SCIENCE FOR DEVELOPMENT

STRENGTHENING THE S&T ROAD MAP

Introduction

- The Department of Science & Technology, Government of India, serves as the model agency for all government led initiatives that create and strengthen the science & technology in our country.
- The DST accordingly co-ordinates with several other department, stakeholder to develop these policies & implement programmes to serve this important mandate.

Here's a peek into some major initiative to meet the goals and the robust roadmap for way ahead:

National Supercomputing Mission (March 2015)	Partners with Dept. 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 facility.
Impacting Research Innovation & Technology (IMPRINT)	Partnership with MHRD, to address major societal and developmental needs as healthcare, information & communication technology, water resources, security & defence, environmental & climate change etc
A Joint R & D initiative with Ministry of Railways	For fuel efficiency enhancement, alternate fuel, fuel conservation in diesel traction etc
Early Career Research Award (ERCA)	To provide rapid research support to researches in early career stages. To attract & retain young scientists discourage brain drain in academic/R & D institution through National Postdoctoral Fellowship (N-PDF) scheme.
Attracting Women to Science	Enables gender parity through a scheme called **Knowledge Instrument in Research Advancement through Numbering (KIRAN)**
Social Benefits Delivered (Energy benefits, Wealth from waste etc.)	• **Surya Jyoti** (to light up homes of poor) – In order to capture

	daylight and concentrate the same inside dark living spaces. A low cost, energy efficient lamp useful particularly for urban slum or rural areas which don't get electricity supply. • **Indigenous technology for rural industrialization –** integrates use of local resources in the rural areas with sustainable industrial activities. E.g. – Rural industry complex in a plot of wasteland at Malunga, a village in Jodhpur (Rajasthan) • **North-Eastern Centre for Ethno Medical Research:** undertake ethno-phyto-chemical research on wild herbs available in N-E region with medicinal & aromatic properties which will also help improve socio-economic status and enhance quality of life of local community.
Going Global Through Mega Projects	
Thirty Meter Telescope	• At Mauna Kea, Hawaii • Collaborated with USA, Canada, Japan, China • Contribute towards the construction phase.
Associate Membership of CERN	• CERN is the world's largest nuclear and particle physics laboratory • To probe fundamental structure of Universe
Laser Interferometer Gravitational wave observatory (LIGO)	• India has agreed in principle to setup an advanced gravitational wave (GW). • Inter-University Centre for Astronomy and Astrophysics (IUCAA), Pune, Institute for Plasma Research, Gandhinagar

	and Raja Ramanna Centre for Advanced Technology (RRCAT), Indore are collaborating with LIGO Labs 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 telescope was installed at Devasthal (Nainital) • It is the largest steerable imaging telescope in Asia and is result of collaboration between Aryabhatta Research Institute of Observational Sciences (ARIES) & DST & Belgian Scientist • will help for frontline scientific research in astronomy and astrophysics
Collaboration with Italy	Trieste based sincrotrone Elettra in Italy opened its 2 new operational stations XRD2 & Xpress which will research on new materials pharmaceuticals and biotechnologies
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, will assist research in field of atomic, nuclear particle and plasma physics.

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Conclusion:

The objective of DST, is to position India among the top 5 countries in scientific research by -

- augmenting the R&D infrastructure
- enhance number of active scientist

  - quality/relevance/impact of research to reverse brain drain for brain gain for societal and industrial development & attract youth to study and pursue career in science and technology.
- Also DST will intensify industry – academic R&D partnership, to find solution to national challenges pertaining to energy, water, health, environment, climate & cyber security.
- In order to create a robust S&T led innovation and start-up ecosystem, DST has developed National Institute for Developing and Harnessing Innovation (NIDHI) to cover entire innovation chain from scouting and mentoring to up scaling the starting.
- Citizen engagement is an important thrust of the DST. The Science Express is a classic initiative that serves this especially for the benefit of children across the country.
- Therefore DST is continuously working to further strengthen India's leadership in these areas and continue deliver value added services for benefit of our country as a whole.

SPACE BASED PLATFORM FOR COMMON MAN

Introduction:

The Indian space programme started 20 years late than developed countries but today it has emerged as one among the six leading space facing nations by achieving self-reliance in technologies for building powerful rockets, satellites for earth observation of communication etc.

Historical Background:

- Indian space programme started with a launch of rocket from beaches of Thumbain 1963 carrying a payload to study the winds in upper atmosphere and ionosphere.
- For space exploration, a Space Science and Technology Centre at Thumba had been set up. Later, this becameVikram Sarabhai Space Centre.
- The SLV 3 was the first launcher which placed a 50 kg Rohini satellite into earth’s orbit in 1980.
- Aryabhatta and Bhaskara were the first two satellite developed for establishing our competence in space craft technology.

- India is the only country which embarked on development of space programme in civilian domain and scientist Dr. Vikram Sarbhai has not only seen the potential of space technology but also its application for benefit of common man.

Space technology: Tool for socio-economic development through the benefit of common man

(a) **Mapping & Monitoring cultivated areas** by providing early warning of pest attack & drought condition. This helps farmers in taking corrective action and in fertilizer movements and date for crop issues.

(b) **Forest Coverage:** Managing periodic monitoring of environment and detect damages if any by human intervention or natural countries like forest fires etc.

(c) **Assessment of Water Coverage:** Assessment of quality of water in ponds, lakes & dams help in better water management. A pilot project namely **'Rajiv Gandhi drinking water mission'** initiated by ISRO is unique in using satellite images to identify potential zones for water and information is used for digging of bore wells in states like Rajashtan & Madhya Pradesh.

(d) **Identification of potential fishing zone:** By analysing colour of ocean, surface temperature and wind condition, Oceansat can identify areas in sea where fish will assemble & such data is communicated to fisherman helping them to improve yield.

(e) **Watershed development:** Using remote sensing, water bodies around a region are assessed. Also, the suitability of land is assessed which in turn helps in developing a sustainable cropping pattern.

(f) **Geostationary Communication Satellites:**

- Communication and DTH television through these satellites is most effective and far reaching, connecting this vast country sparking nearly 3.29 million square Km.
- In disaster management these satellite can communicate in case of energy to remote and in accessible places.
- In 1975, an initiative with NASA named **Satellite Instructional Television Experiment (SITE)** – intended for beaming socially relevant TV programmes to remote villages aiming at educating villages on health hygiene and good agricultural practices was launched by ISRO.

(g) **Telemedicine:** Through this patient information is sent to specialist via the satellite and doctor can conduct tele conference with patient, can provide prescription or advise to follow by patient. Today about 382 hospitals in rural & semi-urban areas are connected to about 60 super specialty hospitals in metros & more than 3 lakh patients are getting benefited from this.

(h) **EDUSAT:** ISRO launched EDUSAT in 2004 to meet demand for an interactive satellite based distance learning education system for country today about 60,000 classrooms are connected in EDUSAT network.

(i) **Disaster Management:** In this case satellite provides instantaneous assessment of damages & inputs for mitigation measures.

In case of cyclones and heavy weather incidents INSAT identify them and early warning can be issued. This information can be used by authorities to evacuate disaster prone area and

avoid loss of life. INSAT satellites also have transponders to relay distress signals from boat, ships or aircrafts when they are in danger, helping in resource and search operation.

(j) **Use in GPS:** ISRO has developed its own navigation system (IRNS) to provide more accurate position and timing signals over Indian region & its neighbourhood.

Conclusion:

ISRO has truly lived up to the vision of Dr. Sarabhai in mastering the complex technologies of Rockets and spacecraft. It has also made innovative application touching the lives of people.

A survey conducted by an independent agency had brought out the direct and indirect benefits for exceeded the investment made by government and helped India to become world leader in application of space technology for improving quality of life for common man.

EARTH SYSTEM SCIENCE FOR PUBLIC SAFETY

- The Ministry of Earth Science (MOES) was established in 2006 by bringing all the agencies specializing in weather and climate service and ocean developmental activities under one umbrella.
- MOES holistically addresses all aspects relating to Earth system processes for providing weather climate, ocean, coastal, hydrological and seismological services.

Earth System Science:

It deals with all the five components of the Earth System, viz., Atmosphere, Hydrosphere, Cryosphere, Lithosphere and Biosphere and the complex interactions among the component.

- The Vision of 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.

Major Achievements:

- Quality of weather and climate services has improved through the augmentation of atmospheric observational network, including Doppler Weather Radar Network. It helped in strengthening of data assimilation efforts.
- New Monsoon Mission was launched in 2012. It has used two dynamical prediction systems to predict the amount of rainfall in India. It has been successfully predicting short to medium range (upto 10 days), extended range (upto 20 days) and seasonal forcasts since then.

- India has developed first version of **Earth System Model (ESM)** with reasonably good fidelity in simulating the present climate. The ESM will be the first model from India to contribute to the forthcoming sixth Intergovernmental Panel on Climate Change (IPCC).
- Agro-metrological advisories for farmers is being provided by Indian Metrological Department which is, at present benefiting around 2.54 crore farmers directly and making them earn more profit.

Agro metrology is the study of weather and use of weather and climate information to enhance or expand agricultural crops in to increase crop production.

- Improvement in track and intensity forecast of tropical cyclones. Accurate forecasts of recent cyclones, Phailin & Hudhhud saved many lives.
- Air pollution monitoring & forecasting network was established at Delhi, Mumbai and Pune to monitor air quality generate air quality forecasts.
- A state of the art High Attitude Cloud Physics observatory at Mahabaleshwar, Pune was established for aerosol and cloud observation.
- It has established a large ocean observing network for Indian Ocean which includes moored buoys, coastal moorings, high frequency radars and AGRO floats etc.

What is Agro float?

An international collaboration that collects high quality temperature & salinity from the upper, 2000m of the ice-free global ocean and currents from the intermediate depths.

- A state of the art **tsunami early warning system** for Indian Ocean rim countries established at Indian National Centre for Ocean Information Science (INCOIS) {an autonomous organization of 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 IOR countries.
- 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.
- Some of the achievements in developing relevant ocean technologies with the help of National Institute for Ocean Technology (NIOT) are:
  - Installation of **desalination plants** in three islands of Lakshdweep using a process based on low temperature thermal technology.
  - An **Autonomous Coring System (ACS)** for finding gas hydrates occurrence
  - A **remotely operable vehicle** for deep water survey and exploration
  - An **Open Sea cage culture** technique for farming fish in open seas has been demonstrated off the Andhra Pradesh coast.
- Ministry along with other institutions made detailed survey & mapping of an area of about 1.6 million sqkm of exclusive economic zone (EEZ).

- Another major achievement was survey and exploration environmental impact assessment and technology **development for exploration of polymetallic nodules (PMN)** in the central Indian Ocean.
- A new research **station 'Bharati'** – a state of the act facility was commissioned at Larsemann Hills, Antartica in March 2012 – focusing on reanographic studies and phenomenon of continental breakup.
  - A research station **– Himansh** was established in Himalayas with several monitoring system to support field survey and laboratory studied in Himalayas.
- A national centre for seismology (NCS) at New Delhi to provide added twist to seismological research in country.Also a major programme on **"scientific deep drilling in the Koynaintra plate seismic zone**" was launched to setup deep borehole observation to unveil the sources governing seismicity in stable continental region.

Vision for 2030:

There is considerable scope for further accelerating the current initiative to enable the country become global leader and for this MOES is taking into account the strength and in working to words its improvements and accuracy for future. Accordingly, a vision document has been prepared for next 15 years (up to 2030).

Features of this document:

1) Farmers require weather forecasts at block level and for this an advanced weather prediction system with high resolution will be required. Hence the present district level advisories will be extended to block level and will be disseminated through 660 district centers by 2019.
2) As global warming is increasing and so increases the frequency of natural disasters and this requires more accurate prediction for its effective management which will involve a new modeling and observational strategy of probabilistic forecasts including establishment of research test beds. A separate program for prediction of severe weather and climate events is therefore envisaged.
3) To strengthen ocean services, the present observing system should be sustained and expanded by including robotic observing system, also to develop advanced high resolution ocean modeling system for predicting the variability of the Indian Ocean.
4) Ministry is also planning to expand its activities on Ocean survey and exploration, with a view to support the Blue economy, initiative of GOI, which will involve conducting bathymetric, geophysical and geological surveys and EEZ.
   - Ministry has also planned to develop on centre of excellence for deep sea research to pressure research on deep sea exploration.
5) To fulfill its mandate of exploring the polar regions, it is envisaged to strengthen scientific activities including observations at these poles.
6) Ministry is also planning to provide excellent services in multi-hazard early warning system like
   (a) Tropical cyclones and associated damages over Indian seas.
   (b) Severe weather condition (ex- heavy rain, Food, Air pollution etc.)
   (c) Location specific now casts of thunderstorm, wind storm a lightening etc.

(d) Hydrological Information system and Food warning support – for all major river basins of country.

Conclusion:

Other future scientific initiative envisaged are strengthening of climate sciences, development of research test beds and process studies, urban meteorology and studies and regional hydrological cycle including development of flood warning systems.

- Ministry will also be investing on basic research, infrastructure and human resource development & further development of international collaboration.
- Thus, ministry is committed to excel in providing weather, climate, ocean, coastal and seismological service and to be global leader in providing these services.

ATOMS IN THE SERVICE OF THE NATION

"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 knowledge of how to release & use atomic energy must be recognized as third epoch of human history" – Homi Jehangir Bhabha.*

- The journey of Indian Atomic Energy programme began in 1954, with the founding of the Atomic Energy Commission (AEC) under leadership of Homi Bhabha.
- Since then much has been achieved in the sphere of power of atom which can act as 'Atoms For Peace' and can benefit all mankind.

Some of the applications are:

1) Health – Care to Cure

- This is one of the most important peaceful use of atomic energy
- Presently, helps nearly 6,00,000 patients annually in India in investigation of diseases.

(a) **Nuclear Medicine** is a medical specialty that uses trace amounts of radioactive substance in the diagnosis and treatment of a wide range of diseases and conditions in a safe and painless way.

- This procedure helps in identification of abnormalities in organ function even in very early stages of disease such as cancer, neurological (Alzheimer's, Parkinson's) & cardiovascular disease.

(b) **Targeted Radionuclide therapy** also called molecular radio-therapy.

- It involves radioactive drug called as radiopharmaceutical that targets cancer cell and designed to deliver therapeutic doses of ionizing radiation to specific disease sites.
- This therapy is widely used in the treatment of neuroendocrine cancers, bone pain palliation, entire gamut of Thyroid problem etc.

(c) **Radiation Therapy** is a treatment involving the use of high energy radiation either by using special machines or from radioactive substance.

- The aim of therapy is to impact specific amounts of the radiation at tumors or part of body to destroy malignant cells.

(d) **External Beam Radiotherapy** also called tele-therapy. It is most common form of radiotherapy in which the radiation at tumor is given from outside the body.

- It can be used to breast cancer, bowel cancer, lung cancer etc.

(e) **Brachytherapy** is an advanced cancer treatment.

- Radioactive seeds/sources are placed in or near the tumors itself, giving a high resolution dose to tumor while reducing radiation exposure in surrounding healthy tissues.
- This is mainly used to treat prostate cancer.

2) Food Security – Supplementing the food basket:

India has ever growing population which poses a great demand on food security and this gives a call to technology driven sustainable management of natural resources for achieving food, nutritional, environmental & livelihood security.

(a) **Nuclear Agriculture:** In this the ionising radiation is used to induce mutation in plant and thus creating a new and improved variety which may show desirable attributes such as high yield, pest resistant, resistance against biotic and a biotic stresses, large seed size, earliness etc. *For example*: BARC has released different verieties of plant to Indian farmers for commercial cultivation which include groundnut, soybean, cowpea, mustard etc.

(b) **Food Preservation (Produce & Preserve):** As mentioned above food security is the need of hour for India. Therefore, preservation comes as in other important factor. As one of the main tragedies of Indian agriculture system is that 30% of food produced is lost due to spoilage because of pest attack, moulds or contamination.

Thus, to stop this and to bridge demand supply gap – radiation processing can provide a viable effective and eco-friendly, and also alternative to chemical fumigants and microbial decontamination as they affect human health and environment.

This technique involves exposure of food & agriculture commodities to controlled doses of radiant energy which can:

- help disinfestations of insects/pests
- delay ripening and senescence of fruits and vegetables
- Inhibits sprouting in tubers, bulbs, rhizomes
- Prevent microbes from spoiling food etc.

3) Energy Security – Nuclear is clean & green:

Global warming is making climate change drastically and CO_2 levels have reached an unprecedented 400ppm and temperature rise of more than 1ºC has taken over in last 3 decades.

- So, nuclear energy opens the door for energy security as being a low carbon footprint industry as compared to fossil fuels.
- Also, India being growing economy and international obligations to control CO_2 emission. Therefore, India needs to rapidly ramp up power production using nuclear energy.
- With 21 operating plants and 12 plants in pipeline; we have poised a period of enhanced growth in this sector.

4) Societal Application – Towards the common Good:

(a) **Sludge Hygenisation(From waste to wealth**):radiation technology has been used to hygenise the sludge to protect public health and environment and in addition, manufacture the manure with desirable qualities for use in farming sector. For instance: Ahemdabad Municipal Corporation has setup first plant in India and takes 100 tons/day of sludge.

- This technology has high potential in helping towards "Swachh Bharat Mission".

(b) **Hydrogel-Healing the wounded:**

- A thin transparent sheet of gel, useful in burn and injury dressing.
- Hydrogel provide moist environment and a cooling effect on the wound due to a regulated oxygen supply to wound through a sterile cover.

(c) **Water – the Elixir of Life:** As water is becoming sequence, but demand is ever-increasing, therefore, isotope hydrology technique enable accurate tracing and measurement of the extent of new and renewable underground water resources at various location.

- Also it is used for monitoring surface water resources for leakages through dams and litigation channels etc.
- Technologies of BARC have also developed a membrane for filtration for removal bacterial contamination and for desalination of brackish water as well as sea water.

5) **Industrial Application – Support to Manufacturing Sector:**

(a) **Radiation sterlisation of Medical Products:** Products such as syringes, cotton, wool, surgical gloves, bandages, ointments, biological preparations such as bone, nerve, skin etc. are sterlised using these radiations.

(b) **Radiography:** Which emit gamma rays can be used to check welds of new gas and oil pipeline system, which have radioactive sources being placed inside.

- Also it can be used to gauge the thickness and density of materials or locate components that are not visible by other means.

Conclusions:

The benefits of atom and radiation energy as discussed above are leading to economic & societal benefits to nation and will continue to be leveraged for a considerable period in future.

These techniques have the potential to bring paradigm shift in whichever sector they are applied.

HIGH-END DIAGNOSTIC FOR HEALTH CARE

Major advancements in science and technology have allowed healthcare decisions to become increasingly granular over-time. But we still have to go long way to understand that why different individual experience disease or responds to treatment differently.

Therefore, a new field in healthcare called "Personalised medicine" is need of time. The goal of personalised medicine is to streamline clinical decision making by distinguishing in advance those patients who are most likely to be benefited from a given treatment from those who will only incur cost and suffer with this treatment.

This tailored intervention for giving precise medicine needs information about patient's genome history which can be done through following:

1) Genetic diagnostics:

Personal genomics is the branch of genomics concerned with sequencing and analysis of the genome of an individual.

- It helps in determining disease risk for common diseases, genetic predisposition towards a disease and thus may help you to determine how to alter your environment and behaviour to avoid the disease.

2) Micro fluidic systems:

This is science of designing, manufacturing and formulating devices and processes that deal with volume of fluid on order of nanolitres (10^{-9}) or picolitres (10^{-12}).

- This micro fluidic systems have diverse and widespread potential such as
  - blood cell separation equipment
  - biochemical assays
  - chemical synthesis
  - genetic analysis – drug screening
  - electro-chromatography – laser ablation etc.
- The major advantage of micro fluids is that it allows for the manipulation of small volumes of liquids in micro fabricated channels and ability to perform all analytical steps, including sample pretreatment reaction, seperation and detection on a microchip in an effective and automatic format.

3) Stem Cell Therapy

Treatment of patients with various degenerative diseases, the regeneration of injured and diseased tissues has always remained a significant challenge.

Therefore, with advancement of cell biology and material sciences, stem cell approach came forward where patients,own cells are transformed into model for studying disease and potential treatment to negate the chances of rejection.

4) Gene Therapy:

Under gene therapy normal genes are introduced into cells in place of missing or defective ones in order to correct genetic disorders. Based on genetic makeup, personalized medicine may be worked out.

For example: Allelic variants of a particular gene are found to be associated with increased risk of malaria and even injection severity. Based on the information of genetic makeup of an individual personalized gene therapy may be employed to reduce the chances of infection and disease progression.

5) DNA Chips also called DNA micro assay – These are solid supports usually of glass or silicon, upon which DNA is attached in an organised grid fashion, each spot of DNA called probe, represents a single gene which helps in easily looking up each person's genetic predisposition to various diseases and help tailor their medical services.

Conclusions:

- We are moving in new era of scientific advancements in healthcare through precision medicine/personalised medicine.
- Medical devices that are minimally invasive, accurate, durable, user friendly and low cost can be used to improve diagnostics, prevention and therapeutic monitoring, which further can be used to meet the need of individuals.

SCIENCE & TECHNOLOGY IN SUSTAINABLE DEVELOPMENT

The recent instance of deteriorating air quality of country and capital after festive season led to use the metaphor of gas chamber for atmosphere with low and stagnant wind, refusing to dilute the noxious pollutants.

Threats, in even forms, thus loom large, challenging our ambitions programmes on Swachh Bharat, breathable air, clean flowing waters in are rivers and streams, healthy terrestrial & aquatic ecosystems.

Therefore, progress of science can be utilized for well being of humans of which environment protection and sustainable development is an integral part.

S. No.	Area	Issues	Technology Status/Requirement	
			Technology expected by 2025	**Technology expected by 2035**
1.	Urban Environment	(a) Quality of a water air in cities	• Clear coal technology • Alternate fuel based transportation • Real time aquifer monitoring	• real time dense spatial quality monitoring • Insitu water purification in pipeline • Self healing pipeline
		(b) Municipal Solid Waste Management	Plasma technology proper design of collection segregation, transportation and compacting system. Development of more efficient biological processes	Treatment of waste at source
		(c) Electronic Waste	Cost effective recovery of precious metal	Technology to reuse 100 per cent waste
		(d) Biomedical Waste	Re-designing of biomedical equipment to facilitate segregation and reuse	
		(e) Sustainable building	Space conditioning technology software for designing of buildings	Research and development for mobile building (modular and portable structure technology)

2.	Green House Gas Minitation & Air Pollution	(a) Clean Energy Technology	• Using Thorium for power generation • Carbon capture by using algae from flowgas. • Advanced fossil fuel extraction • hydrogen energy Bio refineries	• Advanced fossil fuel interaction. • Microbial fuel cells • Zero energy artificial lightening
		(b) Vehicular Pollution	• Development of high power to weight ratio • Storage batteries with fast recharge and long life time.	
		(c) Mining & Processing technique	• Polymers need to be non-toxic & biodegradable • Grouping it with solid waste management we need to advance in science for biological remediation	
3.	Natural Resource Management	(a) Water conservation		
		(b) Soil conservation and reclamation	• Cultivation technology in problem soils (acid, saline & salt effected) • Development of crop varieties (including genetic engineering) resistant to high pH values	
		(c) Forestry		

		(d) Sustainable use of Biodiversity and traditional knowledge	• Using capture recapture modeling through usage of camera traps & software PRESENCE and MARK.	• Molecular biology can be tool for de-extinction
4.	Industrial Environment	(a) Industrial waste water	Low cost treatment at source to make it a resource material	No generation of waste, all to be recycled
		(b) Industrial solid waste	Immobilization technology (biological and chemical for leachable solid waste)	
		(c) Oil contamination	Remediation through nano material for bio and non bio components.	
5.	Agricultural Environment	(a) 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.	
		(b) Contamination of food/drinking water chain	• Research on faster biodegradation of pesticides. • Lowering/shortening half life of pesticides • Development of paste/disease resistant crop	Development of cereals/ crop variety with nitrogen fixation properties.

			varieties • Biological disruption of pest cycle	

- All these benefits of science and development will also help in fulfilling the goals of SDG (sustainable development goals) such as:
  1) targets on thriving lives & livelihood
  2) sustainable food security
  3) sustainable water security
  4) universal clean energy
  5) Healthy & productive ecosystem – which have to be achieved by 2030.
- Science research will also play in important role in meeting other international commitment like the CBD (Convention on Biological Diversity), Ramsar convention (for wetland conservation), UNCCD (United Nation Convention on Combating decertification), CMS (Convention or Migratory Species) etc.
- For example, Camera traps and software PRESENCE and MARK helped in improving the tiger census techniques.
- For making all this come in line, so that science and development also leads towards sustainable development, TERI (The energy research institute) have been organising the Delhi sustainable development summit since 2001. In 2016, the world sustainable development summit was organised in New Delhi.
- Also DST (Department of Science & Technology) which organises the biannual National Children's Science Congress (NCSC) has declared "Science, Technology and Innovation for Sustainable development" as the theme for year 2017.

Conclusion / Way Forward:

Advancement in S&T is a double edged sword and the solution provided by it must not be counterproductive. Global apprehension in Gene therapy and usage of Genetically Modified Organisms (GMO) needs to be addressed. This is pertinent in the context of the spate of suicides by Indian farmers using GMO.

Also certain factors such as dismal investment in R & D, less than 1% of GDP contribution and bureaucracy – scientific community divide needs to be improved and taken case off.

The time has arrived where we need to 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.

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SCIENCE & TECHOLOGY FOR MAKE IN INDIA

- Manufacturing sector contributed only 17% to India's GDP in 2013.
- So the government is trying to push for revival in this sector through 'Make in India' 2015 and 'start up India – 2016' which could usher a new lease of life in this sector.
- Both these initiatives are laudable and these can become more meaningful if steps are taken to enhance the R & D & production capabilities of manufacturing sector for sustaining better production and competitiveness.
- One can notice, that countries like China, South Korea and Taiwan have growing rapidly in their manufacturing sector by paying attention toword R & D (Research & Development) on innovation. Thus, making use of science technology and innovation (STI).

India's Position (A Comparison with China)

To revive the manufacturing by India firms, it is necessary to look at India's position with respect to China in economic, S&T, manufacturing and innovation indices to draw certain lessons:

		1996	2013
1. GDP share in world	India	3.43%	5.77%
	China	6%	16%
2. Technology & Skill intensity of export	India	7%	7%
	China	12%	26%
3. Competitive Industrial Performance (which benchmarks countries ability to produce & export manufactured goods) Ranks	India	42	
	China	7	
4. Share of R & D in GDP (in last 2 decades)	India	< 1%	
	China	2%	

5. No. of R & D personnel per million remained more or less same for India but grown 2.5 times in same period for China.
6. Global competitiveness Index (which is defined through a set of institutions, policies and factors that determine the level of productivity condition of public institution & technical conditions) has gone drawn from 49 (2009-10) to 71 (2014-15) for India and China improved from 29 to 28 in same period.

MSME role in Make in India: STI perspective

- MSMEs are second to agriculture in terms of GDP contribution and contribute 45 per cent of manufacturing and 40 per cent of exports.
- However, there has been a decline in the share of MSMEs towards manufacturing and exports largely because of China's emergence.
- While China has been recognized as efficiency driven economy by the

Global Competitiveness Report, India is still seen as a factor driven economy(factor of production being cheaper in India).

- Revival of MSMEs is must in order to achieve success in Make in India programme.
- A survey report has mentioned that small firms in India are basically "innovation shy" and they are complacent with survival in market rather than indulging in innovation for growth.

Lessons from China:

The phenomenal rise of China within a short span of time is attributed to its strategic push on manufacturing. Share of China in world manufacturing was 23.2% followed by U.S with 17.2% in 2013. China has thus amassed significant capabilities in manufacturing as it has not only boosted investment in S & T but has also taken steps to build its National Innovation System (NIS).

1. To boost S & T capabilities and catch-up with the world, China took series of proactive initiatives in generating and augmenting its human resource by implementing a number of programmes and policies by university modernization.
2. Also the focus of Chinese universities was changed from education to research and to commercialization from 1980's. This helped its universities to setup their own enterprises to counter problems of technology markets.
3. For commercialization of research results, state council launched the TORCH programme which targeted commercialisation of research results from universities, research institutes and high tech industries.

Therefore to make its manufacturing competitive China took major policy initiatives such as targeted funding reforms, restricting of research institutes, consolidation of links among research academic and industry, commercialization by the creation of technology market, creation of S& T parks etc.

Thus, we can conclude that to support and sustain manufacturing without strengthening the institutions related to science, technology and innovation is not possible. We have to target our entire innovation infrastructure including research institution, universities, S&T parks, support structures, fiscal and financial instruments, etc.

Conclusion:

The globalization has brought in ample opportunities and challenges for India. As manufacturing holds the key towards development it stands on three important pillars:

1. Innovation competitiveness
2. Research & Development
3. Human Resources

Though India has progressed well in last 3 decades but there are issues with innovation competitiveness in the manufacturing sector. In order to promote competitive manufacturing, sustained initiative for introducing efficient production processes, improving product quality & introducing new products and improving technologies are required.

- To make 'Make in India' successful, there is need to strengthen the manufacturing by production sector which is dominated Micro small and Medium Enterprises (MSME) sector.
- Therefore, MSME sector requires a dependable innovation support system which can spark the dynamics of innovation in MSME sector by making innovation proactive and help India to contribute a share in manufacturing to 25% and job creation of 100 million by 2022.

GLOBAL TECHNOLOGY LEADING IN LEATHER SECTOR

Introduction:

Council of Scientific and Industrial Research Central Leather Research Institute (CSIR-CLRI) came up with game changing technology named "**Waterless Chrome Tanning Technology"** for enabling leather sector achieve the set target of US$ 27 billion by 2020 by making leather processing environmentally sustainable

What is Waterless Chrome Tanning Technology?

This technology is crucial in addressing present challenges faced by humanity such as global warming and depletion of water resources. It uses given solvents alternate to water such as ethanol, ethyl acetate & ethyl lactate for both pickle based and pickle less tanning.

Significance of the Technology:

1. Eliminates the use of water in tanning
2. Reduces the total dissolved solids in waste water from this process by 20%
3. Brings down the usage of chromium by 15-20%, therefore reducing chromium pollution load.
4. It completely eliminates two processes before and after tanning.

Efforts of CSIR – CLRI:

The institute represents the leather sector in all its planning and policy development and over the time, institute has helped in transforming tradition bound industry into an innovation driven one. Some of its efforts are as follows:

1. Kolhapuri Couture:

Athani (Karnataka) is heartland of Kolhapuri sandals and over 800 families of artisans follow this legacy and footwear craft is there only livelihood. Therefore CLRI's evolution of COUTURE from humble Kolhapuri led to systematic improvements in the skills and overall economic and social well being of families in Athani.

2. Synergistic efforts of CSIR – CLRI, NLDP (National Leather Development Programme) and ASCENT (Association of Communication Enterprise – in project termed enterprises – yielded very beneficial results.

- Hundreds of families trained and skill upgraded.
- Patterns standardised using lasts and templates
- Improved quality of leather & other materials
- Design innovation introduced
- Standardisation of manufacturing methods established.

3. Design & Development of North East Ethnic Material and Leather Combination products:

With an aim to promote ethnicity of local people and help them improve their economy and lifestyle CLRI is working in collaboration with NEIST (North East Institute of Science & Technology) for development of novel leather products based on ethnic designs.

4. The Travel of India in 'Fashion Forecasting for Leather:

In globalising economy, design is perceived as a new engine of economic and industrial growth. Therefore, with industry stakeholders, CLRI forecasts for the world, the

colour and texture trends for leather and products and with the colour card for the world being developed in India, has given Indian leather sector, a niche edge in fashion marekt.

Conclusion:

CSIR-CLRI is a global hub for transformation of a tradition bound leather industry into an innovation driven one and therefore, CSIR through CLRI is meeting requirements of global leather sector, relevant regulatory and statutory bodies and other stakeholders with continued improvements in its services.