. New York. P 319
- Rockstotm et al,(2009). Planetary boundaries: Exploring the safe operating space for humanity. Ecology and Society 14(2) 32,
- Sharma, J.V. (2016) Proceedings of the Workshop on "Role of Forests in India's INDC" . World Sustainable Development Summit .TERI, (WSDS) October 7th, 2016, New Delhi.
- echnology Vision. 2035. (2015). Draft. Technology Information Forecasting and assessment Council. New Delhi. P 114.
- Technology Vision 2035 Programme. Record of the brainstorming meeting on environmental technologies held on 22 December 2011. TIFAC. New Delhi. P2. ❑

(E-mail: s.chatterjee@teriuniversity.ac.in)

Connecting to the Masses

Manoj Kumar Patairiya

Communicating science and development through our 22 Indian languages and over 100 dialects is yet another challenge to penetrate into local populace effectively

India has a rich tradition of communication, especially when it comes to communicating to masses. Folk plays, like *Nautanki*, and religious plays like *Ramlila*, folk songs and folk dances are immensely effective as the means of taking messages of developmental aspects to the masses. *Ramlila* is one of the oldest of folk arts, possibly, which has communicated to millions of people over generations, the code of conduct and ideals of social life. '*... Every cultural pattern and every single act of social behaviors involve communication, in either an explicit or implicit sense*' (Sappier).

The campaigns of Polio eradication (*Do Boond Zindagi Ki...*), Swachh Bharat and Swasth Bharat, etc., are tremendously supported by science and development communication models. The might of mass communication, can be underlined as the root cause of any social change, let alone development. This speaks volumes on the impact of sustained social connect and discourse between different stakeholders through effective mass communication for changing the way the society thinks, behaves and acts. India is known for her early scientific wisdom and a treasure of scientific heritage. Several sages and scholars had been working on medicinal, mathematical, astronomical, agricultural, psychological, physical and chemical sciences in Indian subcontinent. Probably, they had composed books or volumes in their respective fields based on their own self-earned experiences. They have used various means of communication, like oral communication, Guru-Shishya-Parampara (teacher-pupil tradition) of learning, and dissemination of information by interacting people.

According to Toynbee (1976), in Asia, people were so intelligent to make boats and found their way to Australia crossing Timor Sea around 3,200 BC. Undoubtedly, the knowledge of production, use and control of fire was a great discovery of mankind, but it is uncertain that when it was made. However, according to various archaeological evidences, it appears that man first developed the primitive stone tools, followed by the knowledge of use and control of fire, and the development of the civilized society was the next step.

Science and development communication has now drawn the attention of policy makers, planners, scientists, technocrats and media personnel during the past decade world over and so as in India. Currently several activities, approaches and media forms have been tried and

---

The author is Director of the CSIR-National Institute of Science Communication and Information Resources, New Delhi. Earlier Dr. Patairiya was the Additional Director General, Prasar Bharati (Doordarshan/ All India Radio), where he was responsible for setting up Kisan TV Channel. He has received national and international awards and has a number of publications and two Indian Patents to his credit. He has co-edited widely acclaimed books: "Sharing Science" and "Science Meets Communication".

utilized by different agencies, both government and non-government, for development communication. Various means and modes of communication have been utilized in India by the science communicators to reach out to the masses. Every form has its own significance and utility keeping in mind the vast diversities existing. Different communications tools were employed for public dissemination of science and inculcation of scientific temper.

Over the years, there has been a remarkable increase in developmental coverage, be it science, technology, innovation, health, environment or agriculture, etc., in different mass media involving print, electronic, digital, folk or interactive. Several national and regional dailies have started weekly pages and magazines cover columns on these developmental aspects.

A variety of programmes are now available on All India Radio, like Radioscope, Science Today, Science Magazine, Science News, Vigyan Bharati, etc.; the interest was triggered by two radio serials `Method of Science' and `Human Evolution' during late 80s and early 90s. On TV, 'Turning Point' a science based programme was able to catch eyes of viewers, besides other such programmes. Some organizations are actively involved in taking science to the people by way of folk forms, street plays, theater, puppetry, folk songs, skits, etc.

In fact, print and electronic media have certain limits, but the illiterates or neo-literates can also be enlightened through the use of folk medium, as it has no limitation, and offers two way channel of communication, which was proved to be very effective during Vigyan Jatha, a large assemblage of enlighten professionals travelling from village to village taking the messages of science and development to nooks and corners of the country.

Other techniques for such communication, like exhibition, *Vigyan Mela*, projection shows, lectures, demonstration, science museums and planetariums are also part of the ongoing development communication movements in the country. A variety of popular science software has been produced. A number of potential communicators are trained through full time academic courses in science and technology communication and short term science writing and journalism workshops to bridge the gap, who can in turn take up responsibilities of different communication programmes and activities.

Although much has been achieved, the picture is not so rosy and there is an urgent need of appropriate initiatives to work towards putting in every effort to make science communication activities more effective and sufficient both in terms of quality and quantity and a lot is still to be achieved.

It is, however, disappointing that Indian science magazines, like *Science Today, Bulletin of Sciences, Times of Science & Technology* have been closed and Indian editions of some foreign magazines, like *La Recherche* and *Scientific American* have ceased their publication, after bringing out a few issues. Whatever may be the reason, it is clear that science has no territorial boundaries, and so is true for the science communication activities. As far as coverage of science and technology in mass media is concerned, in developing countries, like India, it will increase in near future significantly, as very fast and rapid developments are taking place. On an average, the science coverage in India is around 3.4 per cent, which we intend to enhance up to 10 per cent, as per a resolution of the Indian Science Writers' Association (ISWA).

In terms of international comparison, in India the efforts, like *Vigyan Jatha*, Children's Science Congress, explanation of so called miracles, etc., are widely acclaimed and have no match and are unique and first ever in the world. There is a wide scope of a broad spectrum of development communication activities in future to better serve the mankind.

Information communication technology led communication has given birth to comparatively a new media, known as digital media. It includes Internet, CD-ROM, multimedia, simulations, etc. This is proving to be an effective medium and it can illustrate difficult concepts through text, audio, graphics, video, animation and simulation. It has also made science communication simpler to handicapped segments of the society. This new media has given birth to a more instant and global mode of communication in the form of 'Social Media', involving social and individual networking platform and sites. Blogs on development issues are becoming common offering two way of communication and breaking the limitation of editor's acceptance! Blog has the power of reaching directly to the audience without the fear of being rejected by the editor. Virtual discussion groups are also becoming popular for exchange of views and opinions on developmental issues online.

Communicating science and development through our 22 Indian languages and over 100 dialects is yet another challenge to penetrate into local populace effectively. Selection of target audience has greatest significance. Communication efforts are aimed at various target groups, such as, common man, children, students, farmers, women, workers or specialists, etc. Various forms for presentation are being used to make such communication more interesting and enjoyable, such as developmental news, report, article, feature, story, play, poem, interview, discussion, lecture, documentary, docu-drama, scientoon (science + cartoon), satire, etc. Some of the important modes and means employed for science and development communication are:

1. Popular literature (articles/ features in daily newspapers, periodicals; newsletters and specialized S&T magazines: comic strips, picture-cum-story books, wall charts etc.).
2. Exhibitions on developmental themes (temporary, permanent and mobile).
3. Science Express, Environment Express, etc. - Exhibitions on Train.

4. Natural History Museums (with permanent galleries on basic topics, on country's heritage and on famous discoveries and inventions, among others).
5. Science Centres and Parks (participatory and interactive activities and demonstrations to learn about S&T principles, applications and to encourage development of a spirit of enquiry among children and adults).
6. Contests (quizzes, essays, scientific models, toy and kit making, public speaking, debates, seminars etc.).
7. Popular lectures on development subjects (for general public, for children a students at schools, colleges, universities and other institutions).
8. Tours (guided tours around botanical, zoological gardens, museums, planetariums, bird sanctuaries, industries, factories, etc.).
9. Planetariums (including mobile ones; sky watching with naked eyes or telescope to learn about planets, stars and other celestial objects).
10. Radio and TV broadcasts (for general as well as specific audiences), audio-Visual shows.
11. Digital software, CD-ROMs, etc. (for special or general audiences).
12. Science Films (for general and specific audiences).
13. Folk forms (song and drama, street plays, puppet shows, procession, festival, fairs, Jathas, etc.).
14. Science Club activities, etc.
15. Community Radio, Community TV
16. Webcasts, Podcasts, and Social Media, Blogs
17. Workshops, symposiums, seminars, roundtables, discussions, etc.
18. Low cost kits/ toys and other hands-on-activities (such as water testing kit).

A programme on scientific explanation of so-called miracles was carried out at national level to educate gullible public on the issues of superstition and unlawful practices. This is a very popular programme implemented across the country, wherein various tricks and miracles are demonstrated and explained by trained performers.

More often, we talk about science communication and scientific temper and less on technology communication and technological temper. A major initiative was taken on 'Technology Communication', including hands-on science, with the objectives: i) to inculcate a technological temper; ii) to develop and nurture the spirit of innovativeness, and iii) to focus on technological approach to problem solving. The programme has 3 major elements: i) orientation of artisans and techno-students towards innovativeness; ii) identification of areas of innovation and developing innovative ideas; and iii) technology awareness. The module was successfully tested for implementation.

Science popularization programmes built around the total solar eclipses on the belt of totality for viewing total solar eclipses were organized successfully.

Perhaps, Indian is the only country to have a special provision 'to develop the scientific temper, humanism and the spirit of enquiry and reform' as one of the 'Fundamental Duties' mentioned under Part IV A, Article 51 A (h) of the Constitution of India. The Scientific Policy Resolution introduced on March 4, 1958 has been a guiding factor for development of science and technology in the country. Special attention was given to the scientific approach in the resolution, which reads as: *"It is only through the scientific approach and method and the use of scientific knowledge that reasonable material and cultural amenities and services can be provided for every member of the community, and it is out of recognition of this possibility that the idea of a welfare state has grown"*.

To give direction to the technological development in the country the Government of India announced the Technology Policy Statement in January 1983. The spirit of innovation and awareness about balance in technological development and environment was given special importance, among others in the statement. Government of India has announced a comprehensive 'Science and Technology Policy 2003' that carries a section on "Public Awareness of Science and Technology". A new Science Technology & Innovation Policy was unveiled at the 100th session of the Indian Science Congress, Kolkata on January 03, 2013 that also emphasizes on public communication.

The level of literacy has increased as compared to earlier times, though it has not reached the desired level. Scientific literacy is drastically low in the country. The development communication has still not succeeded in attracting the media to the extent that it could appear on the front page or become a lead story, like the politics, films or sports. Mass media has its commercial compulsions, which superimpose all the development communication efforts and leave a negative impact in the minds of the audiences.

A common science and development news and features pool can be formed to facilitate writers/ journalists to get and exchange information on research and developments for further dissemination through mass media. Looking at the population, size and make up, variety of languages, urban-rural, digital divides, prevalent disparities, poverty, illiteracy, inadequate opportunities, facilities, services, reach of mass media, and so on, India is poised with many challenges, that offer opportunities and possibilities in development communication.

In developed nations, "the science museums, planetariums, exhibitions, lectures, audio-video media and high-end technological application" approach dominates the 'state-of-the-art' in this field, which is capital intensive and urban oriented. In India, same results are achieved through "folk forms, Vigyan Jatha, print and visual media, road-shows, and people's involvement" approach, which is cost effective and fits into our social milieu.

However, India is not legging behind in modern approach and has been able to make world records, especially in case of Science Express - Science Exhibition on Wheels. India was able to win international bids and organize international forums on science and development communication. Many developing countries are more or less following western approach but it is refreshing to note that after organization of these forums in India, not only developing but several developed nations are willing to try Indian models.

Perhaps in Indian context scientific and technological temper has more meaning and relevance for development. What we would like to see is that our population at large, particularly the illiterate and backward rural community, develops a scientific outlook rather than being told about facets of science and development alone, that allows informed and logical decision making and elimination of superstitions and ignorance. In India, therefore, more organic approach has taken shape and making inroads. Use of local languages, dealing with everyday developmental problems, using surroundings and environs, at home, in field and outdoors, learning by doing, are some of the elements of this parallel approach of progressive communication and public awareness campaigns.

Any development issue has mainly two dimensions — 'interest of few and interest of many', which leads to unwarranted but unavoidable uncertainties. Unless the former learn to sacrifice their 'illegitimate interests', the very objective of a development issue will continue to suffer, putting the latter at a risk of sacrificing their 'legitimate interests'. The role of 'development communication' is vital in today's world, especially where complex issues of conflicting interests of development, environment, industry, business, politics, and mass media are increasingly coming to the fore, and public and policy makers need to understand the 'true communication'; the role of 'development communication' has much larger value and impact in analyzing, understanding, and shaping the way how 'public and political understanding of development' can be improved with new models, tools, methodologies, and practices. Science has a bearing on the way one thinks, behaves and conducts in the society. Thinking scientific is establishing harmony with nature. It could best be promoted by communicating science in a scientific way, which has therefore come up to be an evolved technique to channel ourselves to scientifically evolved societies, because distortions if any here have greater ramifications. ❑

(E-mail: manojpatairiya@yahoo.com)

Science & Technology for Make in India

G D Sandhya & N Mrinalini

Make in India must be understood in terms of creation of an innovation eco-system that enhances R&D and technological capabilities of Indian industries and propels the innovation process. The MSME sector requires a dependable innovation support system for the firms which is not only of problem solving type but proactive in enhancing their innovation competitiveness and is nurtured on a long-term basis. This will lead to increased manufacturing and value creation

While India's growth has emerged from a strong services sector, the manufacturing is still in a dire need of a strategic push. Manufacturing contributed only 17 per cent to India's Gross Domestic Product (GDP) in 2013. As the government pushes for the revival of sluggish manufacturing through two of its major flagship programmes "Make in India" and the "Start-Up India", in 2015 and 2016 respectively, the step could usher a new lease of life for the manufacturing. "Make in India" has targeted major initiatives to facilitate investment, foster innovation, protect intellectual property and build best in class manufacturing infrastructure by easing out the procedures, reducing the complexities and enhancing speed and transparency in doing business besides strengthening the infrastructure including creation of clusters. Start-ups can also become important contributors to the "Make in India" programme. Both the initiatives are laudable and these can become more meaningful if steps are taken to enhance the R&D and production capabilities of production sector for sustaining manufacturing.

The Global Competitiveness Report has put India's competitive strength as factor driven where price rather than the technological competition drives the firms (The Global Competitiveness Report, 2014-15). Indian manufacturing, therefore, necessitates a shift from complacent manufacturing to vibrant competitive manufacturing. Manufacturing capability should be seen as an integral part of the manufacturing strategy. R&D and innovation becomes a significant part of the building of manufacturing capability by instilling innovative competitiveness amongst the firms. "Make in India" can, therefore, be seen as an opportunity to revive the crumbling manufacturing sector for manufacturing cannot survive in the absence of firm competiveness. Innovation is required for the upgradation of capabilities in firms and industries for developing existing products; for introducing new products or getting into new streams of activities. The Countries such as China, South Korea and Taiwan have grown rapidly because of their manufacturing push and also by paying attention to developing domestic capabilities of their domestic firms along with providing a dynamic innovation ecosystem. The article looks at the Science Technology and Innovation (STI) perspective of manufacturing to facilitate the "Make in India" programme and it is based on the studies done by us[1].

G.D. Sandhya is Chief Scientist at National Institute of Science Technology and Development Studies (CSIR) and has been working in the area of science, technology innovation policy issues for the last 25 years.

N. Mrinalini at present is working as Chief Scientist at CSIR- NISTADS and has more than 30 years of research experience in the areas of, R&D and innovation studies with a focus on policy issues. She has been working in the area of Management and Economics of technological Innovation with a focus on benchmarking studies of R&D Organizations and R&D and innovation studies.

The revival of manufacturing by Indian firms, for contributing to the "Make in India" programme necessities a look at India's position in economic, S&T, manufacturing and innovation indices. This will be followed by an analysis on the STI perspective of Chinese transformation for drawing lessons. This is just to throw light on how China has emerged a world leader in manufacturing.

India's Position

While envisioning India's preparedness for plunging into manufacturing, it is necessary to assess India's position in innovation capabilities. Indian economy has emerged a major player in the global economy in the last two decades since liberalization. While India's GDP share in world has grown from 3.43 per cent in 1996 to 5.77 per cent in 2013, China's share has grown from 6 per cent to 16 per cent. India's trade balance is negative and China has maintained a positive trade balance from 1996 to 2013. The technology and skill intensity of exports from India has remained at 7 per cent from 1996 to 2013 in contrast to a leap from 12 per cent in 1996 to 26 per cent in 2013 in case of China.

The manufacturing supremacy of China can be gauged by the fact that China has toppled US from top rank at 23.2 per cent of share in world manufacturing leaving US with 17.2 per cent in 2013. The other indices on Competitive Industrial Performance which benchmarks countries' ability to produce and export manufactured goods competitively ranks China at number 7 and India at number 42 in 2013.

The strengths of the production system of any economy are driven by the technological capabilities which go a long way in consolidating the production systems. The share of R&D in GDP in India has remained at less than 1 per cent in the last two decades whereas the figure grew to 2 per cent in case of China. The number of R&D personnel per million has remained more or less same in case of India but grown 2.5 times in the same period in case of China. The involvement of various stakeholders such as business enterprise, government and higher education indicates the importance of stakeholders in supporting the production system. The share of R&D by the enterprises is still small in case of India in comparison to the government. The spending in the higher education sector in India has remained largely unchanged in the same period. This is a crucial factor in supporting innovation competitiveness.

It has been found that access to information/knowledge is found to be a major factor inhibiting innovation and there is a disconnect between the production system and innovation support system. However, a point that needs to be looked into if India wants to boost sustained manufacturing is that what is the role of innovation and innovation ecosystem in complimenting the existing manufacturing capacities and capabilities?

Similarly India's position in Global Competitiveness Index which is defined through a set of institutions, policies and factors that determine the level of productivity of a country, conditions of public institutions and technical conditions, had although gone down from 49 in 2009-10 to 71 in 2014-15. China improved its rank to 28 in 2016.

India has shown improvement in the Global Competitiveness Index and has jumped its ranking by 16 places due to improved macroeconomic fundamentals. Yet, the fact remains that the parameters pertaining to S&T and innovation have not changed significantly.

MSMEs role in the "Make in India" STI Perspective

To support the Make in India initiative, there is need to strengthen the manufacturing by the production sector which is dominated by Micro Small and Medium Enterprises (MSME) sector. MSMEs are second to agriculture in terms of GDP contribution and contribute 45 per cent of manufacturing and 40 per cent of exports. There has been a decline in the share of MSMEs towards manufacturing and exports largely because of China's emergence as a major player in the manufacturing. India is losing out to rival economies even in areas where it could have been a major player. MSMEs are facing tough cost and technological competition which can only be countered with competitive manufacturing by producing superior products with better technologies. It is well known that this sector lacks the technological capabilities to introduce superior products with cost competitiveness. For the revival of this sector for competitive manufacturing therefore, there is a need to provide them the Research and Development (R&D), technological support and non-technological support.

A study on the status of innovation based on sample of 9001 small and medium firms from all over India has shown that small firms are basically "innovation shy" and they are complacent with survival in the market rather than indulging in innovation for growth (mentioned in footnote 2). Although India has a huge network of organizations/agencies involved in promotion of innovation, very few innovative firms had ever accessed the available support system. It has been found that access to information/knowledge is found to be a major factor inhibiting innovation and there is a disconnect between the production system and innovation support system. However, a point that needs to be looked into if India wants to boost sustained manufacturing is that what is the role of innovation and innovation ecosystem in complimenting the existing manufacturing capacities and capabilities?

Lessons from China

China has toppled US from its manufacturing might and gained

the first place to lead the world in manufacturing supremacy. Although, to begin with, much of it was by the MNCs, the domestic enterprises took the lead in due course of time. The rise of China as a major economic power within a time span of around three decades is phenomenal and has been attributed to its strategic push on manufacturing. The share of China in world manufacturing was 23.2 per cent followed by the US with 17.2 per cent in 2013. China leads in indices related to manufacturing competitiveness, competitive industrial performance, and global manufacturing competitiveness besides several others. While China has been recognised as an efficiency driven economy by the Global Competitiveness Report, India is still seen as a factor driven economy (The Global Competitiveness Report 2014-15, World Economic Forum).

While on the one hand, China has amassed significant capabilities in manufacturing in the last two decades and these have been supported by significant capabilities in several areas of science, technology, and innovation. China has not only boosted investments in S&T but has also taken steps to build its National Innovation System. The emergence of China as an economic power based on manufacturing therefore raises an important question on the role of Science, Technology and Innovation (STI). In the following we will look at the STI perspective of China as a facilitator of manufacturing and lessons that can strengthen India's 'Make in India' initiative.

China has consistently improved its global ranking in manufacturing and STI and has emerged as a global player though prior to reforms since the 1980s, both China and India had similar levels of development. Chinese model of development has treated S&T as a complement to economic transformation

As a follow up of the opening up of the Chinese economy, the first directive was to boost its S&T capabilities and catch up with the world. China embarked on a series of policies and programmes in its endeavour to reach the catch up milestone. It took series of proactive initiatives in generating and augmenting its human resource by implementing a number of programmes and policies for university modernization.

Two major initiatives to revamp higher education system in China included the Project 211 and Project 985. The Project 211 was launched in 1996 aimed to strengthen about 100 higher educational institutions and key disciplinary areas as a national priority for the 21st century. These two university modernization programmes were supplemented with other programmes to attract the best manpower from within China and abroad. The focus of the Chinese universities was changed from education to research and to commercialization from the 1980s. Universities have exhibited great potential in knowledge innovation and industrialization of high technologies since then. Chinese universities have become a major force in China's knowledge production activities as well as commercialization.

China encouraged its universities to set up of their own enterprises to counter the problems of technology markets. The practice of university affiliated enterprises is a unique feature of the Chinese innovation system. University Science Parks have been created in China to incubate spin-offs created by university professors and students.

For the transformation of government research system, the policies in China have targeted research, funding, commercialization, manpower, organizational restructuring and commercialization. The ensuing major policy initiatives targeted funding reforms; restructuring of research institutes; consolidation of links among research, academia, and industry; commercialization by the creation of `Technology Markets, creation of S&T parks, etc. This has led to a revamp of existing structures, mechanisms and governance.

The State Council launched the Torch Programme to facilitate commercialization of research results, since the Chinese system of innovation suffered from poor translation of research into applications. The programme targeted commercialization of research results from universities, research institutes, and high tech industries.

The Chinese innovation system has emerged within a dynamic ecosystem, which is marked by the creation of S&T parks, university parks, high technology development zones, technology business incubators with necessary intermediaries support, modernization of the higher education system along with revival of the government research system. The emergence of an innovation system in China has been a part of an organized drive, facilitated by both the centre and the local governments. The creation of S&T parks, university parks, technology business incubators, etc., has been done basically to facilitate innovation. This, accompanied with the structural reorganization of university and public research system, has been instrumental in sustaining the dynamism. The creation of intermediary structures for supporting commercialization along with a supportive policy package has been part of the innovation drive, which has helped in increasing dynamism in these geographical clusters. These parks have a mix of large and medium enterprises, small and medium enterprises and multinational corporations with linkages amongst academia, Government research institutes.

A major issue, therefore is that is it possible to support and sustain manufacturing without strengthening the institutions related to science, technology and innovation? The vision, strategies and policy initiatives taken by China suggest the necessity of a roadmap with necessary changes in all the concerned institutions with ruthless restructuring. There is connectivity and concurrence in policies which got consolidated over time. There is a rational analysis of policy outcomes and achievements which is done with a view to learn from failures. Success or failure is determined by programme/ project outcomes rather than financial accountability.

When China targeted transformation it targeted the entire innovation infrastructure including research institution, universities, S&T Parks, support structures, fiscal and financial instruments, etc. The subsequent structural and organizational changes have not only led to a qualitative improvement in the institutions involved but also enhanced linkages amongst the actors of innovation. For instance, the lack of initial success in China in creating markets for technology was followed by a structural transformation of research institutes into enterprises, supported later by the 'Torch Programme' through the creation of innovation fund and the creation of S&T parks. The research in research institutions was sharpened by the 'Knowledge Innovation Programme'. The changes were later supported by Intellectual Property Rights (IPR) laws and by having their own standards. If, despite the recurrent changes, the results were not found to be very encouraging then the indigenous innovation policy came to support the industry in areas where indigenous research had been undertaken. The different phases show a distinct movement in Chinese policy making from playing catch up to creating a national system of innovation.

As the basic agenda of China was to catch up with the developed countries and to reduce the gap between them and China, spending on R&D as a percentage of GDP grew consistently from 0.6 in 1995 to 2 in 2014. China ranks second in terms of absolute R&D spending. Chinese investments in R&D as per cent of GDP were at par with India prior to 2000 but increased by 161 per cent by 2011. China's increase has been more than 20 per cent each year while India has hardly been able to push the figures up.

Conclusion

The globalization has brought in ample opportunities and challenges for India. The issues that arise for the meaningful outcome of the "Make in India" essentially indicate that there are loose ends which need to be taken care of. Manufacturing holds the key to development and the three important pillars which sustain manufacturing are innovation competitiveness, R&D and human resource. Though India has progressed well in the last three decades but there are issues with innovation competitiveness in the manufacturing sector, which have somehow held back India's rise compared to other economies. In order to promote competitive manufacturing what is needed is sustained initiatives for introducing efficient production processes, improving product quality and introducing new products and processes to cope up with the challenges of fast changing technologies. In the global economy, even production for the local markets requires continuous efforts in innovation. This is made possible by investing in R&D, manpower and innovation.

Public support for R&D and innovation by countries that have become manufacturing giants such as China and South Korea has ranged from up-front R&D grants; modernization of education infrastructure; creation of technology markets; promoting high tech entrepreneurship and transforming the innovation ecosystem. The process of strategization and priority setting has taken decades of planning.

Make in India must be understood in terms of creation of an innovation eco-system that enhances R&D and technological capabilities of Indian industries and propels the innovation process. The MSME sector requires a dependable innovation support system for the firms which is not only of problem solving type but proactive in enhancing their innovation competitiveness and is nurtured on a long-term basis. This will lead to increased manufacturing and value creation. Start-ups too can be important contributors to the "Make in India" programme provided they operate in the business of value creation and not in the domain of value appropriation.

There is neither a dearth of policies nor institutions to support innovation in India but there is a need to spark the dynamics of innovation in the MSME sector by making the innovation support system proactive. If India plans to increase the share of manufacturing to 25 per cent and job creation of 100 million by 2022, it requires a plan which focuses on the technology support system as well as innovation ecosystem. "Make in India" has provided an opportunity to strive for global supremacy in key areas and on a constructive node the "Make in India" has focussed on sectors of India's competitive advantage such as pharmaceuticals, automobiles, chemicals, biotechnology, information technology, renewable energy, etc. India has developed even exports in some of these sectors by showing manufacturing competencies. Strengthening the innovation support system will, therefore add to manufacturing competitiveness and value creation.

Readings

1. Understanding Innovation: Indian National Innovation Survey, Study sponsored by NSTMIS, DST.CSIR-NISTADS, 2014.

   A Comparative Study on S&T, Innovation and Development Strategies of China and South Korea vis-à-vis India, Study commissioned by the Office of the Principal Scientific Advisor to the Government of India, CSIR- NISTADS, 2012.

   India's Innovation Capabilities and Capacities: A comparative Global positioning, CSIR-NISTADS, 2014 ❑

(E-mail: gdsandhya@nistads.res.in; nmrinalini@nistads.res.in)

NORTH EAST DIARY

MOBILE AIR DISPENSARY FOR REMOTE AREAS OF THE NORTH-EAST

Union Minister of State (Independent Charge) for Development of North Eastern Region (DoNER), MoS PMO, Personnel, Public Grievances, Pensions, Atomic Energy and Space, Dr Jitendra Singh has proposed "Mobile Air Dispensary" service for remote and far-flung areas of Northeast, which would envisage a mobile dispensary in a Helicopter with a doctor, necessary equipment and medicines that can fly to remote and far-flung areas on regular basis and also, as and when required. This service will particularly help in those areas from where patients find it difficult to reach a dispensary, a doctor with dispensary can reach them. The same experiment, which would possibly be the first of its kind in the country, can also be replicated in other hill States and remote areas having poor connectivity like Jammu and Kashmir, Himachal Pradesh etc.

$48 MILLION LOAN TO IMPROVE ASSAM'S POWER DISTRIBUTION SYSTEM

The Asian Development Bank (ADB) and the Government of India have signed a $48 million loan to help Assam continue its drive to improve access to efficient and reliable power in the State.

This is the second tranche loan of the $300 million multi tranche financing facility for the Assam Power Sector Investment Program that was approved by the ADB Board in July 2014. The project will help Assam to enhance capacity and efficiency of its power distribution system to improve electricity service to end users. The first tranche loan of $50 million was signed in February 2015.

Impact of Science and Technology on Women

Anitha Kurup

...there is a need for more dialogues and collaborations between the physical scientists and social scientists to be able to unravel the complexities of women in science and technology in India. It is equally important for the STI agenda to move beyond women in science to science for women to reach STI to vast majority of women in society. It is through this symbiotic relationship between science and society through equitable participation that can realize the dream of reaching science to women in India

It has become imperative for a developing country like India that the pace of development needs to be commensurate with the growth and development in the field of science and technology. In this new scenario, characterised by modernisation and industrialisation, the advantage of a nation largely rests on the competitive advantage it can have particularly in its ability to reconfigure knowledge. While most countries rely on technological innovation as an important strategy to get ahead of the rest, the concerns of women and the poor who constitute the vast majority of the population is often forgotten. Bringing women and the poor to the forefront of the S&T policy is a challenge. In other words, in the journey of competitive science how can India be more inclusive?

Women and S&T Policies in India

The National policies on Science and Technology in India have, over the decades, made shifts to engage with science technology and innovation as reflected in the more recent Science Technology and Innovation Policy of 2013. Earlier, India's Policy Resolution of 1958 assumed that technology would flow and be the logical next step from these scientific institutions/ establishments. To provide the much needed filip to technology, India introduced the Technology Policy statement in 1983 with a focus on technological competence and self- reliance.

A review of progress of the earlier policies of S&T in India indicates that there was a need for a synergy between science technology and innovation to make impressive strides towards progress in society. Though science and technology have historically excluded women, it was hoped that, with the addition of innovation, there would be greater participation of the under priviledged and women in general. Innovation in the Indian context has had a more equitable participation of the poor and women, which is illustrated through the several rural innovations documented by the National Innovation Foundation. And this is only the tip of the iceberg, in an ancient country like ours which has historically been engaged in innovation based on traditional knowledge. The current Science Technology and Innovation Policy of 2013 has the potential to expand participation in science and technology to every section of society.. More importantly, the policy emphasis the need to integrate programmes of the socio-economic sectors with research and development to address national problems. The mention of women for

The author is Dean and Professor, School of Social Sciences & Head of the Education Programme at the National Institute of Advanced Studies, Indian Institute of Science Campus, Bengaluru.

the first time in the S&T policy of India has been through a short section on gender parity. The focus of this section has been on the importance of increasing the participation of women in STI activities, thus on women STI professionals. While this is a critical step to link science with society and more importantly to women in society, it does not address (though it can if it wants to) the needs of millions of women who constitute the vast majority of our society.

Having said this, it is important to recognise that the current STI policy opens two windows to allow science and technology to impact women. While the first is to build bridges between science and technology with socio-economic sectors and address national problems; the second is through an increased and real participation of women S&T professional to shape the research agenda of this country.

The advancement of science and technology has been largely pre-occupied with increased resources for R&D and make India globally competitive. In this journey, very often the priorities of STI are in consonance with global needs and often relegate the local and national needs to the background.

Science, Technology and Women

It is interesting to note that the earlier discussions in India regarding science and technology on one hand and women on the other has been constructed post independence in the domain of the previledged sections of society reflected by the English speaking, upper castes/class, men in urban areas predominantly. Thus, the earlier interface of science and technology with women was in the form of recepients of development. The previleged men from predominantly urban backgrounds were the benefactors. In an attempt to reach out to the vast majority of the population predominantly the lower castes/classes; rural; and women who were largely illiterate and still out of formal education system, scientists and technologists focused on domestic daily needs like low cost efficient fuel, drinking water, efficient agricultural equipments to reduce the drudgery of labour, among others. While science and technology research in the above areas was pursued only by a miniscule number of scientists, the vast majority of the S&T professionals were engaged in big funding projects reflecting the global agenda.

Women in Science in India

Today, the statistics of participation of women in science is extremely encouraging with almost equal participation of women in science courses in the under graduate and post graduate levels. India, unlike most countries in the west has a leaky pipeline not at the school or college levels but at the doctoral level.

Thus, as a compromise, a large number of qualified women scientists opt for under-graduate or school level teaching, while others completely drop out of science.

Despite this, women's participation at higher levels of Science in tenured research positions has shown little increase.[11] Women constitute over one-third of the total science graduate and post-graduate degree holders but comprise only between 15-20 percent of the tenured faculty across research institutions and universities in India (INSA Report, 2004). Further, the relatively higher representation of women is seen in the low status jobs (e.g. junior/ ad-hoc faculty, temporary research associates, post-doctoral fellows, etc.) in science that have been vacated by men due to their lower profitability. As Bal (2004) has pointed out, a permanent position with the ability to undertake research projects with appropriate institutional facilities, advise doctoral students, and publish is important for a stable career in science. Since competition to remain and advance in science careers begins at the earliest stage soon after PhD, it is important for women to establish themselves during their early 30s, a period that coincides for most Indian women with marriage and family commitments. Thus, as a compromise, a large number of qualified women scientists opt for under-graduate or school level teaching, while others completely drop out of science.

Even though there is recognition of this 'winding career path'[2] for women, science policy makers often ignore the willingness and need for women to stay active in research despite their other responsibilities. Absence from active research through breaks cannot be compensated for at a later stage in the highly competitive environment of science. Therefore, policies designed to provide extended maternity breaks or temporary research projects may actually not address the central problem and may instead work against the interests of women.

Keeping these factors in mind, a study was conducted by the Indian Academy of Sciences in collaboration with the National Institute of Advanced Studies in order to develop a set of recommendations from the actual experiences of and data obtained from women scientists. Acknowledging the diversity among women scientists (Kurup, A,. et.al, 2007), efforts were made to include women who have continued in science as well as those who have dropped out.

Sample and Methodology: A survey was conducted with 568 women scientists, of whom 312 were engaged in science research (WIR); 182 were engaged in positions other than long-term science research (WNR)[3]; and 74 were not working (WNW). In addition to representing the diversity among women, another unique aspect of the study was the inclusion of men scientists (161) as a comparative group.

Evidence from this study suggests that organizations play a vital role in affecting women's careers through

Data from the study debunks the common assumption that domestic responsibilities and gender-role status of women are responsible for women's drop-out. These assumptions invoke explanations of social attitudes and values and need for change at the societal level for women's poor retention in Science. Instead, the study shows that these factors can be easily addressed through a revision at the organizational and policy level.

The study reveals that despite family and childcare, women work in different ways to put in the ideally required number of 8-10 hours per day for research. While this may not be an indicator of quality, the findings convincingly disprove that myth that women cannot provide enough time for work and research after marriage and childbirth due to family responsibilities.

The data reveals that there is a largely prevalent perception by men that women's domestic responsibilities hinder their optimal performance in Science. However, there is a lack of recognition awarded to women's commitment and ability to manage multiple responsibilities, and the utility of organizational provisions in aiding women's management of career and family.

supportive or disenabling mechanisms. Women scientists report flexibility in timings to be the most useful organizational provision. This entails starting the work day earlier or ending later, depending on one's multiple domestic responsibilities.

A high proportion of women have, however, indicated not taking up previous jobs due to organizational factors such as long, inflexible hours, no room for professional growth and lack of childcare facilities compared to men. Thus, for women more than men, organizational structures that ease the work atmosphere and help balance family life are important.

Prime among the organizational recommendations made in the report is for provisions to manage multiple responsibilities – such as providing accommodation on campus, transportation, childcare and eldercare facilities, etc. While such provisions, where available, are mostly given on seniority basis, there is a need to prioritize such options for younger couples between the 30-40 years age-group, since they would be the likely ones with young children.

A compulsory gender audit with mandatory requirements for all research institutions, universities and national laboratories to provide department-wise gender breakup of students and faculty at all levels needs to be implemented.

In addition, there is a need to provide flexibility in timings to help them balance family responsibilities along with work. Flexibility does not imply work from home without spending the required hours in the laboratory. Rather, it emphasizes the need to support women's commitment to put in the mandatory number of hours at work even when children are younger through extension of office hours.

Further, an important organizational mechanism to retain women would be to introduce mentoring programmes with incentives for mentors to be accrued during the time of performance appraisals and promotions. Mentors and role models will be extremely useful to overcome the general perception among students/parents/ public that the work-life balance for women in science may be difficult to achieve.

A compulsory gender audit with mandatory requirements for all research institutions, universities and national laboratories to provide department-wise gender breakup of students and faculty at all levels needs to be implemented. Along with this, a Time-bound target Recruiting System (TRS), with an emphasis on increasing the recruitment of women to premier research institutions needs to be implemented.

A large number of women in the study (especially those not currently working) have reported **'not getting the job'** as reason for not taking up jobs. Critical research studies **on selection and evaluation procedures** that examine factors responsible for the lower number of recruitments and advancements for women, a policy on the transparency of selection and evaluation procedures will be important.

In order to increase job opportunities, exploring venture capital to expand infrastructure in science with possible patenting provisions for entrepreneurs who have invested in the research is useful. Another option would be to create entrepreneurial opportunities in Science and Technology for scientists who have completed a PhD in Science, Engineering or Medicine.

There is a need for modification of existing schemes for re-entry for women. The study has revealed that a major problem with such schemes is the short-duration of 3 years, along with delay and lack of efficient renewal process. Tere is a need to develop a long-term scheme of 5 years duration that can be renewed periodically based on performance. Dependence on institutions / guides for obtaining or continuing such projects needs to be reduced, since these clauses have led to breaks for many women. Instead, it must be made mandatory for all government universities, laboratories and research institutions to allow women scientists in these schemes to undertake research at their institutions. An advisory group, in place of a single faculty member can be constituted to review work and guide these scientists, in order to ensure their autonomy as well as availability of adequate resource personnel to them.

The study showed significant differences in the perceptions of women and men scientists with respect to women's retention in science. With men forming the majority in science organizations and on important committees, the perception that the problem lies in the socio-cultural realm would prevent the development of proactive policies that can address the issue of women's lower participation in science. Therefore, for policies to be effective, it is essential to have at least one-third representation of women. The data has shown large difference between WIR, WNR and WNW, and some differences across age cohorts. Hence, it is extremely important to implement a system of rotation to represent new members based on merit across different age groups who could provide new insights based on their experiences.

The study advocates for gender-neutral provisions that can be availed both by women and men. This is, firstly, to prevent negative appraisal of women for availing special opportunities and secondly to go a long way in redefining gender roles by providing opportunities for men too, to take on multiple responsibilities.

An essential requirement for these policies is a periodic review to evaluate the extent to which the recommendations have been implemented, or may require modification.

In conclusion, there is a need for more dialogues and collaborations between the physical scientists and social scientists to be able to unravel the complexities of women in science and technology in India. It is equally important for the STI agenda to move beyond women in science to science for women to reach STI to vast majority of women in society. It is through this symbiotic relationship between science and society through equitable participation that can realize the dream of reaching science to women in India.

Readings

Bal, V. (2005). Women Scientists in India: Nowhere Near the Glass Ceiling. *Current Science*: 88(6). pp. 872-878. http://www.ias.ac.in/currsci/mar252005/872.pdf. Accessed: 12 May, 2010; 8:30 am. Chanana, K. (2007). Globalization, Higher Education and Gender: Changing Subject Choices of Indian Women Students. *Economic and Political Weekly*: 42(7). Pp. 590-598

Elgquist-Saltzman, Inga, 1992. Straight Roads and Winding Tracks: Swedish Educational Policy from a Gender Equality Perspective. In *Gender and Education*: 4(1/2). pp.41-56.

'Science Careers for Women: **An examination of Indian women's access to and retention in scientific careers.**' Report published by the Indian National Science Academy, New Delhi . (2004).

Kurup,A., Maithreyi R, Kantharaju B and Godbole.R., (2010). Trained scientific women power: How much are we losing and why? .Bangalore: IAS-NIAS Research Report. pdf

Kurup,A., & Maithreyi.R.,(2011) Beyond Family and Societal Attitudes to Retain Women in Science, Current Science, vol.100(1) Jan. 2011, 43-48 (co-author)

Kurup, A. (In Press) Gender, Science and Technology Education in India, In Transforming Science: Feminist Perspectives in India, Vol:2, New Delhi: Stree Publishers.

Kurup, A. (2015).Will Mentoring Bridge the Gender Gap In Indian Science? In la Physique Au Canada, 71(2).

P. Shastri, A. Kurup, L. Resmi, R. Ramaswamy, S. Ubale , S. Bagchi, S. Rao and S. Narasimhan (2015). Towards Gender Equity in Physics in India: Initiatives, Investigations and Questions. India Country Paper, ICWIP, Waterloo, Canada.

Endnotes

1. Refer Bal, 2002; 'Science Career for Women', published by INSA (2004)
2. Refer Elgquist-Saltzman, (1992) for an explanation of 'winding career paths for women'.
3. WNR included those in undergraduate or school level teaching, temporary research positions such as DST women scientists schemes and consultancy or administrative posts. The defining feature of the category was working on jobs that may not require training at the PhD level. ❑

(E-mail: bkanitha@gmail.com)

Global Technology Leadership in Leather Sector

B Chandrasekaran

The mission of CSIR through CLRI is to meet the requirements of global leather sector, relevant regulatory and statutory bodies and other stake holders with continual improvement in its services, while aligning itself to the National agenda through technology innovation led solutions for the sector

CSIR-CLRI has come out with a "Game changing technology" for enabling leather sector achieve the set target of USD 27 billion by 2020 by making the leather processing environmentally sustainable. This "Waterless chrome tanning technology" is a first of its kind technology to reduce chromium pollution load. Chromium is the most sought after tanning agent with about 2.0 billion sq. ft. of leather being made in India. About 20 thousand tons of chrome tanning agent is discharged in the wastewater. The waterless tanning technology has now found Pan India acceptance, with tanners in all clusters enrolling for its adoption. This is truly a game changing technology that has emerged from the CSIR through CLRI. Significance of this technology is that a) it completely eliminates two processes before and after tanning, b) eliminates the use of water in tanning, c) reduces the total dissolved solids in wastewater from this process by 20 per cent and also d) bring down the usage of chromium by 15-20 per cent, resulting in material saving. Efforts are now on to translate this technology both nationally and globally. Several countries including Ethiopia, South Africa, The Netherlands, New Zealand, Vietnam and Brazil have evinced interest in this technology.

Historical perspective of CLRI:

Just before independence in 1945, Sir A L Mudaliar proposed the concept of the Central Leather Research Institute (CLRI) and it started as Department of Leather Technology in the University premises. A strategic institute among CSIR laboratories, Central Leather Research Institute (CLRI) established in 1948, from the very start had a strong academic and industrial linkage. A unique tripartite arrangement of industry-academy-research is a first of its kind, which is a role model to emulate for other sectors.

The Institute represents the leather sector in all its planning and policy development. Over the years, the institute is the global hub for transformation of a tradition bound industry into an innovation driven one. Technologies for bioprocessing of leather, zero waste water discharge, value added materials from leather and indigenous chemicals for processing are some of the highlighting features of this institute. CSIR-CLRI is a recognised center for testing of restricted substances, finished leather certification. CSIR-CLRI in association with other world bodies develops protocols for testing of restricted chemicals.

The author is Director, CSIR-Central Leather Research Institute (CSIR-CLRI) He is a Leather Technologist and specializes in Cleaner Production Technologies, Leather Education, Leather Product Design & Development, CAD Techniques for Leather Product Design, Organizational Development, Consultancy in R&D and Organizational Excellence. His expertise lies in Inter-Institutional Cooperation and Global R&D Consultancy.

Waterless chrome tanning

Efforts of CSIR-CLRI

Through leather technology mission in the 90s, CLRI reached out to the society, which was another feather in cap of CSIR-CLRI. National Mission Program was implemented by CSIR-CLRI for carcass recovery, raw hides and skins quality improvement, livelihood improvement of traditional artisanal clusters like Athani, in design and development of Kholapuri sandals, benchmarking of best manufacturing practises for leather and products. The recognition from Third World Academy of Sciences is a testimony to the contributions to the leather sector. CSIR-CLRI has several artisanal initiatives to its credit including artisanal empowerment programmes in collaboration with Rural Non-Farm Development Agency (RUDA) and Gujarat Rural Industries Marketing Corporation (GRIMCO). This has paved way for policy formulation for integrated development of leather sector by Government of India.

The Awakening:

Kolhapuri Couture

Athani, in the State of Karnataka, India is the heartland of Kolhapuri sandals and home to over 800 such families of artisans with a rich legacy. Footwear craft is their only

Ethnic footwear manufacture training for artisans

livelihood. Prior to year 2000 most worked as low wage-bonded labour in footwear 'factories' owned by dominant traders. Their life and craft were demeaned - they lived on the very edge.

A revolution for the evolution of "COUTURE" from the humble "Kolhapuri" was necessary.

A systematic improvement in the skills and overall economic and social well-being of the families in the Athani-Nippani belt in a holistic way was planned.

The product required an overhaul in image with respect to standardization, design and quality for greater acceptance and wider outreach.

Synergistic efforts of CSIR-CLRI, NLDP and ASCENT in this project - termed project ENTERPRICE yielded very beneficial results.

- Hundreds of families trained and skills upgraded
- Patterns standardized using Lasts and Templates
- Improved quality of leathers and other alternative materials
- Design innovation introduced
- Standardization of manufacturing methods established
- Improvement in productivity demonstrated

Design and Development of North East Ethnic Material and Leather combination products

The aim is to promote ethnicity of the local people and help them

improve their economy and lifestyle especially that of womenfolk as women are mainly associated with this activity. CLRI is working in collaboration with NEIST (North East Institute of Science and Technology) for the development of novel leather products based on ethnic designs. An expert team under the guidance of CLRI carried out a comprehensive physical survey in the north eastern region and identified development opportunities for leather and allied sector. Ethnic materials available in that region were collected and studied for their colour and material properties. A range of products were designed by CLRI so as to increase its elegance and value by combining leather with the ethnic material in such a way that it does not affect the real outlook and ethnicity of the product.

Growth of any industry strongly depends on the availability of associated skill as well. CSIR has a strong mandate to develop, train and re-train the required manpower for this sector. About 60 per cent of the skilled manpower in leather industry is from CSIR-CLRI. The institute hosts nearly 700 students at any point of time. Currently CLRI has more than 30 different types of training programs. Training comes at all levels, be it the technical

degrees or vocational programs, the institute has tailor made programs to suit the needs of the industry from time to time including reaching the unreached and under-privileged sections of the society. The National Scheduled Castes Finance and Development Corporation and Andhra Pradesh Scheduled Castes Co-operative Finance Corporation Limited have joined CSIR-CLRI in skill development initiatives. Through these programs the ministry envisages

- almost 30 per cent enhancement of per capita income of 10000 people in different villages
- improvement in social status significantly
- standardization and global visibility to Indian ethnic products

The Travel of India in 'fashion forecasting' for Leather

In a globalizing economy, design is being perceived as a new engine of economic and industrial growth.

Fashion Hand Bag – Inspired from Head Gear

> Leather has emerged as a fashion product. Colour, texture and other highlights add to the fashion values of creatively designed leather products. These add significantly to the value realization from leather products. "To emerge as a strong global player in the world leather trade, all efforts to take proactive measures to be ready with the fashion leathers when the fashion does emerge, is crucial."

Design and breakthrough innovations can play a pivotal role in positioning of Leather and Leather Product industries in the global arena by value addition apart from enhancing competitiveness. In association with the industry stakeholders, CLRI forecasts for the world, the colour and texture trends for leather and products, 18 months in advance. With the colour card for the world being developed in India, this has given Indian leather sector a niche edge in the fashion market.

Getting one Indian colour into the Modeurop Colour Card in 1994 was a matter of prestige. Today, we have almost 70 per cent of the colours chosen, featuring from Indian proposals. The challenge and opportunity today is to capitalize on the winning colours and translate them into fashion products.

Global Colour Shade Card is first released in India giving a tremendous lead time over the competition.

Through the institute, Indian leather sector strives to achieve economic and environmental sustainability, leading to more than doubling of the annual turnover from the present in about 4 years. CSIR has been hand holding the industry since its establishment and has taken the export turnover of Rs 40 crores in 1960s to Rs. 40,000 crores in 2015 through technological interventions, training and service. The re-enabling of the tanneries in Tamil Nadu in 1996 stands a strong testimony to the contributions of this organisation.

Over the years, CSIR-CLRI is the global hub for transformation of a tradition bound leather industry into an innovation driven one. CSIR-CLRI's role in R&D consultancy has paved way for other sectors like metal, food, pharma and chemicals for similar interventions and positioning themselves globally. The mission of CSIR through CLRI is to meet the requirements of global leather sector, relevant regulatory and statutory bodies and other stake holders with continual improvement in its services, while aligning itself to the National agenda through technology innovation led solutions for the sector. ❑

(E-mail:directorclri@gmail.com)

Modeuropcolor roundtable for fashion forecasting

Historic Move to end Corruption and Black Money

In a historic move towards ending corruption, black money, money laundering, terrorism and financing of terrorists as well as counterfeit notes, the Government of India announced a massive demonetization drive on 8th November 2016. In a live address to the nation, Prime Minister declared circulation of all ₹500 and ₹1000 banknotes as invalid and announced the issuance of new ₹500 and ₹2000 banknotes.

Key provisions of the move are as follows:

- Five hundred and one thousand rupee notes cease to be legal tender from the midnight of 8th November 2016
- Notes of one hundred, fifty, twenty, ten, five, two and one rupees continue to remain legal tender.
- Accepting the recommendations of the RBI, two thousand rupee notes and new notes of five hundred issued.
- Old notes of ₹500 and ₹1000 allowed to be deposited in banks and post offices from 10th November to 30th December 2016 without any limit.
- Cash withdrawal from banks limited to ₹10,000 per day and ₹20,000 per week. (This was later increased to ₹24,000 from 14th November and the withdrawal limit of ₹10,000 was also cancelled.)
- Exchange of old notes of ₹500 and ₹1000 allowed at banks, head post offices and sub post offices with valid ID proof. A limit of ₹4000 (later increased to ₹4500/- and further revised to ₹2000/- per person) set for exchange upto 24th November 2016.
- Withdrawal from ATMs restricted to ₹2000/- which was later increased to ₹2500/-.
- No restriction on any kind of non-cash payments by cheques, demand drafts, debit or credit cards and electronic fund transfer.
- On humanitarian grounds notes of five hundred and one thousand rupees were accepted at government hospitals, pharmacies in government hospitals (with prescription of a doctor), booking counters for railway tickets, government buses, airline ticket counters, petrol, diesel and gas stations of PSU oil companies, consumer cooperative stores authorized by the state or central government, milk booths authorized by state government and crematoria, burial grounds.
- It was later decided (15th November) to introduce indelible ink used during elections for over the counter exchange against old ₹500/- and ₹1000/- notes to prevent misuse of exchange facility and enable larger number of persons to draw cash.

  The government announced some new rules on demonetisation on 17th November.

- Families allowed to withdraw ₹2.5 lakh for weddings from one account of either of the parent
- Farmers allowed to withdraw upto ₹25,000 in a week against sanctioned crop loans and credit it to their accounts
- Central govt employees up to group C allowed to draw salary advance up to ₹10,000 in cash that would be adjusted against their November salaries.

This is a continuation of a series of measures taken by the government so that the menace of black money is overcome. The very first decision of the present government was the formation of a SIT on black money. A law was passed in 2015 on disclosure of foreign bank accounts. In August 2016 strict rules were put in place to curtail benami transactions. During the same period a scheme to declare black money was introduced. Over the past two and a half years, more than ₹1.25 crores of black money has been brought into the open.

(Updated up to 17th November, 2016)

Published on 23 November 2016
Posted on 25-26 November 2016

Regd. No. RNI 949/57
Licenced U(DN)-56/2015-17 to post without
pre-payment at RMS, Delhi (Delhi Post
Postal Regd. DL(S)-05/3230/2015-17
No. Pages 76

Printed & Published by Dr. Sadhana Rout, Additional Director General and Head on behalf of Publications Division, Soochna Bhawan, C.G.O. Complex, Lodhi Road, New Delhi - 110 003. Printed at Chandu Press, D-97, Shakarpur, Delhi-110 092 Phone: 22424396, 22526936.