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***Commentary***

# The Contribution of Various Government Policies and Schemes in Facilitating and Fostering an Inclusive, Innovative, Technology Enabled Stable Industrial Growth with Enhanced R&D Investments

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Science & Technology (S&T) with frugal innovation is the key to economic stability and prosperity of the country as it can provide the path to sustainable growth and help build a technologically driven economy capable of providing social welfare even to the bottom most layer of the society. R&D is an integral part of technological advancement and the Government of India has made concerted efforts to build upon S&T and industrial capabilities in the country. This compilation is an attempt to examine the national strategy adopted by the government and the various policies working in interaction to leverage the industrial sector, S&T and technological innovation in the country. The framework of the document also presents before the readers a brief glimpse of the measures adopted by the government at policy, structural and regulatory levels to drive innovation and create an enabling environment for the private sector in the industry to enhance investments in R&D, innovations and intellectual property. The study also reflects the trends in R&D investments by the government and the industry in India with comparisons to their global counterparts and the obstacles faced by the industry in enhancing R&D expenditure.

**Keywords: Research & Development; Frugal Innovation; Licensing; Liberalization; Technology**

## Introduction

The growth and development of the industrial sector plays a pivotal role in the economic development of the country as it is a means of fast, sustainable and broad base inclusive growth. In the past one decade Indian companies have performed exceptionally well in some of the sectors and the trend should continue to increase and strengthened. Efforts have been made to make India an innovation hub and move beyond the formal R&D parameters to promote knowledge based industries which may enable converting knowledge into product/value or worth through innovation. The delivering of an affordable, quality and value product to the India's teeming millions is a colossal task with huge challenges and opportunities on the way. Meanwhile the industry should be enabled to innovate and channelize the benefits to people lying even at the bottom of the economic pyramid.

R&D in the industrial sector is the measure of innovation index and the Indian firms should elevate their research and innovation capabilities to develop new product line, support frugal innovation and provide cost-effective solutions. The Indian enterprise has a huge responsibility to work for consumer expectation and satisfaction and the government has extended full funding and policy support to leverage the enabling factors for innovation and technological development. The government has announced several policy reforms and has taken proactive steps to ensure stable industrial growth in the country. The paper examines some of the extensive measures and reforms placed by the government at policy, structural and regulatory levels and their impact on fostering economic development, facilitating manufacturing and broadening the R&D base in the industry.

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**Industrial Policies and Their Impact on Industrial Development**

India inherited a drained and shattered economy at the time of Independence and the visionaries who laid the foundation of a strong and vibrant nation had already realized the importance of sound policy, structural and procedural reforms, technology and innovation for the growth and development of the country. India was primarily an agrarian economy and despite the paucity of resources, it was expected to achieve a phenomenal increase in industrialization. The country was in dire need of economic reforms and Pt. Jawaharlal Nehru, the first Prime Minister of India advocated for socialistic pattern of society, which is reflected in the economic reforms and policies placed during his tenure.

The government introduced the Industrial Policy Resolution in 1948 even before the constitution of India was adopted and gave a succinct view of how the government plans to have the industrial sector in India. The industrial sector was broadly divided into three wings: the government (public Sector), private sector and the joint sector. The policy resolution emphasized the need for having a sustainable economy with the continuous increase in the production of goods and their equitable distribution amongst all the sections in society. The focus was to lay the foundation of a mixed economy where both the public and private sector would work together for the industrial growth of the country. Later, the central government passed the Industries (Development and Regulation) Act, 1951 to foster development and regulation of industries in India through licensing. This entrusted the government with power and autonomy to facilitate the establishment and expansion of existing plants only with the approval and licencing by the government. The Act empowered the government to have price control, regulation on the methods and volume of production and on the distribution channels.

Pt. Jawaharlal Nehru was a strong supporter of the socialistic pattern of society and this was reflected in the high level of central and state control on the industrial and business sectors in the country. The era also witnessed reservations for foreign direct investments and considerable emphasis was given to develop as a self-reliant economy. During the 1950's, the economic, technological and entrepreneurship base of the country was not strong enough to support industrialization in the country on a fast pace, and therefore, the government took the lead role and responsibility in giving a push to the industrial development.

The Industrial Policy Resolution of 1956, was one of the most widely accepted and influential policies for almost two decades and was put forward to provide a definitive structure to the mixed economy model and to the concept of socialistic pattern of society in India with an aim to ebb regional inequalities and imbalances (Thakur *et al*., 2012). The industrial sector was now classified into three schedules, A, B and C depending upon the role and stake of the government in developing that sector. The Schedule A, comprised of only those industries (17 in number) whose future development was the exclusive responsibility of the state like the industries dealing with the development of arms & ammunition, atomic energy, iron and steel, heavy castings and forging of iron and steel, air transport, railways, ship-buildings, telegraph and wireless apparatus and generation and distribution of electricity. The Schedule B, comprised of those industries (12 in number) which were primarily state owned and in which the private sector was welcome to supplement the efforts of the state, for example, industries catering to basic and intermediate products required by chemical industries such as those involved in manufacture of drugs, fertilizers, synthetic rubber, carbonization of coal, chemical pulp etc. The Schedule C, comprised of those industries which were not included in the Schedule A and B.

The industrial policies contrived during the 1950's had several deterrents which led to slow pace of technological development, modernization in industry, low access to the competitive markets, reduced focus on research & development and economic instability. These drawbacks to some extent were addressed in the industrial policy statements introduced during the 1973, 1977 and 1980 which laid emphasis on high priority sectors in the industry where foreign investments could be encouraged. The seventh five year plan period (1985-89) witnessed several policy reforms during which efforts were made to open the domestic markets in the country to increase competition, enhance productivity, quality of produce and to lower the cost of product. The tenet was to prepare the industry face international competition.

The government drifted its focus towards decentralization and enforced open market system. The role of small scale and medium industries was emphasized for promoting competitive domestic markets and for adopting modern and upgraded technology for production. This rejig led to a noticeable change and India started pushing itself towards major economic reforms which gained momentum during the mid-80s and finally in the year 1991, the government announced the new industrial policy which promoted economic liberalization, privatization and globalization. The public sector was confined to the core and basic industries such as industry operating in the sphere of security, strategic and military considerations, hazardous chemicals, railway transport etc. whereas the private sector was deregulated and given the freedom and flexibility to perform and respond to the competitive markets (source: Statement on Industrial Policy, July 24, 1991). The industrial licensing was abolished irrespective of the investment levels. The three industries catering to motor cars, white goods and leather were delicenced in 1993. Later, industries catering to entertainment, electronics industry, animal fats and oil, wood and paper, newsprint, drugs and pharmaceuticals were also delicenced. There was a paradigm shift in the industry environment and research & development started to be being viewed from the perspective of innovation, commercialization and profitability.

Two and a half decades down the line, India has witnessed a humongous change. The country has worked hard to push itself into the top echelon of the competitive economies. The government batted for technology development, technology acquisition, indigenization and skill development keeping in mind the mounting pressures on the available resources and the ever expanding population. The private sector which was initially refrained from engaging in strategic areas like defence, civil nuclear, space and missile development programs has been provided the floor under 'Make in India' initiative to build upon technological capabilities in the field of defence manufacturing to curtail imports and international dependence. The government encouraged the private sector to come forward to share the responsibility for generating employment and invigorating economic growth.

The Indian economy is large and the private sector too has an important role to play in earning a global reputation for providing simple and affordable solutions. The Indian firms are making notable efforts to ensure the growth and production of goods and services that are comparable in the international market and are affordable, accessible and user friendly. The industry is encouraged to undertake frugal innovation, which holds much relevance in the emerging economies like India, China, Brazil and South Africa where knowledge and technology are used to develop products/ processes from a scarce resource in a cost-effective way to enable the nation suffice the needs of the people lying in the bottom most layer of the pyramid. Development of low cost eye surgeries with good surgical standards, an affordable family car-Tata Nano, production of generic medicines, a vaccine for Hepatitis B at a cost lower than the earlier products, solar powered lightening of rural houses in Karnataka by SELCO in Bangalore, low cost LED lightening solution, small refrigerator sold by Godrej, cell phones and feature phones made by local companies, the Indian Mars spacecraft, are some of the great examples of frugal innovation. India also has a reasonable manufacturing strength and thriving service sector supported by rich demographic dividend and cost-effective labour but lately efforts have been made to devise an innovation ecosystem which is knowledge driven, technology enabled, inclusive and frugal to tap the unused potential of the country, promote indigenization and commercialization.

There is also a great chasm amongst different countries and the methods in which the things may be done. The policy makers have been instrumental in bringing about a massive change in the Indian industry in building up infrastructure, churning out technological innovations and ideas leading to prototype and its commercialization. The government is also encouraging the start up culture in industries operating in areas like biotechnology, healthcare, cloud computing, ecommerce, big data analytics and similar ones. These start-ups are primarily intellectual property centric and are on the prowl for premier talent which could easily embrace the start-up culture, take risks and evolve a product which despite having a long gestation period for delivery has a proven use in the societal development. In a nutshell, the government has taken proactive steps in strengthening the policy framework and the regulatory system to enable industries perform good business and invest in research and development.

**Role of Science & Technology and National Education Policies for Promoting Growth and Development of the Industrial Sector**

The role of S&T in the industrial sector has to be in alignment with the goals and interests of the national policy to accomplish holistic development, accelerated growth, sustainability, inclusivity and international competitiveness. A favourable and supportive S&T policy, entrepreneurship, resource capital, adequate infrastructure, investments, trained scientific manpower, skills with inclusive innovation and inventiveness play a pivotal role in the growth and development of the country. The policies and schemes introduced during the different five year plans in the country have played a significant role in transforming and stimulating the industrial growth in India. Increased investments in R&D is being observed as the benchmark for emerging economies and India can achieve this through the increased support of the government and the private sector collectively and collaboratively.

The R&D in Indian industry was in infancy during the 1970's but picked up momentum in the later decades. The role of S&T policies in achieving industrial growth has been enormous and should be viewed as an inseparable and integral part of industrial reforms. The Scientific Policy Resolution of 1958, Technology Policy Statement of 1983 and S&T policy 2003 emphasized on promoting R&D in industries. The Science & Technology policy 2003 emphasized the need for investment in R&D. The government proposed for incentivizing the establishment of new in-house R&D centers and strengthening of the existing in-house R&D base in the industries. Indigenous technology development, technology acquisition, technology transfer, dissemination, scale up and commercialization, were given prime importance for the small, medium and large industries with focus on increased global and domestic competitiveness. The R&D intensity and R&D commercialization factor of the industry was also emphasized to be strengthened with increased investments in R&D to enable industry attain technological self-reliance, sustainability and survival in the international competitive economies.

The creation of a strong scientific and engineering research base was emphasized for the development of new knowledge based innovation that can be readily converted into products and processes to address the issues related to national security and the disadvantaged sections of the society. Emphasis was also given for the revamp of the certification process of quality standards and accreditation of the testing and calibration laboratories as per the international requirements to enable the Indian industry avoid non-tariff barriers in global trade (Science & Technology Policy, 2003). The S&T Policy 2003 also provided strengthening of S&T infrastructure in the academic institutions, specially the universities, engineering colleges and medical institutions. Policy measures were announced to ensure the induction of quality and skilled human resource capital and provisions were made for the mobility of scientists and technologists between industry, academic institutions and research laboratories. The focus of the Science, Technology & Innovation Policy 2013 is also to create an enabling environment for higher participation of the private sector in R&D, facilitate private sector investments in R&D and to treat R&D at private sector at par with public institutes for availing public funds.

The educational institutes, universities and the higher learning centers were impressed upon to collaborate with the industry on mutual benefit basis to enable the exchange of knowledge, expertise and technology for product/process development. The National Policy on Education 1986, with some modification undertaken in the year 1992 introduced reforms in the higher education system and curricula to diversify, expand the coverage and quality of education in India**.** A system of education was to be cultivated and evolved with greater emphasis on Science and Technology that could increase the employability of the youth, provide them with skills and on the job training to meet the industry requirement. Ministry of Human Resource Development made efforts to do away with the redundant curricula and various professional courses/ add-on courses were introduced and re-designed at the under-graduate and post-graduate level in the universities, national research institutes and NITs to cater to the technological needs of the industry. All India Council of Technical Education (AICTE) advocated for the growth of technical education in India and the government provided full policy and financial support for the creation of one of the most

vaunting education system in the country. Many central government funded institutions like the Indian Institutes of Technology (16), Indian Institutes of Management (13), Indian Institute of Science, Bangalore, Indian Institutes of Science, Education and Research (5), National Institutes of Technology (30) and Indian Institutes of Information Technology (4) have been created to impart quality education and increase employable workforce. Many of these institutes enjoy the status of institutes of national importance and frame their own curricula to enable the students work independently in the industrial environment. Some of the prestigious colleges like College of Engineering, Pune and PSG college of Technology, Coimbatore are offering integrated engineering programs and industrial training to their students to facilitate the industries by providing immediate employable and knowledgeable workforce. Central Institute of Plastics Engineering and Technology (CIPET), an autonomous organization under the Ministry of Chemicals and Fertilizers, GoI, is providing courses leading to M. Tech degree and post graduate diploma in various disciplines of plastic engineering and technology at its high learning centers in five places (Source: Central Institute of Plastics Engineering & Technology : UG&PG Programs-Overview). Similarly, Rajiv Gandhi Institute of Petroleum Technology (RGIPT), Raibareli (U.P) is an institute of national importance and offers UG/PG courses in various areas of petroleum sector as per the requirement of oil, gas and petro-chemical industry (Source: Rajiv Gandhi Institute of Petroleum Technology-Academic Departments). Department of Biotechnology, Ministry of S&T, GoI, supports postgraduate students of life sciences and biotechnology with biotechnology industry training fellowships. Some of these examples provide an evidence to signify that methods were identified to foster government, academia-industry research collaborations that would help in sharing and transfer of knowledge across boundaries, particularly when the knowledge base of the partners were different.

Institutes like Indian Institutes of Technology (IITs), The Indian Institute of Science (IISc) Bangalore, and various CSIR, ICAR and ICMR institutes are also engaged in providing an access to the Indian industries for conducting research using their readily available research infrastructure, networking platform, technological support, and research expertise of the scientists and faculty in these institutes. Zonal Technology Management and Business Planning and Development Unit, Indian Agricultural Research Institute, New Delhi has a network of 21 ICAR institutes and provides for commercialization of technologies to agro industries along with incubation support and capacity building of agripreneurs. Similarly, there is an agribusiness incubator in International Crops Research Institute for Semi-Arid Tropics (ICRISAT), Patencheru, Hyderabad. Some of the CSIR labs like Central Food Technological Research Institute (CFTRI) Mysore, Indian Institute of Chemical Biology (IICB) Kolkata, Central Leather Research Institute (CLRI) Chennai, Central Institute of Medicinal and Aromatic Plants (CIMAP) Lucknow, National Metallurgical Laboratory (NML) Jamshedpur and Institute of Microbial Technology (IMTEC) Chandigarh are in the process of setting up incubation centres to help the start-ups working in an array of fields and to facilitate them take CSIR technologies to the general masses. Venture Centre, one of the India's largest science business incubator, hosted by National Chemical Laboratory, Pune strives to nurture and nucleate new businesses through their start-up phase by not only providing space to such entities but also by providing them business mentoring, network and scientific and technological information (Source: Venture Centre, Pune -Activities & Programs). Foundation for Innovation and Technology Transfer (FITT), New Delhi is running the Technology Business Incubation Unit (TBIU) at the Institute Campus to promote partnerships with new technology entrepreneurs and start-up companies (Source: FIIT Annual Report 2015). Society for Innovation and Entrepreneurship (SINE) manages a technology business incubator at Indian Institute of Technology, Bombay and is supported by several government departments such as Department of Science and Technology, Department of Electronics and Information Technology and Technology Development Board. The IIT Madras incubation cell recognized as a Technology Business Incubator by National Science & Technology Entrepreneurship Development Board (NSTEDB), Department of Science & Technology, Ministry of Science & Technology, GoI, nurtures technology ventures through their start-up phase by providing all the support necessary to help entrepreneurs establish themselves

before they scale up their ventures. Society for Innovation and Development, located in Indian Institute of Science, Bangalore, provides for the incubation of IP based start-ups by way of providing them infrastructure, seed funding and mentoring to such start-ups.

The government has also made efforts to facilitate smooth import of technology knowhow to the industries, creating a vast pool of scientific talent and R&D manpower. Various public-private R&D partnerships and funding to industrial R&D projects were encouraged. Research and development in various sectors like power, telecommunications, space research, defence, atomic energy, information technology, medicine and healthcare were given importance and modalities were worked out to incentivize and promote R&D in these sectors. Through this compilation, an attempt has been made to provide an overview of the schemes run by the different departments under the aegis of Ministry of S&T and other scientific organizations to drive the innovation ecosystem in India with a glimpse of salient achievements of the respective organizations. The compilation also provides a brief idea on the status of private sector participation in industrial R&D in comparison to the government/ public sector and the methods devised and adopted thereof by the government to enhance private sector investments in R&D.

**Industrial R&D in India and its Contribution to National R&D Expenditure**

A balanced industrial growth is the centre stage of a developing economy for achieving long lasting productivity gains and inclusive growth. Research & development has been the main reason for technological development and advancement in developed nations whereas developing countries have limited focus on the R&D activities in the industry. It is rather perceived as an investment for the future to help the industry survive in business when it is exhausted with the existing product line that is technologically outdated or overtaken by the competitors. There are several factors like market size, market forces, technology area, technology diversity, usage and life cycle of a product which govern investments in R&D by industries and provide them a choice to invest 1 per cent to 10 per cent of their revenues. R&D in industry constitutes the major part of technology improvement and innovation and therefore, its remissness may cause the industry to solely rely upon technology import and diffusion which may involve huge costs. The government has always been supportive and facilitative in promoting research and development in the industry to enable competitiveness, innovation and a broad based inclusive growth. The industries have started establishing in-house R&D centers to build a nexus between technology, innovation, productivity and growth.

The idea of recognition to in-house R&D centres was first conceived by Department of Science & Technology, Ministry of Science & Technology, GoI in 1973 and a scheme was formulated for according recognition to the in-house R&D centres based on R&D strength and acumen of the industry. The activity was later transferred to the Department of Scientific & Industrial Research, Ministry of Science & Technology, GoI with its formation in 1985 and the recognition of R&D centres was formalised. Within a due course of time, a new scheme for recognition to non-commercial research institutions called Scientific & Industrial Research Organisations (SIRO) was implemented by DSIR in 1988. The organization should be registered under the Company's Act (under section 8 or 25 in 2013/1956 Act) or the Societies Registration Act, 1860 or any such Act passed by the state government and can be established by either the public sector or private sector. The R&D centres and SIRO organisations recognized by DSIR, were allowed an incentive of OGL facilities by the Ministry of Commerce, which gave a big relief in importing pilot plants, analytical instruments, spare parts and consumables for R&D purposes but after the 1991 liberalisation policy, this OGL facility got diluted as most of the imports were liberalized. However, the companies having recognition from DSIR continued to seek renewal and increasing number of companies started seeking fresh recognition mainly because of the prominence and distinction of having recognition from government.

The companies having DSIR recognized in-house R&D centers have increased from 100 in 1973 to about 600 units in 1980-81 to 1,762 as on December 2014 and 1,800 in December 2015. The R&D expenditure incurred by these companies have also

increased from Rs. 200-300 crores in 1980-81 to the order of about Rs. 30,000 crores per annum in 2015-16. Of the total number of industries recognized by DSIR, nearly 1,650 are in the private sector and the remaining units are in public/joint sector. Of the total number of recognized in-house R&D centers, 100 companies have spent over Rs. 50 crores each per annum on R&D while 490 companies have spent between Rs. 5 crores to Rs. 50 crores each per annum on R&D and 450 companies have spent between Rs. 2 crores to Rs. 5 crores each per annum on R&D. There are about 640 SIROs in the field of natural and applied sciences, medical sciences, agricultural sciences, social sciences and 600 Public Funded Research Institutions like universities, IITs, IISc Bangalore, Regional Engineering Colleges (other than a hospital) duly recognized by DSIR till 2015-16 (Source: DSIR Annual Report, 2015-16). DSIR has also supported extramural R&D funding of Rs 11.2 crores in the financial year 2009-10. The in-house R&D centres recognized by DSIR have established excellent infrastructure facilities for conducting research & development and have an estimated manpower of over 1,50,000 qualified personnel.

**Promotional Schemes of the Government of India for Facilitating Industrial R&D and their Salient Achievements**

The government has introduced several schemes to stimulate R&D investments in the industry. The Department of Scientific & Industrial Research (DSIR) works with the private sector, industry associations and academia to foster an environment that is conducive to innovation, scientific excellence and industrial competitiveness. The department had introduced major schemes and programmes for the 12$^{th}$ five year plan like :

(i) **Promoting Innovations in Individuals, Start-ups and MSMEs (PRISM):** The scheme aims towards supporting individual innovators, autonomous institutions/organizations or registered societies for translating ideas to prototypes/working models or technology solutions which would eventually be useful for MSME units in industrial clusters.

(ii) **Patent Acquisition and Collaborative Research and Technology Development (PACE):** The scheme acts as an interface between the technology seekers and technology providers where Indian industries are supported to acquire patented technology at an early stage from within the country or overseas on an exclusive as well as non-exclusive basis. The scheme facilitates the industry in identification and carrying out due diligence of the patents/ technologies to be acquired. The scheme also aims at supporting the scale up of lab scale technology for development and demonstration of products and processes that can be commercialized.

(iii) **Building Industrial R&D and Common Research Facilities (BIRD):** The scheme has two main components broadly divided into providing fresh recognition and renewal of recognition to the in-house R&D units of the industry, scientific & industrial research organizations (SIRO's) and public funded research institutions (PFRI). Recently, the department has announced the relaxation in guidelines of having at least three years of existence to companies engaged in the business of biotechnology, for granting short term fresh recognition to biotech start-ups established in the incubator centre or technology parks. These start up companies should have identifiable R&D infrastructure, adequate research programs and capable of earning revenues. The institutions recognized by DSIR can avail customs and excise duty exemptions, fiscal incentives u/s 35(2AB), 35(1) (ii) and 35(1) (iii) of the Income Tax Act 1961 along with funding from various government funding agencies. The second component is focussed towards the development of Common Research and Technology Driven Hubs (CRTDHs) as a part of industry-institute interaction for enhancing translational research to enable the industries have access to the modernistic, new fangled research facilities and expertise available in research institutions that would facilitate the industry take up product/ process development and skill enhancement activities. During the FY 2015-16, DSIR was in the process of setting up two hubs in the sector of affordable healthcare each at CSIR- Institute of Himalayan Bio resource Technology (IHBT), Palampur and CSIR-Centre for Cellular and Molecular Biology (CCMB), Hyderabad and

one hub in the sector of environmental interventions at CSIR-National Institute for Interdisciplinary Science and Technology (NIIST), Thiruvananthapuram.

(iv) **Access to Knowledge for Technology Development and Dissemination (A2K+):** The scheme aims at providing access to science, technology and innovation related information to the industry, industry associations, SIRO's and research/academic institutions.

Several fiscal incentives have also been announced by the Government of India from time to time for boosting R&D investments in the industry such as (i) weighted tax deduction @ 200 per cent on the R&D expenditures inclusive of capital and revenue, incurred by the industry u/s 35(2AB) of the I.T Act 1961 (ii) weighted tax deduction @ 200 per cent for approved sponsored research in national laboratories, IITs, central/state universities u/s 35(2AA) of the I.T Act 1961, (iii) weighted tax deduction @ 175 per cent to the donor for any sum paid to research associations like SIROs approved and notified under section 35(1) (ii) and 35(1) (iii) of the I.T Act 1961 (iv) customs duty exemption on goods imported for R&D and central excise duty waiver on purchases of indigenous goods for R&D to public funded and privately funded institutions registered with DSIR (v) accelerated depreciation allowance on plant and machinery set-up based on indigenous technology under Rule - 5(2) of IT Rules (vi) Central Excise duty waiver for 3 years on the goods produced based on indigenously developed technologies and duly patented in any two of the countries out of India, European Union (one country), USA and Japan.

**Council of Scientific & Industrial Research (CSIR),** an autonomous organization having pan-India presence, under the Department of Scientific & Industrial Research, Ministry of Science & Technology, GoI have adopted a slew of measures to enhance entrepreneurship, technological development and innovation in industries. Several public-private partnerships like The Centre for Genome Application (TCGA) is the first ever PPP body formed in collaboration with Institute of Genomics & Integrative Biology/CSIR and Institute of Molecular Medicine for providing life science solutions. IICT- Evolva Partnership is also the first of its kind in biotech-SME segment in India with partnering between IICT Hyderabad and Evolva Biotech, Singapore. CSIR has also implemented the New Millennium Indian Technology Leadership Initiative (NMITLI) in public-private partnership mode based on inverse risk investment profile notion for nationally evolved and industry oriented projects with public-funded R&D institutions, academia and private industry. CSIR has also been closely working with the leather, electronics, mining, minerals and material industry including healthcare and communication for technology up gradation and diversification.

**National Research Development Corporation (NRDC)** working under the administrative control of Department of Scientific and Industrial Research (DSIR), Ministry of Science and Technology, facilitates the promotion, development and commercialization of indigenously developed technologies with an effective and smooth flow of technology transfer from the various national R&D centres/labs, IITs, universities and individual inventors to the industry. During the FY 2015-16, the organization was assigned more than 40 new processes and has signed almost similar number of licence agreements.

**Department of Science & Technology (DST)** has been the major source of extra mural research funding in the country. DST extends Grant-in-Aid to scientific research institutions, scientific associations and bodies for undertaking many of the mega science projects and basic research in frontier areas of S&T. DST has established the **Science and Engineering Research Board (SERB)**, as an autonomous organization for supporting basic research in India. Recently, SERB has instituted a scheme that provides an opportunity for collaborative research between the academic institutions and the industry. The scheme aims to bridge the gap between the public funded research and industrial R&D. The department has also undertaken several new initiatives like the creation of national centres for advanced research, providing start-up research grant for Indian diaspora undertaking faculty assignments in Indian academia, DISHA scheme for women in science programme, i-STED (Innovation, Science and Technology led Entrepreneurship Development), DST-MHRD Collaboration in Impacting Research Innovation and Technology (IMPRINT) Project and many other schemes for promoting basic and applied science.

DST is operating the Drugs and Pharmaceutical Research Programme (DPRP) which helps create a link between public funded research institutions and Indian pharmaceutical industry for drug development and clinical trials. The **Technology Development Board (TDB)** is a statutory body of DST that helps the industry in commercialization of indigenous technologies. The Board provides financial support in the form of equity capital, loan or grant (in exceptional cases) to industrial concerns and other agencies attempting development and commercialization of indigenous technology or for the adaption of imported technology for wider domestic application. The financial assistance is provided during the commencement, start-up or growth stages of industrial concerns. Technology Development Board also provides support to the incubators through its seed support scheme. **The National Science and Technology Entrepreneurship Development Board (NSTEDB)** of DST has implemented programmes like Science & Technology Entrepreneurship Parks (STEPs) and Technology Business Incubators (TBIs) to facilitate the development of knowledge based and innovation driven enterprise. NSTEDB has facilitated the establishment of 18 STEPs and 68 TBI's in various host institutions which may be academic or R&D institutions, science parks or IT parks. TBI's generally provide infrastructural, technical, IPR and legal support services to the start-ups and the incubatees.

**Biotechnology Industry Research Assistance Council (BIRAC)** is a not for profit, public sector enterprise of Department of Biotechnology (DBT), Ministry of Science & Technology, Government of India, set up as an interface agency for DBT to serve as a single window for the emerging biotech industry especially the SME's. The organization promotes academia-industry collaboration, international linkages and techno-entrepreneurship. BIRAC supports several schemes like **Biotechnology Ignition Grant (BIG)**, **Small Business Innovation Research Initiative (SBIRI)** and **Biotechnology Industry Partnership Programme (BIPP).** Biotechnology Ignition Grant was launched to support scientist entrepreneurs, academia and start-ups to facilitate the validation of a proof of concept (POC) and an idea with commercialization potential/implementation. The support is provided in the form of Grant-in-aid capped at Rs. 50 lakhs. SBIRI scheme has supported number of start-up units, small and medium enterprises and other private biotech industry. SBIRI is a flagship public-private partnership programme of Department of Biotechnology and supports research initiatives of Indian biotech industry. The scheme caters to discovery, proof of concept and early stage innovations in companies for developing a biotechnological product and process having societal relevance. Biotechnology Industry Partnership Programme (BIPP) is also an Advanced Technology Scheme (ATS) of DBT with the industries for support on cost sharing basis for high risk discovery and innovation, accelerated technology development especially for futuristic areas. This new scheme facilitates to promote R&D in biotech industry and public private partnership programmes with the government contribution of 30-50 per cent to the industry for discovery linked innovation. BIRAC has supported approximately 300 companies and more than 100 academic institutes and entrepreneurs as per the latest updates provided in the compilation (BIRAC Innovators: Nurturing the Opportunities). The seven major theme areas supported by BIRAC through BIG, SBIRI, BIPP, Contract Research Scheme (CRS) and Social Innovation Programme for Products Affordable and Relevant to Societal Health (SPARSH) include drugs with drug delivery, bio-similars (including stem cells), vaccines and clinical trials, devices and diagnostics, agriculture (including aquaculture and veterinary science), industrial biotechnology (including secondary agriculture) and bio-informatics. BIRAC has supported maximum number of projects in the area of devices and diagnostics followed by industrial biotechnology whereas the response of private sector participation was higher in the area of vaccine and clinical trials, (Source: BIRAC Innovators-Nurturing the Opportunities).

The Department of biotechnology has also established several biotech parks and incubation centres like the TICEL Bio Park, Chennai, BT Park, Hyderabad, and The Golden Jubilee Biotech Park for Women at Siruseri, Kanchipuram District, Tamil Nadu for technology incubation, demonstration and pilot plant studies.

The **Ministry of New & Renewable Energy** has a scheme in place for research, design,

development & demonstration (RDD&D) to develop new and renewable energy technologies, processes, material, components and subsystems. The scheme can be easily taken up by the developers and manufacturers of new and renewable energy technologies, processes both in the public and private sector or by research and development institutions, academic institutions and autonomous organizations. Local bodies, panchayats, community based and organizations of civil societies such as nongovernmental organizations, citizens and institutions funded by union/state/UT governments can also take up the projects. The Ministry provides financial assistance of only upto 50 per cent of the project cost to partners from the industry or civil society organization whereas proposals from the universities or government research institutions can receive complete funding support.

**Department of Electronics & Information Technology** (DeitY), Ministry of Communications & IT, GoI is operating a scheme known as Multiplier Grants Scheme (MGS) with an aim to encourage the industry collaborate with academic and government R&D institutions for development of products/ packages that are indigenously developed and to bridge the gap between R&D, proof-of-concept and commercialization. DeitY is also supporting innovation and incubation activities through a scheme like Technology Incubation and Development of Entrepreneurs (TIDE). Support For International Patent Protection In Electronics & Information Technology (SIP-EIT) is a scheme to provide financial support to MSMEs and Technology Start-up units for international patent filing to encourage innovation and recognize the value and capabilities of global IP along with capturing growth opportunities in ICTE sector. Reimbursement is limited to a total of Rs. 15 lakhs per invention or 50 per cent of the total expenses incurred in filing and processing of patent application up to grant of patent, whichever is lesser. The schemes of Deity have enabled in the transfer and commercialization of technologies related to Green IT, bio-informatics, nanotechnology, UbiComp technology, bio-photonics, convergence and broadband technologies, microelectronics, VLSI etc. The promotion of R&D activities has mainly been done through the programmes undertaken by several R&D groups/divisions and R&D organizations of DeitY such as Centre for Development of Advanced Computing (CDAC), Society for Applied Microwave Electronics Engineering and Research (SAMEER), Centre for Materials for Electronics Technology (C-MET) and Media Lab Asia (MLAsia). (Source: Ministry of Electronics & Information Technology-Schemes & Policies).

It is extremely difficult to provide a comprehensive list of significant achievements/ technologies developed and commercialized, success stories and innovation capabilities developed and achieved in each of the scheme run by DSIR or any other scientific organization in India whether autonomous institution or public sector within the framework of this compilation, but nevertheless, an attempt is made to highlight some of the achievements made under various schemes/policies in the scientific organizations and is attached at Annexure 1.

**Investments in Research & Development by the Government vs Industry**

The industrial policy reforms that led to rise of globalization and privatization during the last two decades drifted the focus towards the private sector for the growth and economic development of the country. However, the irony is that major R&D investments still come from the government/public sector. Government is rather playing a more crucial and significant role in driving, facilitating and regulating economic development in the private sector. The scope and coverage of the private sector companies in this compilation includes in-house R&D units and SIRO's recognized by DSIR including the MNC's and the companies not covered by DSIR under its recognition scheme. According to World Bank, the percentage of Gross Domestic Expenditure on R&D in India was 0.8 per cent in 2011 which had hardly changed from 0.75 per cent of GDP in the year 1990-91. The R&D/ GDP ratio of India was around 0.88 per cent during the 11$^{th}$ plan period which has reported to have slightly increased from 0.81 percent in 2004-05 to 0.87 percent in 2009-10. The Government sources contributed 71.1 percent of the total R&D expenditure whereas 28.9 percent came from the private sources during 2009-10 (DST: Research and Development statistics at a glance 2011-12). This has been a major cause of concern to the government because even though the national expenditure on research & development has risen to Rs. 53,041.30 crores in 2009-10 from an

abysmally low figure of Rs. 760.52 crores during 1980-81, the investments from the private sector has been continuously low in comparison to the government sector. The various state governments like that of Gujarat, Maharashtra, Karnataka, Andhra Pradesh, Uttar Pradesh, Tamil Nadu and Punjab have also made concerted efforts to contribute heavily for research and development in State Agriculture Universities and other state owned organizations/departments. It was estimated that during the financial year 2011-12, the investments from the central sector, state sector, private sector and the higher education sector would be Rs. 42,614.53 crores, Rs. 5,090.84 crores, Rs. 21,965.31 crores and 2,949.76 crores respectively. This implies that private sector would contribute nearly 30.24 per cent of the total expenditure on R&D. The central government including the public sector industry accounted for 59.7 per cent share of R&D expenditure during 2009-10, whereas the private sector, state government and higher education sector contributed 28.9 per cent, 7.3 per cent and 4.1 per cent respectively (Fig. 1, Source: Data collected and compiled by DST).

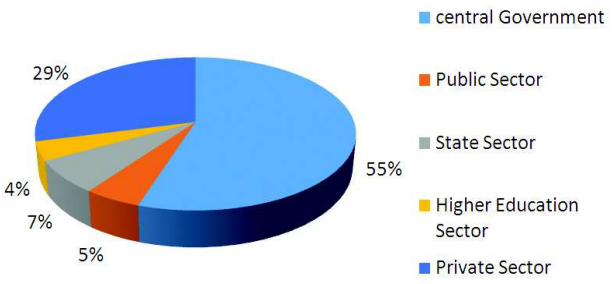


**Fig. 1: R&D Expenditures during 2009-10. Source: DST: Research and Development statistics at a glance 2011-12**

The public sector together with the private sector is called as the industrial sector. Table 1 reflects the R&D expenditures by the industrial sector over a four year period from 2006-07 to 2009-10. It is evident from the Table 1, that the industrial sector spent Rs. 18,120.11 crores on R&D activities which accounted for 34.2 per cent of the national R&D expenditure (Rs. 53,041.30 crores) during 2009-10. Hence, the industrial sector investments on R&D worked out to be 0.30 per cent of the GDP at current prices for the FY 2009-10. The R&D expenditure of the industrial sector as a percentage of sales Turnover for the year 2009-10 worked out to be 0.61 percent. Further, it is interesting to note from the Table 1 that the 84.5 per cent of the total industrial sector investment on R&D was contributed by the 93.7 per cent of the private sector in-house R&D units whereas rest of the 15.5 per cent was invested by 6.3 per cent of the public/ joint sector during 2009-10 and the per unit R&D expenditure for private and public sector was Rs. 8.8 crore and Rs. 24.1 crore respectively during the FY 2009-10. This variation can be attributed to the size of public sector companies and their need for complex, sophisticated technological infrastructure to cater projects of national importance and priority. The private sector on the other hand include large, medium and small scale industries and given the heterogeneity in nature and size of industry, has a predilection to invest in R&D based on project/ product development analyzing cost-benefit ratio.

The government has declared 2010-20 as "Decade of Innovation" and has proposed to increase the total amount of R&D investment to two per cent of GDP by the end of 12$^{th}$ plan Period. Increasing gross expenditure in research & development (GERD) to two per cent of GDP has been the aim of the government for some time and this can be achieved if the private sector increases its R&D investments to at least equate with the public sector R&D investments from the current ratio of around 1:3 (Science, Technology and Innovation policy 2013).

**Table 1: R&D expenditures by the industrial sector from a period from 2006-07 to 2009-10**

| Sector | Period | Public Sector | Private Sector | Industrial Sector |
|---|---|---|---|---|
| No. of R&D Units | 2006-07 to 2009-10 | 117 | 1746 | 1863 |
| R&D Expenditure (Rs. In Crores) | 2006-07 | 1465.41 | 10485.58 | 11950.99 |
| | 2007-08 | 1877.25 | 12926.14 | 14803.39 |
| | 2008-09 | 2457.02 | 14365.40 | 16822.42 |
| | 2009-10 | 2814.56 | 15305.55 | 18120.11 |

Source: DST: Research and Development statistics at a glance 2011-12

The R&D ecosystem in India is primarily government funded and therefore, there is an urgent need for the private sector to embark upon funding research programs aimed at national and societal development.

**Position of India in Terms of R&D Spending Amongst Global Counterparts**

Amongst the BRICS nations, India had the smallest percentage of R&D spends in the year 2009-10 in comparison to China which accounted for 1.70 per cent followed by Russian federation 1.25 per cent and Brazil 1.17 per cent respectively (DST: Research and Development statistics at a glance 2011-12). This clearly indicates that India having the third largest GDP in the world next to US and China in terms of purchasing power parity (Report on 2014 Global R&D Funding Forecast sponsored by Battelle and R&D Magazine, Dec., 2013) needs to stress on the S&T component for growth and prosperity of the country when it is observed that most of the developed nations spend more than two per cent of their GDP on research & development. According to World Bank, research and development expenditure as a percentage of GDP for countries like USA, Germany, Denmark and Finland had been 2.79, 2.92, 2.98 and 3.55 respectively. USA accounted for the largest share of global R&D spending with 33.9 per cent contribution in 2014 followed by China, Japan and Germany with 17.5 per cent, 10.2 per cent, 5.7 per cent respectively whereas India accounted for only 2.7 percent of the total global R&D spends (Report on 2014 Global R&D Funding Forecast sponsored by Battelle and R&D Magazine, Dec., 2013). It is further presumed that all the developed and developing nations in the European Union, Middle East & Africa, South East Asia will undergo a modest growth in terms of R&D spends in the backdrop of historic economic slowdown in the recent past but China is emerging as a huge economy because of its progressive reforms and may takeover USA in a couple of years as its gross expenditure on R&D is continuously increasing with a double digit change in R&D investments annually. China is also having Science & Technology co-operation with the power centers of the world like the USA and the European Union. China is having S&T co-operation agreement with the United States under the 1979 Science and Technology Cooperation Agreement and provides for S&T co-operation in agriculture, energy, environmental protection, public health, earth, atmospheric and marine sciences, basic research, standards and metrology and nuclear safety (Suttmeier, R. P., 2014). R&D intensity of Korea is also commendable but has still not match the pace with China. Countries like China, Japan and Korea are aggressively working towards expanding their R&D base and time is already ripe when India needs to rethink and ponder over the causes for low competitiveness in science & technology both in the public and private sectors. The S&T indicators like trained Ph.D students, publications, patents have a direct co-relation with the investments in research and development. During 2006-2010, India's growth rate of scientific research publication was 12 percent and 10 percent as per the SCOPUS and SCI database respectively as against the world average of 4 per cent (DST- Research and Development statistics at a glance 2011-12). It is further observed that though the number of capacity building programmes and publications have increased in the last few years in India but there is a need for critical assessment of publications appearing in journals, national/ international to analyze the quality of publication and the number of papers contributed by the industry to have a glimpse on the quality of basic and applied research being conducted in India. This may also enable the assessment of technologies, both qualitative and quantitative having commercialization potential. India has intensified the efforts towards strengthening its IP regime and programs for the creation of IP awareness and the importance of recognizing early stage invention/know-how amongst the technopreneurs have been undertaken to facilitate the industry in creation of proprietary technologies and commercialization of IP.

**Factors Influencing the Investment Sentiments of the Industry**

Investments in research and development are the building block of a strong economy and industrial growth but the story in India is asymmetrical. The industry considers investments in research and development as a sunk cost which is not easy to recover and therefore, has a predilection to invest more as capex which can easily be capitalized in the books of accounts. The industry also tends to be very strategic and critical with respect to its research programs and considers investing in research which is cost-effective and can be accomplished within a

reasonable time frame. The industry supports more of the self-funded research from the profits arising from the sales turnover of its products and brands and therefore, tends to make judicious investments in R&D depending upon the need to develop and innovate the product based on consumer demand, price profitability and average rate of return on the innovation. The small and medium industries generally lack the required capital, infrastructure, technology and research personnel to undertake high end research and therefore, the investments by these industries remain inadequate. The access of funds from the family and friends, angel investors and venture capitalists is also not easy and therefore, the government intervention at this juncture becomes essential for the industry to help provide them the required support and funds for undertaking research and business.

There are several factors both external and internal governing the R&D spends by the industry. The general recession in the world and economic slowdown in the recent past, market size, market forces and changing needs of the customer had made impact on the trends in R&D investments by the industries in the last decade. Within the country, factors like political stability, government policies for industry, different tax regimes for concessions and incentives to industry, timeframe for seeking statutory approvals for the projects, ease and simplified business procedures, merger and acquisitions, increasing competitive markets for domestic players, foreign direct investment in some industrial sectors, research environment, returns to R&D investments and high risk innovations, degree of government regulation, formation of special economic zones and strategic location availability to the industry or availability of space in industrial parks, business flexibility have greatly altered the way in which the industries are investing in research and development. Research have also indicated that the mergers and acquisitions in industry are governed by the legal protection of intellectual property and it is imperative for the companies to safeguard their technology and innovation by means of patent, copyright, trademark and registration of industrial design in order to prevent unauthorised use. The absence of a strong IP system leads the industry to invest less for R&D and there is no breakthrough research. The technical collaborations of the industry with academic and research institutions and the ease of technology acquisition, transfer, commercialization and scope of technology also affect the investment sentiments of the industry in research and development. The pharmaceutical companies, for instance invest a considerable amount in R&D each year to develop a new drug and bring it to market but with the increase in investments, the risk factors for the return on R&D and realizable profits also increases as the regulatory bodies might take time for approving the developed technology or therapy and the IP. This reduces the thrust of the industry to invest more in R&D and in the absence of strong IP system, the innovation process and product can be easily copied by the other companies. Hence, there is a need for more responsive policy and greater public support to lubricate the wheels of innovation, provide fertile environment and availability of funds and incentives to industry to augment investments in R&D and improve technological capability and exports. The role of the government therefore, becomes more responsible in supporting basic and applied research in the country through a network of policies and schemes. The seeds of change have been sown and fruition may be observed in the time to come.

**Discussion**

The industrial sector has evolved considerably in the post-liberalization era and has played a pivotal role in the economic development of the country. The Indian government had undertaken several policy reforms which have been friendly and progressive but the comparison of the role of the industrial policies pre and post liberalization era and the S&T development in India in nurturing the industrial growth of the country with the rest of the developed nations would be unreasonable and not pragmatic keeping in view of our available infrastructure, resources and technically sound manpower. In comparison with the national expenditure, the percentage of expenditure by the industries may appear small but the objectives are also different. Each five year plan has witnessed higher budget allocations of the government for improvement in Science & Technology. The bulk of government research and development expenditures goes to only five agencies, Defence Research and Development Organisation (DRDO), Department of Space, Department of Atomic Energy, Indian Council of Agricultural Research and Council of Scientific and

Industrial Research. The government for long has been the largest source of funding for macro projects under space research, atomic energy, defence and aerospace, missile development programmes, railways, power, health and environment, emerging academic disciplines like biotechnology, nanotechnology, funding to national projects like National Agriculture Technology Project (NATP), National Agricultural Innovation Project (NAIP) and National Agricultural Science Fund (NASF) in the stream of agriculture, exploration and exploitation of earth and others because of which India is well equipped, poised and successful in promoting defence and security-related large-scale scientific endeavours, such as space, nuclear science programs, energy and telecommunications than any other developing nation. The Mars Orbiter Mission with a comparatively economical project cost of just US$ 72 million, launch of GSAT-14 (communication satellite), Indian Regional Navigation Satellite System IB (IRNSS IB), PSLV-C 23 and a manned mission to space by ISRO; development of research vessel Sindhu Sadhna for various observational studies of the sea and marine explorations; designing, construction and commissioning of the DHRUV reactor for attaining self-sufficiency in the production of radio-iostopes, development of digital radiography and tomography techniques for use in non-destructive testing procedures in India and indigenous development of instrumentation, detector, sensors and mass spectrometers by Bhabha Atomic Research Centre (BARC), Mumbai; success in nuclear experiments and materials research, ALICE experiment at the Large Hadron Collider (LHC) at CERN, Geneva, Switzerland by Variable Energy Cyclotron Centre (VECC), Kolkata are examples of some of the spectacular achievements of the government run scientific organizations.

The public sector had also played a significant role in the economic development of the country and has undergone progressive expansion in the last two decades. The government is extending full support and co-operation to the PSE's to empower them expand their business and emerge as global giants. The Steel Authority of India Limited (SAIL), Hindustan Aeronautics Limited (HAL), Bharat Electronics Limited (BEL), Bharat Earth Movers Limited (BEML), Bharat Heavy Electricals Limited (BHEL), National Thermal Power Corporation (NTPC), Gas authority of India Limited (GAIL), Bharat Petroleum Corporation Limited, Oil India Limited, Nevyeli Lignite Corporation Limited, Oil and Natural Gas Corporation (ONGC) are some of the dominant players in the public sector and have been instrumental in rolling out products and services at an affordable cost that have changed the lives of millions of people. BHEL has developed products like the smart wall blowing system for cleaning of boiler tubes during operation, 165 tonnes per hour Atmospheric Fluidised Bed Combustion (AFBC) boiler, acoustic steam leak detection system for boilers, High Voltage Direct Current (HVDC) transmission systems, hydro turbines with improved efficiencies, space grade solar cells etc. HMT Tractor Unit manufactures wide range of tractors from 25 HP to 75 HP to cater to the specific needs of the agriculture sector. Hindustan Antibiotics Limited was the first company in India to launch a recombinant DNA product rHU-Erythropoietin (Hemax) in 1993. Indian Drugs & Pharmaceuticals Limited (IDPL) played a major role in the strategic National Health Programmes like Family Welfare Programme & Population Control, anti-malarials (Chloroquine) and prevention of dehydration (ORS) by providing quality medicines. During the country's calamity of outbreak of plague in 1994, IDPL was the only company to supply tetracycline for the entire nation. Similarly, company had made uninterrupted supply of Chloroquine to combat malaria epidemic in different parts of the country and in the year 2005, the company supplied the required Doxycycline capsules within no time to combat national emergency (Leptospirosis) arising due to floods in Maharashtra. IDPL has supplied quality medicines and its presence has played a price balancing role in the competitive business environment. Bharat Immunologicals and Biologicals Corporation Limited (BIBCOL), Government of India Undertaking is the leading biotechnology company based in Uttar Pradesh and the supplier of a range of pharmaceuticals products such as Oral Polio Vaccines (OPV Vaccine), Zinc Tablet and Diarrhoea Management Kits etc.

The objectives and prime focus of the centre and state governments and the private sector have also been different. The centre has always given importance to applied sciences and natural sciences whereas for the state governments, agriculture, forestry, aquaculture, animal husbandry, dairy,

irrigation, waste water management and the other allied activities have been of considerable importance. The focus of R&D investments by the industry has been in areas of engineering and technology like information technology, transportation, telecommunication, biotechnology, drugs & pharmaceuticals, agriculture and agriculture machinery, chemicals, automobiles, electrical and electronic equipment, food & beverages etc. Several new sectors have also emerged like the bio-fuel industry did not exist in India during the 1990's but now there are companies which are making substantial investments in the bio-fuel R&D. The bio-pesticide and the bio-fertilizer industries are also new and the Indian firms are making notable investments on R&D in these areas. Among the companies in industrial R&D, drugs & pharmaceutical sector have contributed to (27.7 per cent) followed by transportation (14 per cent), Information & Technology (13.6 per cent) and defence (6.1 per cent) respectively for the overall R&D spends during the year 2009-10. The defence and the fuel sector had a profound share of R&D investments from the public sector.

The industry contribution towards R&D is increasing over the last few years as depicted in Table 1, but it still contributes to less than 35 per cent of the overall R&D spends. The government has chalked out a viable roadmap to facilitate growth in the industrial R&D by the private sector. Some of the measures that can catalyse investments in industrial R&D could be to have an effective and conducive policy to stimulate private research in India. Foreign investments in Indian industry and collaborative research projects with the research institutions in various countries may be encouraged. Improvements in IPR environment and regulation, business incubation and tax incentives are required to encourage private sector R&D investments. Industrial transformation research programs may be initiated to help solve the problems of the industry related to technology know-how, cost and improvement. Profitable and social enterprises catering to the basic needs of the society based on innovative technology may be promoted. Large Indian industries may be encouraged to establish globally benchmarked stand-alone R&D centres with upgraded infrastructural facilities on the lines of R&D centres set up by multinational companies (MNCs). Strong collaborations between industry and academia with the formation of research innovation clusters for areas like software technology, food processing, automotive industry and electronic manufacturing may be promoted and strengthened to develop globally accepted technologies which are business and demand driven. Steps to consolidate our existing technological base may be taken to strengthen the R&D base in industry. Government may also promote Start-ups and MSMEs as they play a crucial role in the economic growth and development of the country.

The industry may be encouraged to develop technology which can be easily commercialized and is cost-effective, reliable, maintainable and widely accepted by the end consumer. Seminars/workshops/ trainings may be organized with local business and chambers of commerce to help disseminate information, hands on experience of technology and benefits of the IP system to the small and medium sized enterprises. There should be a mass popularization of the various schemes floated by the government for availing tax benefits, customs, and excise duty exemptions to Industry to elevate their investment sentiment.

India has much to change with adequate economic reforms and should look for core competencies. There is a swelling need for the creation of specialized and trained workforce to meet the demand in industry. Government has taken steps for capacity building in frontier areas of science like ICT, open source drug discovery, electronics & engineering, agricultural biotechnology etc. The young scientists/ talent working or settled abroad should be allured to come back and work in Indian industry. This would help in creating a pool of highly skilled scientists and technologists and acquiring skills and resources that lead to improvement of R&D investments in the country. The private sector should also participate in the skill development and training of its employees. The industry should view the creation of an employable workforce as a part of nation building rather than a corporate social responsibility. Industry should also fund for scholarships/fellowships to the students in the academia to pursue research career/higher studies.

India has made substantial investments in the R&D sector during the 11$^{th}$ five year plan period laying a strong foundation for S&T sector in the country. It

had been imperative for the government to evolve new strategies and mechanisms to infuse investment by industry if one per cent of GDP investment on R&D is to be targeted by the private sector. The government has already initiated measures to improve the private sector contribution to R&D expenditure but still the sectors like space, defence, atomic energy, protection of environment, exploration of earth, seas and atmosphere are the strategic and critical component areas which the government should be proud of retaining with itself. The central government (including public sector and the higher education sector) has in the past continued to contribute a major share of the national R&D expenditure for these sectors, because of which the contribution by the public sector has always been more than the private sector. If we compare with the other countries like, China, USA, Korea and Japan, where it has been observed that private sector R&D expenditure is around three -fourth of the total R&D spends, then it can be the prerogative and choice of one's individual country as to which strategic sector the government wants to retain with itself or there could be sectors/ objectives, which the government of that country would have given totally or partially to the private sector.

The Indian industries whether the public sector or private sector have been passing through difficult times governed by both the political and economic factors. The companies have established in-house R&D centres and have invested a good amount for R&D in spite of the economic slowdown and global recession in the past. It is also observed that the number of R&D centres have not only increased but the industry is also working on diversified research programs which are well defined, time bound with an objective to enhance the quality and domain of research in the centres. For example, the BHEL has established 14 centres of excellence which are in operation focussing on new product/process development and has recently filed more than 400 patents and copyrights. Aircraft Research and Design Centre (ARDC) of Hindustan Aeronautics Limited has 13 successful aircraft designs to its credit, ranging from basic piston trainers to the frontline combat aircraft (HT-2, PUSPAK, KRISHAK, MARUT, KIRAN MK-1, BASANTH, AJEET, KIRAN MK-II, HPT-32, AJEET TRAINER, HTT-34, LCA and IJT). NEPA Limited was a single product company producing the standard newsprint but now the company has produced for the first time in India 42 GSM newsprint, meeting practically all the international parameters of strength, opacity, surface smoothness and brightness that has enabled the company meet the demand across all the categories of newsprint customers. Centre for Applied Research & Development (CARD), Nevyeli Lignite Corporation Limited has patented a process for the production of potassium humate from lignite that will help build up organic matter in the soil and is a plant growth stimulant. The commercialization of this product will bring lignite have a diversified utility in producing a value added product and thereby promoting agricultural growth in the country. Bharat Earth Movers Limited (BEML) which is catering to core sectors like defence, rail, power, mining and infrastructure has recently diversified its business for successfully assembling stainless metro coaches for Delhi Metro Rail Corporation (DMRC) under technical collaboration with M/s Rotem of South Korea. Some of the companies have also been able to compete with multi-nationals in the world market adhering to the international quality standards and are in quest for further contracts for running business. There has also been an increase in number of the domestic filing of patents and some of the scientific organizations, industries who have made to the list of top patent applicants are Council of Scientific & Industrial Research, Defence Research Development Organization, Indian Council of Agricultural Research, Department of Biotechnology, Rotary wing Research and Design Centre – Hindustan Aeronautics Limited, Centre for Development of Advanced Computing, Department of Electronics & Information Technology (DeitY) and Indian Space Research Organization. Amongst the institutes and universities, the Indian Institute of Technology (collective) and Indian Institute of Science, Bangalore have been amongst the list of top applicants for patent filing (Source: Intellectual Property India- The office of the Controller General of Patents, Design, Trademarks and Geographical Indicators, Department of Industrial Policy and Promotion, Ministry of Commerce & Industry, Government of India; Annual Report 2014-15).

The country is watching a change and is moving on the transformation stage. Though we have challenges to subjugate, a strategized and collective approach can definitely help us upsurge an economy

which is innovation driven rather than factor driven. The government has embarked upon several new policy initiatives to help the country have breakthrough innovation and a globally competitive environment. The Make in India campaign of the Government of India with a slew of simplified business procedures, statutory clearances, favourable investment policies, tax reforms in the country and land acquisition regulation is an approach in the right direction to revive the distressing economy. The stage is set to focus on the industrial development in the country with a number of foreign investors and major industry players finding India a favourable investment destination. The country will benefit from the expertise and knowledge of the other developed nations for futuristic technologies while achieving the goal of self- reliant and self-sustaining economy through learning and training. The series of policy initiatives along with several reforms in place shall reverberate with the increased research & development sentiments in the industry with increased push for intellectual property creation, protection and management. It is envisaged that the upcoming policy of the government for start-ups shall also support for innovation and entrepreneurship base in the country, bringing a relief to the start-up community for funds and execution of business. In a nutshell, the government is poised and focussed towards targeted development and is making efforts to mobilize all the adequate resources required for thriving a fertile innovation ecosystem in India.

## References


BIRAC Innovators: Nurturing the Opportunities

Central Institute of Plastics Engineering & Technology: UG &PG Programs - Overview: http://www.cipet.gov.in/academics/ugpgprograms_overview.php, Retrieved on 06.07.2016

Creative India: Technopreneur Promotion Programme (TePP), DSIR, Ministry of S&T, New Delhi, Vol. **V** 2010

Department of Scientific & Industrial Research *Annual Report* 2015-16

Department of Science & Technology: *Research and Development Statistics at a Glance* 2011-12

Foundation for Innovation and Technology Transfer *Annual Report* 2015

Indian Council of Medical Research *Annual Report* 2013-14

Intellectual Property India: The office of the Controller General of Patents, Design, Trademarks and Geographical Indicators, Department of Industrial Policy and Promotion, Ministry of Commerce & Industry, Government of India *Annual Report* 2014-15

Ministry of Electronics & Information Technology-Schemes & Policies http://meity.gov.in/content/schemes-and-policies, Retrieved on 19.08.2016 and http://deity.gov.in/content/schemes-and-policies Retrieved on 21.07.2016

Rajiv Gandhi Institute of Petroleum Technology-Academic Departments: http://www.rgipt.ac.in/academic_departments.htm. Retrieved on 06.07.2016

Report on 2014 Global R&D Funding Forecast sponsored by Battelle (www. battelle.org) and R&D Magazine (www.rdmag.com): December 2013 2014_global_rd_funding_forecast (1).PDF; Retrieved on 16.03.2015

Science & Technology Policy 2003

Science, Technology & Innovation Policy 2013

Statement of Industrial Policy, July 24, 1991

http://dipp.nic.in/English/Policies/Policy.aspx

Suttmeier R P (2014) Trends in U.S-China Science and Technology Cooperation: Collaborative Knowledge Production for the Twenty-First Century? Research Report Prepared on Behalf of the U.S-China Economic and Security Review Commission

Thakur B, Gupta R and Singh R (2012) Changing Face of India's Industrial Policies: A Look; *International Journal of Scientific and Research Publications* **2**(12) pp 1-7

The World Bank http://data.worldbank.org/indicator/GB.XPD.RSDV.GD. ZS?order=wbapi_data_value Retrieved on 04.03.2015

Venture Centre, NCL Innovation Park, Pune http://www.venturecenter.co.in/activities_programs.php. Retrieved on 08.07.2016


## Majority of the information in preparing this manuscript has been obtained from the following websites


1. Bhabha Atomic Research Centre: www.barc.gov.in/about/anushakti_rd.html
2. Bharat Heavy Electricals Limited: http://www.bhel.com/about_recent.php
3. Biotechnology Industry Research Assistance Council: http://www.birac.nic.in/index.php
4. Bharat Immunologicals and Biologicals Corporation Limited: http://www.bibcol.com

5. Council of Scientific & Industrial Research: http://www.csir.res.in/
6. Department of Science & Technology: http://dst.gov.in/
7. Department of Biotechnology: www.dbtindia.nic.in/index.asp
8. Department of Industrial Policy & Promotion: http://www.dipp.gov.in/
9. Department of Public Enterprises: dhi.nic.in/dpe.nic.in
10. Hindustan Aeronautics Limited: http://www.hal-india.com/Aircraft/M__145
11. HMT Tractors: http://www.hmttractors.co.in/
12. Indian Council of Agricultural Research: http://www.icar.org.in/en/aboutus.htm
13. Indian Agricultural Research Institute: www.iari.res.in
14. Indian Council of Medical Research: http://www.icmr.nic.in/annual/annual.htm
15. Indian Drugs & Pharmaceuticals Limited: http://www.idpl.gov.in/about.php
16. Ministry of New & Renewable Energy: http://www.mnre.gov.in/schemes/r-d/scheme-10/
17. National Research Centre on Plant Biotechnology: http://www.nrcpb.res.in/success-stories
18. NEPA Limited: http://www.nepamills.co.in/newsprint_product.htm
19. Neyveli Lignite Corporation Limited: https://www.nlcindia.com/
20. National Science & Technology Entrepreneurship Development Board http://www.nstedb.com/
21. Planning Commission: www.planningcommission.nic.in
22. Technology Development Board: www.tdb.gov.in
23. The World Bank: www.Worldbank.org

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## Annexure I

### (A) Salient Achievements of Department of Scientific & Industrial Research, New Delhi

(I) **Industrial R&D Promotion Programme (IRDPP) -**This is one of the flagship schemes of DSIR which has supported in providing recognition and registration to about 1,800 in-house R&D units of the companies and 1,200 Scientific and Industrial Research Organization (SIRO's) and Public Funded Research Institution (PFRI's) so far. The institutes and industry recognized by DSIR can claim for income tax relief on R&D expenditure, customs and excise duty exemption, weighted tax deduction u/s 35(2AB) of the IT Act 1961. The incentive of 200 per cent weighted tax deduction is one of the best in the world and provides for incentivizing the R&D sentiments of the industry to attain global competitiveness. The department at present is providing fiscal incentives to over 1,000 companies for claiming weighted tax deduction u/s 35(2AB) of IT Act 1961. The department has submitted reports valued at around Rs.10,000 crores to the Director General of Income Tax (Exemptions) during the FY 2015-16 to enable the industry claim weighted tax deduction u/s 35(2AB) of IT Act 1961 (Source: Department of Scientific & Industrial Research, Annual Report 2015-16). The foregone revenue due to several tax exemptions and concessions have been increasing over the years but has significantly contributed to the R&D and innovation in the industry.

(II) **Technopreneur Promotion Programme (TePP) -** This is an erstwhile scheme of DSIR and has been one of the most creative schemes for promoting individual innovator, grass-root innovator by providing grant-in-aid support to them for converting their ideas into economically viable products/ processes. DSIR has supported more than 600 individual innovators and more than 30 TePP outreach centres. Several success

stories have been created and awarded patent. Some of these are: (i) Development of pollution free technology for starch processing plants (ii) Development of extendable width cultivator which is workable with higher horse power tractors and the futile need of purchasing the matching implement is avoided (iii) Production of filler grade PTFE, which will reduce plastic waste and help in minimizing ecological problems (iv) Development of a cost-effective method for synthesizing and processing nanocrystalline hydoxyapatite (HAP), a bioactive and bio-compatible material used as bone substitute material and in drug delivery systems. This innovation will enable the orthopedic surgeries become affordable even by the common masses. (v) Development of wet and dry scrubbers as pollution control devices for diesel vehicles, tractors and DG sets upto 15KVA, (Source: Report prepared by Department of Scientific & Industrial Research (DSIR) on Creative India, Technopreneur Promotion Programme (TePP), 2010). Some of the other completed projects during the year 2013-14 are (i) Development of portable, non-invasive oral cancer detection system (ii) low cost multi-media projector (iii) supportive limb for physically challenged and (iv) Mrityunjay - an advanced electronic distant patient monitoring system.

(III) **Promoting Innovations in Individuals, Start-ups and MSMEs (PRISM) –** It is a newly formulated scheme and some of the ongoing projects under the scheme are (i) automated garment dyeing, chemical washing and effluent treatment wet processing machine for cotton textiles and cotton garments. (ii) Low cost sequence embroidery machine for zari and zardosi work. (iii) Development of pesticide mixer cum sprayer agricultural pump which is operable by single person and will replace traditional system of spraying in orchids, crop and vegetable fields. The accuracy in the ratio of water to pesticides is also maintained (Source: Department of Scientific & Industrial Research, Annual Report 2015-16).

(IV) **Patent Acquisition and Collaborative Research and Technology Development (PACE) -** It is also a newly formulated scheme under the $12^{th}$ plan and supports projects for technology development and demonstration in the industry and some of the projects that have been supported are the following:

(i) Technological upgradation of steam sterilization based pelletization facility for development of microbe free, herbal veterinary supplement for the benefit of livestock such as poultry, aqua ruminants etc. which are a part of the food chain.

(ii) Macro algal Bio-refinery for $CO_2$ sequestration and production of bio-fuel and value added compounds for economic sustainability.

(iii) Chitosan based drug delivery system for dental and oral diseases.

(iv) Development of genetically engineered cellulose for alkaline xylanase through submerged fermentation process (SMF). Due to the inconsistency in the yield of the product, the company had opted for recombinant route for expressing the gene viz. *Bacillus pumilus* in *Pischia pastoris,* a well studied host used in the production of recombinant enzymes.

(V) **Access to Knowledge for Technology Development and Dissemination ($A2K^+$) -** The scheme is supporting (i) Technology Development and Utilization Programme for women for creating awareness and training of women for promotion and adoption of new technologies. (ii) Technology Development and Demonstration Programme (TDDP), which is operational since 1992 and the department has supported more than 250 projects with a total project cost of Rs. 750.60 crore in which the DSIR support had been about Rs. 280 crore. 76 technologies developed under the TDDP scheme have been commercialized and the department has earned a cumulative royalty of around Rs. 33crores. Some of the technologies that have been commercialized are (i) Digital axle counter for railway signaling (ii) PC based CNC system (iii) Development of microbalance of 200 gm capacity with 1 mg accuracy. (iv) Glargine process improvement (v) Development

of an interactive multimedia package for intellectual property rights training.

**(B) Salient Achievements of Council of Scientific & Industrial Research, New Delhi**

1. (i) CSIR through NMITLI scheme has been successful in developing a reflectance confocal microscope and has paved the way for photonics research in India. This is one of the best examples of "Made In India", high end product.

   (ii) CSIR under the NMITLI scheme, with a focused effort to develop sustainable energy solutions has endeavored to develop indigenous know-how and technology for building proton exchange membrane fuel cell (PEMFC) multi cell stack of desired power output, which has also been validated for commercial application and use as telecom tower power backup. The modular test bed for validation has been designed, built and commissioned with in-house know-how at Reliance Industries Limited, Patalganga site.

2. (i) The National Aerospace Laboratory (NAL), Bangalore is a proud associate with Indian Space Research Organization (ISRO) in India's first reusable Launch Vehicle – Technology Demonstration (RLV-TD). The acoustic test on RLV-TD were carried out at the Acoustic Test Facility of CSIR, NAL during April 2016.

   (ii) The National Aerospace Laboratory (NAL) has also developed spectrally selective coatings for solar thermal power generation and application. The know-how for the development of technology for commercial production of absorber coatings is available with NAL.

   (iii) The National Aerospace Laboratory (NAL) and the Indian Meteorological Department (IMD), are jointly producing the Drishti system, which is an indigenous hi- tech visibility system to manage take off and landing at airports under conditions of lowest visibility of 50 meters. Till now, only seven airports in the country have been armed with the Drishti visibility system and mega project of installing such 70 systems across the country's various airports is under way.

   (iv) The Aeronautical Development Agency (ADA) and Department of Defence R&D is the nodal agency for the design and development of Light Combat Aircraft, Tejas. Hindustan Aeronautics Limited (HAL) was the principal partner in LCA programme with participation of Defence Research Development Organization (DRDO) and CSIR laboratories, public and private sector industries. National Aerospace Laboratory (NAL) has spearheaded the team effort to design, develop and certify the fly-by wire flight control laws and air data algorithm for Tejas.

3. The Central Scientific Instruments Organization (CSIO), Chandigarh, has developed an earthquake warning system (Eqws) which records the events and generates SMS to the concerned action point in real time. Recently, CSIO using this (Eqws) has alerted the Delhi Metro about the 6.8 magnitude of the earthquake recorded in Hindukush region of Afganistan on 10$^{th}$ April, 2016.

4. National Botanical Research Institute, Lucknow, has developed low arsenic rice grain. The new variety has "arsenic methyl transferase gene", isolated from a fungus that accumulates less arsenic and would be less toxic. The variety is almost ready for field trials.

5. CSIR, with Department of Science & Technology has developed the first Indian Gyrotron (a device used in nuclear fusion process and which is presently imported in the country) and is ready to be tested at the Institute of Plasma Research, (Department of Atomic Energy), Gandhinagar, which is a partner institute of the project.

6. CSIR - Indian Institute of Petroleum, Dehradun has developed and transferred the technology for making a catalyst that will reduce Sulphur in LPG.

7. CSIR and Oil and Natural Gas Corporation Ltd. (ONGC) has established a unique PPP mode for exploration of natural resources for oil and gas from ONGC oil fields in Krishna –Godavari basin.

8. (i) CSIR-Central Mechanical Engineering Research Institute (CMERI) has developed a 10 hp tractor named Krishi Shakti which is cost effective (Rs. One lakh) and is suitable for small and marginal farmers. CMERI had done the nation proud when in 1970 it first designed and developed the 20 hp Swaraj tractor, the first indigenous tractor of the country. Thereafter, CMERI designed the 35 hp Sonalika tractor, which has gone into major production.

   (ii) CMERI has also developed Soleckshaw (Solar-Electric Rickshaw). It is an eco-friendly mode of urban transport system which is dual powered and driven partly by pedal and partly by electric power supplied a battery that is charged from solar energy. The technology has been commercialized to some of the companies.

9. National Physical Laboratory (NPL), New Delhi developed the chemical composition of the indelible ink which is used as an electoral ink and the process involved in the manufacturing of the ink is licensed and is a closely guarded secret.

10. Central Food Technological Research Institute (CFTRI), Mysore, during the late 1950's developed a process for the production of infant food from buffalo's milk. The technology was licensed to the Kaira District milk producers union at Anand, Gujarat, which produced infant food under the brand name Amulspray and which soon became a popular household name. The product has also been distributed under the special nutrition programme, Integrated Child Development Service Scheme (ICDS), run by the various state Governments.

11. Institute of Microbial Technology (IMTECH), Chandigarh has designed a new-generation clot buster protein streptokinase and the know-how for the production has been licenced to Nostrum Pharmaceuticals Inc., USA about a decade ago. The primate studies for toxicological safety and efficacy have been successfully completed, validating the proof-of-concept of this molecule.

**(C) Salient Achievements of Indian Council of Agricultural Research, New Delhi**

Indian Council of Agricultural Research has a vast network of research institutes, national research centres and bureaus, state agriculture universities and is a pioneer organization responsible for sustainable food-grain production in India with major milestones being achieved as green revolution (food grains), white revolution (milk), yellow revolution (oilseeds), blue revolution (fish) and golden revolution (fruits and vegetables). The research and development efforts of the organization have enabled the increase in production of food grains by five times, horticultural crops by more than nine times, fish by more than 12 times and milk by around eight times in the last 60 years. Some of the remarkable achievements of ICAR are enumerated below:

(i) Developed and released nearly 3,300 high-yielding varieties/hybrids of field crops for different agro-ecological zones.

(ii) Developed single cross hybrids in Quality Protein Maize (QPM) and baby corn for high nutritional value in addition to high yield.

(iii) Agriculturally important micro-organisms, plant growth promoting rhizo-bacterium (PGPR), *Bacillus amyloliquefaciens* IISR GRB 35 has been bio-encapsulated for smart delivery in crops. The patent for the invention has also been filed.

(iv) Developed the bio insecticide strain DOR Bt-l, registered and commercialized its formulation KNOCK W.P. along with a low-cost mass multiplication methodology for integrated management of semilooper caterpillar in a number of crops; developed endosulfan-tolerant strain of *Trichogramma chilonis (Endo-grama)*; deployed Pest Management Information System including Interactive Kiosks for Basmati rice, cotton, mustard, chickpea and groundnut.

(v) Prepared soil resource maps of the country (1:1 million scale), states (1:250,000 scale) and 55 districts (1:50,000 scale); soil degradation map of the country (1:4.4 million scale) and state soil erosion maps (1:250,000 scale).

(vi) Developed a portable soil test kit/mini lab (*Mridaparikshak*) to supplement soil testing service in the country. The kit is useful in analysing soil samples for the purpose of distributing soil health cards to farmers.

(vii) Developed liquid bio fertilizer formulations with longer shelf life. Identified potassium and zinc solubilising bacteria and standardized vermi/bio-enriched composting technology.

(viii) Indian Agricultural Research Institute has developed an indigenous semi-synthetic super absorbent polymer "Pusa Hyrogel" which has a remarkable ability to reduce irrigation/ fertigation requirement of crops besides improving crop yield and quality under restricted or limited irrigation conditions. The bench scale technology has been licensed to six companies.

(ix) National Research Centre on Plant Biotechnology (NRCPB) has developed transgenic brinjal with a Bt gene (cry1Fa1), which is very effective against BSFB.

(x) National Research Centre on Plant Biotechnology has also developed transgenic tomato (Pusa Ruby) with cry1Ac gene for protection against the fruit borer. The Bt-tomato was tested with promising results and licensed in 2011 to a private company for bio safety testing and commercialization under Public-Private partnership.

(xi) NRCPB has developed a high yielding mustard variety, named, 'Pusa Jai Kisan' through tissue culture technique, called soma clonal variation. The popular commercially released variety, Varuna (Type 59) was used as a donor parent for generating somaclonal variation.

**(D) Salient Achievements of Indian Council of Medical Research (ICMR), New Delhi**

ICMR promotes biomedical research in the country through intramural research (by its own institutes/ centres) and extramural research (through grants-in-aid given to projects to non-ICMR institutes). ICMR is working under the Department of Health Research (DHR) and has a country wide network with more than 30 institutes. Some of the major milestones achieved by ICMR in the field of affordable diagnostics, therapeutics-drugs and devices/treatment methods and vaccines are enumerated below.

(i) Indigenous technologies for the following have been developed and launched (a) Japanese Encephalitis vaccine (JENVAC) under public private partnership with Bharat Biotech India Pvt. Ltd., Hyderabad. (b) Thalassemia detection kit developed by National Institute of Immunohaemotology, Mumbai (c) An "AV Magnivisualizer" for detection of cervical cancer developed by Institute of Cytology and Preventive Oncology (ICPO), Noida (d) PCR based food pathogen detection kit, ELISA kit for Ferritin estimation and Dried Blood Spot (DBS) collection kit for vitamin A analysis, all developed by the National Institute of Nutrition, Hyderabad, (Source: Indian Council of Medical Research, Annual Report 2013-14).

(ii) The National Institute of Virology (NIV), Pune completed the restructuring of Virus Repository at par with international protocols of bio security and standards. The activity has been successfully launched as a part of the NIV Bio Banking programme and viruses given to researchers in the country.

(iii) Regional Medical Research Centre, Port Blair has worked for the development of DNA vaccine against leptospirosis. The DNA vaccine construct based on LipL45 sequence elicited both cell mediated and humoral immune response in experimental animals and the Centre is providing referral services in leptospirosis to various institutions in the country as well as to neighbouring countries. Diagnostic services (Microscopic Agglutination Test performance) was provided to 11 centres, leptospiral reference strains were supplied to 22 centres and control sera to three centres.

(iv) Technology on Vijaysar, an antidiabetic drug generated in 1999 has been sold to a company after signing a tripartite agreement and

assignment deed between the Indian Institute of Integrative Medicine (IIIM), Jammu and ICMR. This technology was an outcome of the joint effort of Indian Institute of Integrative Medicine (IIIM), Jammu (CSIR) and ICMR.

(v) Enterovirus Research Centre, Mumbai has contributed significantly to the understanding of epidemiology of poliomyelitis and developing polio vaccination strategies in India and the most significant achievement of the Centre has been the achievement of "zero polio" status in India.

(vi) The Desert Medicine Research Centre (DMRC), Jodhpur has developed herbal composition against larvae of dengue vectors which can be used as an effective and sustainable bio-larvicide to check vector breeding and eliminate virus foci possibly circulating through vertical transmission.