Basics of Science and Technology

Science and Technology have always been an integral part of Indian culture. The ability to perform creatively in science came to be backed with an institutional setup and strong state support after the country's independence in 1947. Since then, the Government of India has spared no effort to establish a modern S&T infrastructure in the country. The Department of Science and Technology plays a pivotal role in promotion of science and technology in the country.

Jawaharlal Nehru, the first Prime Minister of India, initiated reforms to promote higher education, science, and technology in India. The Indian Institutes of Technology – conceived by a 22-member committee of scholars and entrepreneurs in order to promote technical education – was inaugurated on 18 August 1951 at Kharagpur in West Bengal by the minister of education Maulana Abul Kalam Azad.

More IITs were soon opened in Bombay, Madras, Kanpur and Delhi as well in the late 1950s and early 1960s. Beginning in the 1960s, close ties with the Soviet Union enabled the Indian Space Research Organisation to rapidly develop the Indian space program and advance nuclear power in India even after the first nuclear test explosion by India on 18 May 1974 at Pokhran.

The roots of nuclear power in India lie in early acquisition of nuclear reactor technology from a number of western countries, particularly the American support for the Tarapur Atomic Power Station and Canada's CANDU reactors.

The Indian space program received only financial support from the Soviet Union, which helped the Indian Space Research Organisation achieve aims such as establishing the Thumba Equatorial Rocket Launching Station, launching remote sensing satellites, developing India's first satellite—Aryabhatta, and sending astronauts into the space. India sustain its nuclear program during the aftermath of Operation Smiling Buddha – India's first nuclear tests.

In 1981, the Indian Antarctic Programme was started when the first Indian Expedition was flagged off for Antarctica from Goa. More missions were subsequently sent each year to India's base Dakshin Gangotri.

Indian agriculture benefited from the developments made in the fields of Biotechnology, for which a separate department was created in 1986 under the Ministry of Science and Technology. Both the Indian private sector and the government have invested in the medical and agricultural applications of biotechnology. Massive Biotech parks were established in India while the government provided tax deduction for research and development under biotechnological firms.

On 25 June 2002 India and the European Union agreed to bilateral cooperation in the field of science and technology. A joint EU-India group of scholars was formed on 23 November 2001 to further promote joint research and development. India holds observer status at CERN while a joint India-EU Software Education and Development Centre is due at Bangalore.

Bangalore is considered to be the technological capital of India. IT, Biotechnology, Aerospace, Nuclear Science, Manufacturing Technology, Automobile Engineering, Chemical Engineering, Ship Building, Space science, Electronics, Computer Science and other Medical Science related research and development are going on a large scale in the country. The southern part of India is responsible for the lion share of technology and advancements the country has made. The golden triangle of IT and technology (Hyderabad, Bangalore and Chennai) forms the backbone of Indian Manufacturing, R&D and Science and Technology.

In 2017, India became an associate member of European Organization for Nuclear Research.

Space Exploration

Mars Orbit Mission

The Mars Orbiter Mission, also called Mangalyaan was launched on 5 November 2013 by the Indian Space Research Organisation (ISRO). It is India's first interplanetary mission making ISRO the fourth space agency to reach Mars, after the Soviet space program, NASA, and the European Space Agency and the first Asian nation to reach Mars orbit, and the first nation to do so on its first attempt.

Chandrayaan-1

On 18 November 2008, the Moon Impact probe was released from Chandrayaan-1 at a height of 100 km (62 mi). During its 25-minute decent, Chandra's Altitudinal Composition Explorer (CHACE) recorded evidence of water in 650 mass spectra readings gathered during this time. On 24 September 2009 Science journal reported that the Chandrayaan-1 had detected water ice on the Moon.

Thirty Meter Telescope

The Thirty Meter Telescope (TMT) is a planned, eighteen story, astronomical observatory and extremely large telescope to be built on the summit of Mauna Kea in the state of Hawaii. The TMT is designed for near-ultraviolet to mid-infrared (0.31 to 28 μm wavelengths) observations, featuring adaptive optics to assist in correcting image blur. The TMT will be at the highest altitude of all the proposed ELTs. The telescope has government-level support from several R&D spending nations: China, Japan, Canada and India.

India is aggressively working towards establishing itself as a leader in industrialisation and technological development. Significant developments in the nuclear energy sector are likely as India looks to expand its nuclear capacity. Moreover, nanotechnology is expected to transform the Indian pharmaceutical industry. The agriculture sector is also likely to undergo a major revamp, with the government investing heavily for the technology-driven Green Revolution. Also, several automobile manufacturers, from global majors such as Audi to Indian companies such as Maruti Suzuki and Mahindra & Mahindra, are exploring the possibilities of introducing driverless self-driven cars for India. The Government of India, through the Science, Technology and Innovation (STI) Policy-2013, among other things, aspires to position India among the world's top five scientific powers.

Science, Technology and Innovation (STI) Policy 2013

In 2013, Government of India released a new science, technology and innovation policy that lays greater thrust on innovation, establishing research institutes and encourages women scientists with an aim to position itself among the top five scientific powers in the world by 2020.

Decade of Innovation: India has declared 2010-20 as the "Decade of Innovation". The Government has stressed the need to enunciate a policy to synergize science, technology and innovation and has also established the National Innovation Council (NlnC).

The STI Policy 2013 is in furtherance of these pronouncements.

Investments in Science and Technology

- Global investments in science, technology and innovation are estimated at $1.2 trillion as of 2009. India's R&D investment is less than 2.5% of this and is currently under 1 % of the GDP.
- Increasing Gross Expenditure in Research and Development (GERD) to 2% of the GDP has been a national goal for some time.
- Achieving this in the next five years is realizable if the private sector raises its R&D investment to at least match the public sector R&D investment from the current ratio of around 1 :3. The new paradigm is "Science technology and innovation for the people".

Position in Research Publications

- The gross budgetary support for the science and technology sector has significantly increased during the last decade. The impact of such increase is becoming evident.
- India ranks ninth globally in the number of scientific publications and 12th in the number of patents filed. The Composite Annual Growth Rate (CAGR) of Indian publications is around 12±1% and India's global share has increased from 1.8% in 2001 to 3.5% in 2011.
- But the percentage of Indian publications in the top 1 % impact making journals is only 2.5%.
- By 2020, the global share of publications must double and the number of papers in the top 1 % journals must quadruple from the current levels.

Key Elements:

- Promoting the spread of scientific temper amongst all sections of society.
- Enhancing skill for applications of science among the young from all social strata.
- Making careers in science, research and innovation attractive enough for talented and bright minds.
- Establishing world class infrastructure for R&D for gaining global leadership in some select frontier areas of science.
- Positioning India among the top five global scientific powers by 2020.
- Linking contributions of science, research and innovation system with the inclusive economic growth agenda and combining priorities of excellence and relevance.
- Creating an environment for enhanced Private Sector Participation in R&D.
- Enabling conversion of R&D outputs into societal and commercial applications by replicating hitherto successful models as well as establishing of new PPP structures.
- Seeding S&T-based high-risk innovations through new mechanisms.
- Fostering resource-optimized, cost-effective innovations across size and technology domains.
- Triggering changes in the mindset and value systems to recognize, respect and reward performances which create wealth from S& T derived knowledge.
- Creating a robust national innovation system.

Focus of the Policy

- Facilitating private sector investment in R&D centres in India and overseas.
- Promoting establishment of large R&D facilities in PPP mode with provisions for benefits sharing.
- Permitting multi stakeholders participation in the Indian R&D system.

- Treating R&D in the private sector at par with public institutions for availing public funds.
- Bench marking of R&D funding mechanisms and patterns globally.
- Modifying IPR policy to provide for marching rights for social good when supported by public funds and for co-sharing IPRs generated under PPP.
- Launching newer mechanisms for nurturing Technology Business Incubators (TBls) and science-led entrepreneurship.
- Providing incentives for commercialization of innovations with focus on green manufacturing.

Important Observations

- Policy places greater thrust on innovation, establishing research institutes and encourage women scientists with an aim to position itself among the top five scientific powers in the world by 2020.
- It talks about modifying the intellectual property regime to provide for marching rights for social good when supported by public funds and co-sharing of patents generated in the public private partnership mode.
- Aims at producing and nurturing talent in science, to stimulate research in universities, to develop young leaders in the field of science and to reward performance.
- Seeks to create a policy environment for greater private sector participation in research and innovation and to forge international alliances and collaborations to meet the national agenda.
- Talks of raising gross expenditure in R&D to two per cent of GDP from the current one per cent in this decade by encouraging enhanced private sector contribution.
- Seeks to trigger an ecosystem for innovative abilities to flourish by leveraging partnerships among diverse stakeholders and by encouraging and facilitating enterprises to invest in innovations.

Criticism:

The document is full of wishes and desires. The declaration lists 12 points to capture India's aspirations in STI — promoting the spread of scientific temper; enhancing skills; making careers in science, research and innovation attractive; establishing world-class infrastructure and gaining global leadership in select frontier areas; making India among the five top global scientific powers; enhanced private-sector participation in research and development (R&D) and converting it into applications through a PPP model; seeding science and technology based high-risk innovations. All of these aim to create a robust national innovation system. But it hardly describes any structural or procedural changes which will achieve the grand goal of integrating science, technology and innovation to create value in an inclusive manner.

Recent changes in the policy

The new government implemented institutional change affecting the research policy area:

- The National Institution for Transforming India (NITI Aayog) replaced the earlier Planning Commission
- The National Innovation Council, established by the prior government in 2010 / 2011, is practically discontinued with the Niti Aayog and ministries taking over its functions.
- The current government continuous the expansion of the top layer of federal higher education institutions also performing research. Since 2006, six Indian Institutes of Science Education and Research (IISERs) have been established (the latest one in 2015) with two more in the pipeline. Their mandate is to perform frontier research in the basic sciences (as well as related higher education). The group of the more engineering and applied sciences oriented Indian Institutes of Technology (IITs) was also expanded (from 16 until 2014 to 18 in 2015 and 22 in 2016);
- The largest number of R&D personnel, however, continues to be employed in public research institutions (like the labs of the Council of Scientific and Industrial Research (CSIR) or of Ministries like the Department of Biotechnology, the Department of Atomic Energy, etc.). The majority of higher education institutions focus on teaching (most of the 750 universities; exceptions are the IISERs, the IITs, the Indian Institutes of Management (IIM), the All India Institutes of Medical Sciences (AIIMSs), the Indian Institute of Science, the Tata Institute of Fundamental Research and around 20 major central universities);
- In terms of publication output, India's share in worldwide output rose from under 2% in the year 2000 to over 4% in recent years;
- The prior government announced the 'Decade of Innovation' 2010-2020 and launched a Science, Technology and Innovation Policy in 2013 (STIP 2013);
- The new government endorsed the STIP 2013 policy. The visibility and prominence of STI topics increased with the new government. The current scenario is more decentralised, however (compared to the earlier situation where the PM's office together with the Planning Commission and the Ministry of S&T were the sole decision makers in S&T matters);
- The new government announced a series of National Flagship Programmes/Schemes: -

  - Make in India (promoting manufacturing in India; stirred by Min of Comm and Ind);
  - Digital India (aiming to continue India's relative success in the ICT sector) Skill India (a new Ministry of Skill Development and Entrepreneurship was launched);

   - Green India (focusing on renewable energy and innovation; electric vehicles);
   - Smart Cities and Urban Development (100 smart cities shall be built);
   - Clean India (Ganga Rejuvenation Programme with various ministries involved; plus the Clean India Campaign (Swachh Bharat) focusing on clean neighbourhoods;
   - Creating New Infrastructure (ports, industrial corridors, etc.);
- Public R&D resources are expected in these programmes. In line with the observation of a certain decentralisation mentioned above, they will be managed and implemented by the responsible line ministries (not channelled through DST);
- Beyond these programmes, the government has also announced a focus on the ease of doing business especially aiming at foreign investors (expanding the visa on arrival scheme, removing certain distinctions in FDI, etc);
- Under the above-mentioned Niti Aayog, the Atal Innovation Mission (currently endowed with a budget of around € 20m) aims to provide an innovation promotion platform and related R&D funds. It's mandate states that it should promote a network of world-class innovation hubs (e.g. as part of IITs, IIMs, AIIMs, etc);
- he new government also launched an FDI Policy 2015 and a new National IPR Policy.
- The new government's programmes and initiatives might provide entry points for novel cooperation formats with the European Union and its Member States (e.g. by re-opening discussions on matching H2020 funding or by including India in ERA-Net or JPI schemes).

Technology Missions:

Information and communications technology

Information and communication technology (ICT) is an extended term for information technology (IT) which stresses the role of unified communications and the integration of telecommunications (telephone lines and wireless signals), computers as well as necessary enterprise software, middleware, storage, and audio-visual systems, which enable users to access, store, transmit, and manipulate information.

The term ICT is also used to refer to the convergence of audio-visual and telephone networks with computer networks through a single cabling or link system. There are large economic incentives (huge cost savings due to elimination of the telephone network) to merge the telephone network with the computer network system using a single unified system of cabling, signal distribution and management.

However, ICT has no universal definition, as "the concepts, methods and applications involved in ICT are constantly evolving on an almost daily basis". The broadness of

ICT covers any product that will store, retrieve, manipulate, transmit or receive information electronically in a digital form, e.g. personal computers, digital television, email, robots. For clarity, Zuppo provided an ICT hierarchy where all levels of the hierarchy "contain some degree of commonality in that they are related to technologies that facilitate the transfer of information and various types of electronically mediated communications". Skills Framework for the Information Age is one of many models for describing and managing competencies for ICT professionals for the 21st century.

The ICT Development Index ranks and compares the level of ICT use and access across the various countries around the world. In 2014 ITU (International Telecommunication Union) released the latest rankings of the IDI, with Denmark attaining the top spot, followed by South Korea.

Information and Communication Technology can contribute to universal access to education, equity in education, the delivery of quality learning and teaching, teachers' professional development and more efficient education management, governance and administration.

In modern society ICT is ever-present, with over three billion people having access to the Internet. With approximately 8 out of 10 Internet users owning a smartphone, information and data are increasing by leaps and bounds. This rapid growth, especially in developing countries, has led ICT to become a keystone of everyday life, in which life without some facet of technology renders most of clerical, work and routine tasks dysfunctional. The most recent authoritative data, released in 2014, shows "that Internet use continues to grow steadily, at 6.6% globally in 2014 (3.3% in developed countries, 8.7% in the developing world); the number of Internet users in developing countries has doubled in five years (2009-2014), with two thirds of all people online now living in the developing world

ICT continues to take on new form, with nanotechnology set to usher in a new wave of ICT electronics and gadgets. ICT newest editions into the modern electronic world include smart watches, such as the Apple Watch, smart wristbands such as the Nike+ FuelBand, and smart TVs such as Google TV. With desktops soon becoming part of a bygone era, and laptops becoming the preferred method of computing, ICT continues to insinuate and alter itself in the ever-changing globe.

Information communication technologies play a role in facilitating accelerated pluralism in new social movements today. The internet according to Bruce Bimber is "accelerating the process of issue group formation and action" and coined the term accelerated pluralism to explain this new phenomena. ICTs are tools for "enabling social movement leaders and empowering dictators" in effect promoting societal change. ICTs can be used to garner grassroots support for a cause due to the internet allowing for political discourse and direct interventions with state policy as well as change the way complaints from the populace are handled by governments.

Telecommunication

Telecommunication is the transmission of signs, signals, messages, words, writings, images and sounds or intelligence of any nature by wire, radio, optical or other electromagnetic systems. Telecommunication occurs when the exchange of information between communication participants includes the use of technology. It is transmitted either electrically over physical media, such as cables, or via electromagnetic radiation. Such transmission paths are often divided into communication channels which afford the advantages of multiplexing. The term is often used in its plural form, telecommunications, because it involves many different technologies.

Early means of communicating over a distance included visual signals, such as beacons, smoke signals, semaphore telegraphs, signal flags, and optical heliographs. Other examples of pre-modern long-distance communication included audio messages such as coded drumbeats, lung-blown horns, and loud whistles. 20th and 21st century technologies for long-distance communication usually involve electrical and electromagnetic technologies, such as telegraph, telephone, and teleprinter, networks, radio, microwave transmission, fiber optics, and communications satellites.

Telegraph and telephone

Sir Charles Wheatstone and Sir William Fothergill Cooke invented the electric telegraph in 1837. Also, the first commercial electrical telegraph is purported to have been constructed by Wheatstone and Cooke and opened on 9 April 1839.

Samuel Morse independently developed a version of the electrical telegraph that he unsuccessfully demonstrated on 2 September 1837.

There have also been dramatic changes in telephone communication behind the scenes. Starting with the operation of TAT-8 in 1988, the 1990s saw the widespread adoption of systems based on optical fibers.

Mobile phones have had a significant impact on telephone networks. Mobile phone subscriptions now outnumber fixed-line subscriptions in many markets.

The first transatlantic telegraph cable was successfully completed on 27 July 1866, allowing transatlantic telecommunication for the first time.

The conventional telephone was invented independently by Alexander Bell and Elisha Gray in 1876.

The first commercial telephone services were set-up in 1878 and 1879 on both sides of the Atlantic in the cities of New Haven and London.

Radio and television

In 1832, James Lindsay gave a classroom demonstration of wireless telegraphy to his students.

On 25 March 1925, John Logie Baird was able to demonstrate the transmission of moving pictures

Most of the twentieth century televisions depended upon the cathode ray tube invented by Karl Braun.

The broadcast media industry is at a critical turning point in its development, with many countries moving from analog to digital broadcasts. This move is made possible by the production of cheaper, faster and more capable integrated circuits.

For television, this includes the elimination of problems such as snowy pictures, ghosting and other distortion.

A revolution in wireless communication began in the first decade of the 20th century with the pioneering developments in radio communications by Guglielmo Marconi, who won the Nobel Prize in Physics in 1909. Other notable pioneering inventors and developers in the field of electrical and electronic telecommunications include Charles Wheatstone and Samuel Morse (inventors of the telegraph), Alexander Graham Bell (inventor of the telephone), Edwin Armstrong and Lee de Forest (inventors of radio), as well as Vladimir K. Zworykin, John Logie Baird and Philo Farnsworth (some of the inventors of television).

Computers and the Internet

On 11 September 1940, George Stibitz transmitted problems for his Complex Number Calculator in New York.

In the 1960s, researchers started to investigate packet switching, a technology that sends a message in portions to its destination asynchronously without passing it through a centralized mainframe. A four-node network emerged on 5 December 1969, constituting the beginnings of the ARPANET, which by 1981 had grown to 213 nodes. ARPANET eventually merged with other networks to form the Internet. While Internet development was a focus of the Internet Engineering Task Force (IETF) who published a series of Request for Comment documents, other networking advancement occurred in industrial laboratories, such as the local area network (LAN) developments of Ethernet (1983) and the token ring protocol (1984).

The Internet is a worldwide network of computers and computer networks that communicate with each other using the Internet Protocol.

It is estimated that the 51% of the information flowing through two-way telecommunications networks in the year 2000 were flowing through the Internet (most of the rest (42%) through the landline telephone). By the year 2007 the Internet clearly dominated and captured 97% of all the information in telecommunication networks (most of the rest (2%) through mobile phones).[83] As of 2008, an estimated 21.9% of the world population has access to the Internet

The effective capacity to exchange information worldwide through two-way telecommunication networks grew from 281 petabytes of (optimally compressed) information in 1986, to 471 petabytes in 1993, to 2.2 (optimally compressed) exabytes in 2000, and to 65 (optimally compressed) exabytes in 2007. This is the informational equivalent of two newspaper pages per person per day in 1986, and six entire newspapers per person per day by 2007. Given this growth, telecommunications play an increasingly important role in the world economy and the global telecommunications industry was about a $4.7 trillion sector in 2012. The service revenue of the global telecommunications industry was estimated to be $1.5 trillion in 2010, corresponding to 2.4% of the world's gross domestic product (GDP).

Social Impact

Telecommunication has played a significant role in social relationships. Nevertheless, devices like the telephone system were originally advertised with an emphasis on the practical dimensions of the device (such as the ability to conduct business or order home services) as opposed to the social dimensions. It was not until the late 1920s and 1930s that the social dimensions of the device became a prominent theme in telephone advertisements. New promotions started appealing to consumers' emotions, stressing the importance of social conversations and staying connected to family and friends.

Since then the role that telecommunications has played in social relations has become increasingly important. In recent years, the popularity of social networking sites has increased dramatically. These sites allow users to communicate with each other as well as post photographs, events and profiles for others to see. The profiles can list a person's age, interests, sexual preference and relationship status. In this way, these sites can play important role in everything from organising social engagements to courtship.

Prior to social networking sites, technologies like short message service (SMS) and the telephone also had a significant impact on social interactions. In 2000, market research group Ipsos MORI reported that 81% of 15- to 24-year-old SMS users in the United Kingdom had used the service to coordinate social arrangements and 42% to flirt.

In cultural terms, telecommunication has increased the public's ability to access music and film. With television, people can watch films they have not seen before in their own home without having to travel to the video store or cinema. With radio and the