REPORT OF THE

WORKING GROUP

ON DST

ELEVENTH FIVE YEAR PLAN
2007-12

DEPARTMENT OF SCIENCE & TECHNOLOGY
GOVERNMENT OF INDIA

Contents

Chapter 1

Background

1 Constitution of the Working Group

A Working group was constituted under the chairmanship of Secretary, Department of Science and Technology by the planning commission through O.M. Prn/ADV/SC/2006 dated May 11, 2006 for the formulation of XIth five year Plan 2007-2012 proposals for the department. The Composition and Terms of Reference of the Working Group are given in Annexure I. In order to assist the Working group, various sub groups through O.M. 1(1)/2006-PC dated January 24, 2006 (Annexure II) for each of the major program areas of the Department were constituted in keeping with the Terms of Reference of the working group. The status of science & technology in the country has been reviewed by various bodies. Empowered Committees have made specific recommendations for monitoring vision led intervention for deepening the research and development base of the country. These specific recommendations are placed in annexure IV and V. It is based on the reports and recommendations of sub-groups and deliberations of the Working group of DST as well as vision-led proposals of empowered bodies like SAC-PM, SAC-C and various thought leaders, the approach and plans for the 11th five year plan perspectives of DST have been formulated.

1.1 The Need for linking Science and Technology to the Growth Aspirations of India

The approach paper of India for the XIth plan period 2007-2012 aims towards faster and more inclusive growth. Indian economy is growing steadily for the last 15 years. The growth rate of the Gross Domestic Product has remained in the range of $7 \pm 2\%$ since 1991. Growth processes of Nations are closely connected to ability to add values raw materials through the use of technology and gaining global competitiveness gained through technology led manufacturing. Innovation has emerged the most critical element in wealth generation in the current world economy. Legal systems on Intellectual Property Rights and WTO regimes have made Indian S&T system respond to the changing needs of the time. Integration of Indian S&T with global systems has been facilitated by strengthening of legal support on IPR, TRIPS and other WTO compliant regulatory framework.

For faster growth plan of India to be realized, technology-led growth of GDP forms the key element. India may need to double, if not treble, the contributions of technology-led GDP growth within 2020. The pronounced Indian Vision 2020 demands that the country be technologically developed.

India is currently a happening and an aspiring country. The youth power of India does not suffer from lack of ambitions. The zeal to feel powerful as a Nation is rich and wide. The new found optimism of India and China to emerge as major economic powers by 2030 and 2020, respectively, has altered the landscape of Indian science and technology.

1.1.1 Strategic Approach of the Department of Science and Technology for XIth Plan Period

A conscious and well structures effort to link technology to the faster growth agenda of the country is an essential strategy for India. The more inclusive growth model selected by the country demands that the Indian Science and Technology system responded quickly to the essentiality of linking S&T developments to the rural India. A strategic approach to deliver results for strengthening science and technology base of the country in short span of time is essential. The Department of Science and Technology ahs therefore, developed an approach, which targets planned and timely interventions in the supply-, delivery- and demand- sides of resources for science and technology.

Consistent with the approach paper of the planning commission towards the faster and mode inclusive growth model, the Department of science and Technology has developed its plan for 2007-2012 periods on a dualism model. The current investments into research and development in India are far below the required levels for meeting the growing aspirations of the country to emerge a strong knowledge economy. While the public investments into research and development may be increased through the public policy support, unless a matching effort to rejuvenate the science education and research support systems in the university is made and the ability to absorb higher financial allocations for science and technology are likely to cause asymmetries in the innovation infrastructure of India.

The Department of Science and Technology, Government of India, has, therefore, enrolled into the approach model of the planning commission for the country and has undertaken upon itself a critical and facilitating role in enabling the science, technology and innovation infrastructure of India over a wider cross section. A coherent and synergized effort to participate in the talent supply chain for science and engineering has been planned. It is plan with a difference. It has been planned in the background of optimism and desire of India to emerge major global player. The approach adopted addresses to the essential steps in areas where corrective measures are required while planning also for an ambitious future by preparing a science and technology base for XIIth and XIIIth plan periods.

1.1.2 Case for Enlarging Public Investments into the Science and Technology

Indian investments into research and development have been compared with those of some select nations in Table 1. The comparative assessment reveals that the comparative strength of India in knowledge infrastructure would be seriously disadvantaged in competition to other Nations with similar of even smaller sizes of economy relative to India. India makes an investment of about US $ 5 billion into Research and Development annually. On the other hand, China has announced recently that her planned investments in Science and Technology for the year 2007-08 are US $ 130 billion which will be next only to those of the United States of America. Consequently, output indicators for the status of science and technology of India in comparison to other nations like China or Korea are not favorable. However, Indian outputs indicate an increasing trend during the last five year plan periods. This increasing trend can be traced to larger outlay for science and technology during the ninth and tenth plan periods.

Allocations of budget into science and technology are better viewed as investments into the future rather than using model of expenditure control. A mind set of investment into science and technology is particularly necessary for the eleventh plan period of India, when the country is poised for emerging a major global player by 2025. Strong cases are made for a total allocation of Rs 100,000 crores for science and technology for the XIth plan period. Such a dis-continuous growth path for science and technology can be expected to deliver significant outcome in the not-too distant future.

The Department of Science and Technology, Government of India, has therefore developed its approach plan in the framework of the ongoing national debate on the need for larger outlay for science and technology and emerging Vision of India for Science and Technology.

1.1.3 Science and Technology Vision of India: Basis for Eleventh Plan of the Department of Science and Technology

Global Competitiveness of India in Science and Technology Sector: Whereas technology has entered the National agenda through Indian vision 2020, S&T indicators show that the growth rate of India in science and technology needs to be enhanced significantly. There have been several reviews and comparisons on the scientific outputs of India in comparison to China and other nations [1-3].

In 1985, Indian share of publications in SCI journals was 2.9% which was reduced to 1.5 in 1995. Although number of scientific publications in journals included in Science Citation Index from India has increased from about 11,500 to 19,500, the share of India has remained low at 1.9% as of 2003. India ranks currently 14th among nations contributing to number of publications in SCI journals.

A correlation of number of papers published from various countries against the level of investments in R&D in billions of US$ has been made and presented in **Figure 1.**

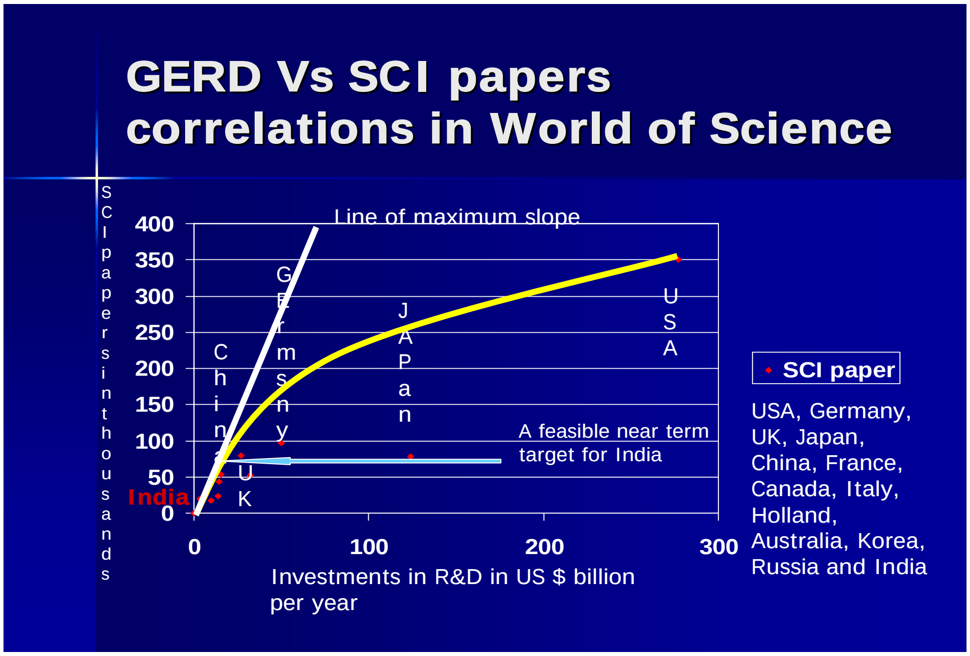


Figure 1: Correlation of number of publications in SCI journals with level of R&D investments in US $.

An analysis of data presented in **Figure 1** reveals that although per dollar output of India in terms of number of publications in SCI journals is high. Although the productivity of Indian science stream for dollar invested is attractive, the production of Scientific and technological outputs do not match the potentials of the country. An inter comparison of India and China in terms of inputs into R&D and S&T outputs is made in table below.

Inter comparison of China and India in performance in science publications for the year 2002-2003

Parameter	China	India
Input side • R&D Professionals • PhD outputs/ year • R&D investment in US $ billion	 • 8.5 lakhs • 40,000 • 15.5	 • 1.5 lakhs • 4,500 • 3.7
Output side A. No of SCI papers B. Citation frequency C. Relative rank	 D. 53,000 E. 3.9 F. 5th	 G. 19,500 H. 3.5 I. 14th

Office of the Principal Scientific Advisor to the Prime Minister has carried out a systematic study of the status of research and development indicators. There have been serious concerns growth trends in science and technology are commensurate with the competitiveness potentials of the country. Since economic growth competitiveness of Nations is expected to be closely linked to global competitiveness of technology, the need to strengthen urgently the Science and Technology system of India has been stressed. The need for special interventions for attraction of talents to study and careers with science and technology is widely recognized

1.1.4 Faster Growth Agenda of India: Calls for Global Technology Competitiveness

Minimum level of investments needed for improving the relative rank of India with respect to the number of SCI publications at the current level of productivity has been estimated from the line of maximum slope in Figure 1. At least a 4.0 fold increase in the level of R&D funding relative to the current levels of R&D funding seems necessary for improving the competitiveness of India.

1.1.5 Interventions Needed for Rejuvenation of Science and Technology Base of India

Whereas the increase in R&D investments may increase the supply of resources, without the matching interventions to improve the delivery side and scale expand the absorption side for increased resources, India can not realize the full benefits of increased R&D funding. Other developing Nations in Asia Pacific region are investing heavily into research and development and are expanding the number of researchers per million human populations. The share of Nations in Asia Pacific region in global research and development outputs has increased significantly. In emerging areas like materials science, the region enjoys a higher growth rate than American and EU countries.

India is emerging as an efficient R&D hub of the world. The returns from expertise base of India for Dollar invested in research and development are the largest as of now. It is estimated that as many as 220 multi-national companies are investing in research laboratories in India currently. If the current trends continued, a potential for the Indian talent generating Intellectual Properties for wealth creation in other countries can not be ruled out.

There is an imminent need to create a National ambience for research and development leading to the intellectual properties which generate wealth for India. The cost-of not- doing such efforts could be serious. The Department of Science and Technology has made a serious attempt and planned some critical interventions in this approach paper

1.1.6 Next Five Steps necessary to increase the competitiveness of India

Based on an analysis of current scenario of the global competitiveness of India in performance in science and technology, the ministry of science and technology foresees a need to make planned interventions for rejuvenation of science. Five next bets steps necessary have been identified through a wide consultation. They are

- **Attraction of talent to study and career with science through efficient talent supply chain management**
- **Larger investment into science**

- **Efficient mechanisms of support to science and technology through system improvement**
- **Expanding and Strengthening of Institutional infrastructures for research**
- **Developing measurements and assessment of Scientific outputs for increased accountability**

1.1.7 Attraction of Talent for Careers with Science

Careers with science and technology do not seem to attract talent in competition with other socio-economic endeavors any longer. With higher returns for individuals arising out of service sectors like IT/BPO operations, the extent to which service sector is able to attract talents, growth sectors like manufacturing or science and technology are not able to. To some extent, the inability of science and technology to attract talents is on account of low levels of demand pull for qualified scientists and engineers in the country.

It is estimated that about 1.5 lakh personnel are employed in S&T sector in India. The current displacement rate of S&T professionals per year due to retirement and resignations is about 4%. This amounts to an annual requirement of about 4500 R&D professionals. In some sense, the number of PhDs produced in S&T sector at 4500 per year reflects the steady state conditions of R&D sector in the country.

The nation is at the verge of launching an excellence based inclusive growth model. Large expansions of capacities in higher learning institution are planned. Hence there is a need to make adjustments in the supply side of S&T professionals for both teaching and R&D sectors. Whereas China expanded the number of PhDs produced from approximately from 4000 to 40,000 in fifteen years, Indian output has remained steady at about 4500 per year in science streams.

With bulging demands for technology led growth paradigms and India emerging a reliable global R&D hub for knowledge economies, the outputs of 4500 PhDs per year does not seem optimum. On account of relatively lower ability of S&T% sector for job creation, demand pull from other commercial sectors of economy is causing maladjustments in talent supply chain management in India. S&T sector does demand higher talent base for India to remain competitive not only in science and technology but also in technology and innovation-led economic growth paths. Currently, talent supply is better attracted early (say in the age group of 15 to 18) by financially more rewarding professions than science. As a consequence Science sector is necessarily having to content with available supply of talent. Therefore, there is a need to develop special mechanisms for attracting talents of the country to careers with science and technology. An Assured Opportunity Scheme for Careers with science needs to be developed and implemented during the eleventh plan as a priority.

A suitable scheme to provide assurances for career with science for about 1000 young people leaving schools per year with an expectation that at least 50% of them will enter S&T systems after PhD per year is necessary. Entry of 500 talented young people in science through a special “Scheme for Early Attraction of Talent for Science” (SEATS) at plus two level (say at the age of 17) would need an early commitment of 10% of total number of jobs being filled currently in S&T system by 10-15 years ahead. It is believed that it is critical for India to launch a special scheme for attracting talents for science the during the Eleventh plan period.

Special schemes need to capture three essential elements. They are a) some early assurances of career potentials, b) joy of experiencing early in life psychic income potentials of career with science and c) mentorship value from contact with global icons in science to wet an aspiration of winning for India high recognitions. Implementation of a carefully designed and implemented scheme for attraction of talents supply to science is the most essential first step for India during the Eleventh plan.

1.1.8 Larger Investments in Science

Thought leaders of India have been concerned about the relatively weaker outputs indicators of Indian science and technology system in relation to other countries in Asia and Pacific region during the last ten years.

On account of low overall investments in research and development funding, the relative position of India among Asian Nations is receding. Japan, China and Korea have surpassed India in terms of aggregate number of publications as shown in **Figure 2**. However, those nations have invested in research and development considerable higher than India.

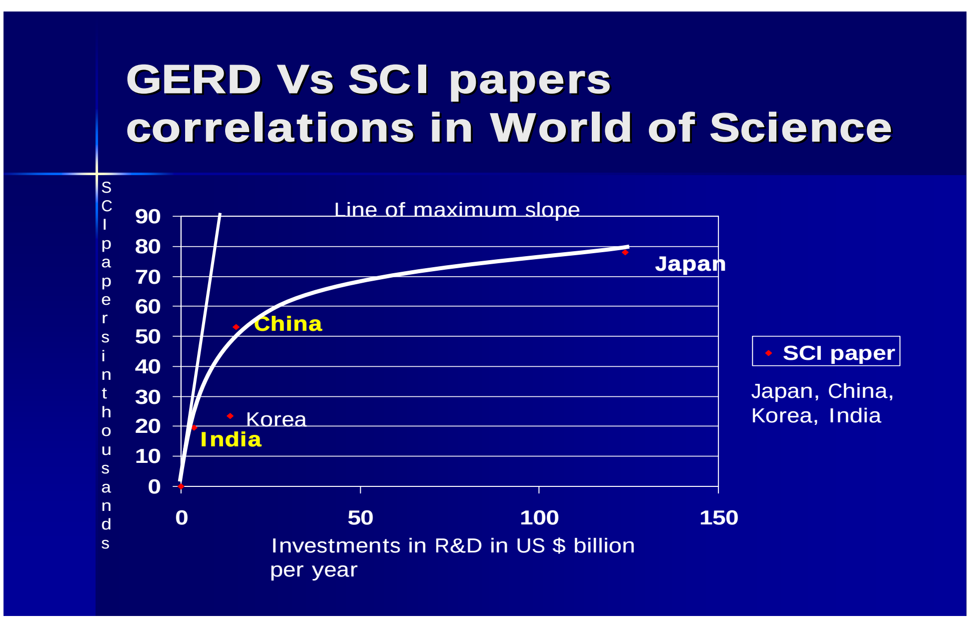


Figure 2. Correlation of number of publications in SCI journals against the level of investment of major Asian Nations

If India were to target a relative position of five overall in the world match the performance of China, the minimum investment in science for non-strategic sectors at the current productivity per dollar invested would be of the order of at least US $ 12 billion per year. Even at that level, Indian investment would of the order of 75% of that of China. Larger investments in science and technology during the eleventh plan seem essential for the country to remain competitive among nations in Asia and Pacific region.

Current share of investments into R&D by public and private sectors is estimated at 75:25 in India, while the corresponding ratio in China is reported as 33:67. Therefore, policy initiatives for attraction of larger investments of the private sector into R&D may need to be further strengthened during the eleventh plan period.

An investment of at least Rs 1,00,000 crores in S&T sector during the eleventh plan period seems required, if India were to remain competitive in research, innovation and technology. The cost-of-not investing in science and technology need also be assessed for making investments into S&T in India.

1.1.9 Efficient mechanism for Delivery of S&T support

Apart from supply side interventions through allocations of funds for S&T systems, there is also an essential need to increase the efficiency of delivery of resources to R&D groups. Currently designed delivery mechanisms for funds for research seem to demand about 12-16 months from the date of initial application.

Science and Technology generation being the outputs of creative endeavors of human minds, it is necessary to shorten the waiting time for funds from the current 12-16 months average to at least 4-6 months. Best practice systems of National Science Foundation of the USA or other comparable systems of R&D funding need to be studied and matched by Indian during the eleventh plan period.

One of the most widely celebrated mechanisms of Extra mural funding of science and technology system in the country is Science and Engineering Research Council embedded in the Department of Science and Technology of the Government of India. New models and mechanisms of delivery of funds are required to be designed and commissioned within the S&T mechanism. Department is required to strengthen the systems such that the delivery of funds is achieved within 100 days of processing by the S&T machinery. This would call for innovative design of systems and use of technology tools including IT empowered decision -making process.

1.1.10 Expanding and Strengthening of Institutional Framework

The institutional framework of higher learning and research in India is showing signs of saturation and maturity. The accelerated growth processes desired by the country call for development of new aggressive models and establishment of institutions without jeopardizing the existing S&T systems.

Indian Institutes of Science and Education Research form parts of an expanding network of institutions of higher learning and research. There are plans to expand the in-take capacities of Indian Institutions in higher learning. Universities and colleges are engaged in increasing the teaching capacities. There have been concerns that universities and colleges are not able to undertake research and development to the required levels.

Whereas major contributions in science and technology emanate from university systems in other countries, share of the Indian university systems in scientific outputs of the country is decreasing. There is an urgent need to strengthen the research infrastructure for science and technology in the Indian university system. Fund for Institutional Strengthening (FIST) introduced by The Department of Science and Technology six years ago has made a beginning. This program needs to be continued for further period of at least five years in some modified form.

Nourishing the root of innovations in the university system is essential if India were to bear the fruit of investment in science and technology by 2020. While internal governance systems in the universities in India may pose challenges and limit the absorption rate of resources for science and technology, there is a compelling need to readjust the supply side through proactive interventions and strengthen the demand side for public funded research grant utilization in the university system in the country.

Research and Development system of the country, whether be in the public or private funded bodies, depends only upon the strength of the university system to promote advanced research. Strengthening of the existing S&T capability of our universities is an essential step that merits an all out effort from Ministry of Science and Technology.

1.1.11 Measurements and Assessment systems for Enhanced Accountability of S&T System

While Science and Technology support systems may be able to make a case for additional and large investments during the eleventh five year plan, it is the duty of the S&T machinery to develop sound evidence based decision tools to justify the support provided by the national planners. Measurement and assessment systems suited to the S&T landscape of the country and an enhanced accountability of research and technology institutions are critical requirements.

Investments of a country in R&D can not any longer be considered without reference to the measurable outcomes on the socio-economic health of India. There are engines of economic growth in the industrial sector. An organic link between technology and trade areas is necessary. It has become pertinent for India to undertake a correlation of capacities to develop globally competitive technologies in the form of innovations and IPR products with the volume of trade of the corresponding sector for the engines of industrial growth. For example, S&T back up systems for sectors like textile, information technology, pharmaceuticals, telecommunication, which have registered high growth rates, may need to be analyzed for their current strength and if necessary, a strategy for strengthening will require to be implemented.

A special cell for S&T indicator based decision support unit is required. Capacity for building Technology foresight and policy formulation based on evidence is essential within the S&T ministry. A national capacity for S&T policy studies and foresight building for the country as a whole is one of the key and essential next best step to be undertaken during the eleventh plan period.

1.2 Enhanced Role of DST in the Emerging India S&T Vision

The Department of Science and Technology of the Government of India founded in the year 1971 has been adopting an input led growth model for supporting the science and technology systems in the country. The Department recognizes a need to include also an output directed development path in relating technology led growth path of the GDP in future. Innovations in science and technology can participate more actively to wealth generation and addition of value to employment.

Department of Science and Technology recognizes a need for the department to review critically all programs and institutional mechanisms and realign its core functions to suit the emerging the expectations of the country from science and technology institutions and agencies.

The Indian vision of science and technology is to assist the emergence of the country as global economic power through a technology- and innovation-led growth of GDP. The Department of Science and Technology enrolls itself as a major player and agency of the Government of India in meeting the grand challenge. The proposal of eleventh plan, of DST is therefore, with reference to the emerging needs of the S&T sector rather than one of extending the past from the activities and programs of the Xth plan along the models adopted in the previous plan periods.

Chapter 2

Review of Performance During the Xth Plan

2.1 Tenth plan Programs: Ongoing Activities and Resource Base

Department of Science & Technology has been playing a pivotal role in the promotion of science & technology in the country including basic research and technology development in the public funded institutions in the country. Some of flagship programs of DST could be grouped as

- Science and Engineering Research Council
- Nano Science and Technology
- Autonomous Institutions
- Technology Development Board
- Science communications
- Pharmaceutical industrial technologies
- International cooperation
- Technology and Entrepreneurship Development
- Science and Society programs

The Department has committed itself for gearing S&T towards meeting the basic needs of the masses through interventions and programmes at various levels. These include:

- ➢ Increase the S&T infrastructure to meet the challenging demands in basic research, technology development, scientific services and societal development;
- ➢ Create suitable conditions for attracting and nurturing young talent to take to research and development;
- ➢ Providing special opportunities to women scientists and also programme for empowerment of women through S&T interventions;
- ➢ Develop world-class 'Centres of Excellence' in R&D in frontier areas of science and technology;
- ➢ Develop appropriate mechanisms for reducing the time lag between an invention and its commercialization;
- ➢ Develop methods for forecasting and mitigation of natural disasters such as cyclones, earthquakes etc.;
- ➢ Attract industrial investment in research and development to cope with the increased competition in a global market; and
- ➢ Popularize S&T and nurture a scientific temper among our citizens.

DST has also been overseeing two sub ordinate departments namely, Indian Meteorological Department and Survey of India. The allocation of resources of DST for various activities and programs supported by the department during the tenth plan period
is indicated along with the DST proposals for the 11th plan in Chapter 6.

2.2 Review of Major Tenth Plan Programs: Achievements

The Department of Science and Technology has emerged the major and critical department supporting Extra Mural Research (EMR) with a 40-44% share of the EMR funding provided in the country. For purposes of convenience, some output indicators of programs are included in this report.

2.2.1 Science and Engineering Research Council Programs

Critical Role Player by SERC in Extra Mural Research Funding in India: Science and Engineering Research Council of The Department of Science and Technology has emerged the major support system of Extra Mural Research funding in the country. Data presented in Figure 3 illustrate the critical role of the SERC program in fostering basic and applied research in the country. SERC support for EMR funding during the tenth plan period has averaged around Rs 13-15 lakhs per scientist per year.

Publications and their impact factors emanating from SERC supported project during the years 1999-2003 have been presented below.

PERFORMANCE IN BASIC RESEARCH (1999-2003)

(Based on Science Citation Index CD Version

Year	CSIR		IIT		ATOMIC ENERGY		ICMR		ICAR		DST/SERC	
	Total Papers	Impact factor per paper	Total Papers	Impact factor per paper	Total Papers	Impact factor per paper	Total Papers	Impact factor per paper	Total Papers	Impact factor per paper	Total Papers	Impact factor per paper
1999	1699	1.538	1298	1.160	628	1.23	109	1.948	234	0.839	538	2.27
2000	1667	1.520	1279	1.235	598	1.691	99	1.834	200	0.805	500	2.29
2001	1700	1.696	1347	1.258	486	1.474	111	1.780	215	0.907	512	2.24
2002	1944	1.632	1440	1.455	758	1.546	102	2.110	269	1.021	545	2.25
2003	2273	1.751	1617	1.514	795	1.609	136	2.814	257	1.023	497	2.13

Impact Factors of publications emanating from SERC supported projects in various institutions have been consistently ranged 2.2 ± 0.1 per paper. Considering that per paper impact factor compares favorably with the values in national laboratories and institutions, the robustness of processes and mechanisms adopted for funding for SERC is evident.

Research Centres of Excellence

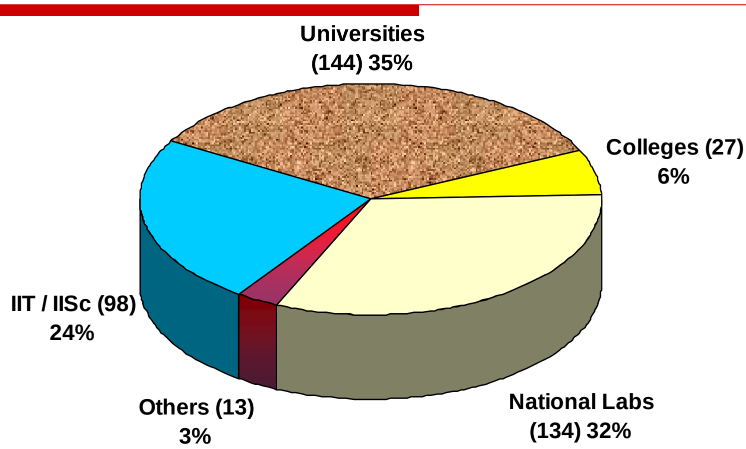
SERC has over the years created a chain of research centers of excellence in diverse fields of S&T. This has contributed to augment R&D capabilities at academic institutions and national laboratories Many of these Centres have advanced research facilities to attract young researchers to continue their research activities.Some outstanding examples are:

- National Facility for High Field NMR at TIFR
- Non-Destructive Evaluation (NDE) facility at NML and IIT Chennai
- NMR facility for biological research at IISc, Bangalore
- Low temperature High Magnetic field facilities at University of Hyderabad
- Centre for study of Ultra fast Processes at University of Madras, Chennai
- National Facility for Protein sequencing at IIT Bombay
- Samtel center for Display Technology,IIT,Kanpur
- SQUID based MEG system for Non-Invasive studies of Human Brain at IGCAR, Kalpakkam
- Centre for fuel cell Technology at ARCI, Hyderabad
- Centre for Soft Computing Research at ISI, Kolkata
- Stable Isotope Facility at CWRDM, Kozhikode
- Linear Accelerator with conformal Radiotherapy & Intensity Modulation Radiotherapy Facility at SGPGIMS, Lucknow
- Nanophosphor Application Centre (NAC) at Allahabad Universit
- Centre for Biomedical and Bioseparation Technologies at Vellore Institute of Technology
- Ten Centres on Nano Science for quality nanoresearch aimed at anchoring technology development programmes

Infra structural Strengthening of University System in Research: SERC has played a crucial role in strengthening of S&T infra structure in the universities in India during the tenth plan period. Data presented in Figure 4 illustrate the important part played by FIST in strengthening S&T support structure in universities. Nearly 40% of funds of SERC have been deployed in strengthening of S&T infrastructure in universities and colleges during the tenth plan

SERC SUPPORT - INSTITUTION WISE

2005-06



An independent review of the outcome of FIST on university centered research has been undertaken. Since the full blown implementation of the FIST scheme is only during the last five years and many universities have needed more than two years to absorb the resources provided, the proposed review process had to wait. There are, however, indications of positive outcome already. An intense meeting of various measures for improving the efficiency of the FIST support system has been undertaken in consultation with Chairpersons of all FIST task forces. It has been widely recognized that FIST like programs will play an important part in the rejuvenation of research in the university system in the country. Strongly favorable outcomes from the FIST program are indicated.

S&T indicators of Autonomous Institutions supported by DST

The Department of Science and Technology has been supporting a select number of autonomous institutions without artificially imposing a corporate internal governance structure in the framework of national laboratories. These are stand alone institutions with their own individual character and statutory bodies for governance. Three types of institutions are supported by DST. They can be grouped as a) centers of higher learning and research, b) units serving a specific cause and program providing S&T services and c) professional bodies and associations serving S&T communities. Centers of higher learning and research supported by DST totaling 15 are listed below.

Autonomous Institutions: Centers of excellence higher learning and research

Indian Association for Cultivation of Sciences, Kolkata (IACS)
Bose Research Institute, Kolkata (Bose Institute)
Raman Research Institute, Bangalore (RRI)
Indian Institute of Astrophysics, Bangalore (IIA)
Indian Institute of Geomagnetism, Mumbai (IIG)
Indian Institute of Tropical Meteorology, Pune (IITM)
Sri Chitra Thirunal Institute Medical Science and Technology, Trivandrum (SCTIMST)
Birbal Sahni Institute of Palaeobotany, Lucknow (BSIP)
S N BOSE Research Institute, Kolkata (SN BOSE)
Agarkar Research Institute, Pune (ARI)
Wadia Institute of Himalayan Geology, Deradhun (WIGH)
Jawahar lal Nehru Center for Advanced scientific Research, Bangalore (JNCASR)
Advanced Research Center International, Hyderabad (ARCI)
Center for Liquid Crystal Research, Banaglore (CLCR)
Aryabhatta Research Institute for Observational Sciences , Nanital (ARIES)

Autonomous institutions of special and expert S&T services supported by DST are listed below.

Autonomous Institutions: In Special and Expert S&T services and Professional Bodies

Autonomous Institutions: In special and expert S&T services
Technology Information, Assessment and Forecasting Council, New Delhi (TIFAC)
National Accreditation Board for Testing And Calibration Laboratories (NABL)
Vigyan Parashar, New Delhi (VP)
Technology Development Board, New Delhi (TDB)

Professional bodies supported by DST
Indian National Science Academy
Indian Academy of sciences
National Academy of Sciences India
Indian National Academy of Engineers
Indian Science Congress Association

Scientific, technological and HRD related outputs of the 15 autonomous institutions supported by DST have been computed for the first four years of the tenth plan period and presented in the table below.

Some Output indicators of Autonomous institutions supported by DST

ACHIEVEMENTS OF AIDED INSTITUTIONS

AUTONOMOUS INSTITUTIONS	PAPER 2002-06	Average Impact factor	PATENTS	TECH. TRFER	Ph.Ds.
IACS,KOLKATA	1296	2.00	0	3	153
BOSE INST.,KOLKATA	504	2.06	0	0	59
RRI, BANGALORE	399	3.33	0	0	22
IIA, BANGALORE	266	3.33	0	0	0
IIG, MUMBAI	107	1.51	0	0	9
IITM, PUNE	135	1.60	0	0	0
SCTIMST,TRVM	269	2.90	26	11	139
BSIP, LUCKNOW	235	0.50	0	0	8
S N BOSE, KOLKATA	475	2.15	0	0	21
ARI, PUNE	132	1.00	17	7	20
WIHG, DEHRADUN	104	1.74	0	0	15
JNCASR, B'LORE	801	3.32	0	0	26
ARCI, HYDERABAD	132	0.93	9	21	20
CLCR, BANGALORE	76	1.83	2	0	4
ARIES, NAINITAL	162	4.62	0	0	15
	5007	2.30	45	49	509

The Autonomous institutions supported by DST have performed well during the tenth plan period. The average output indicators per scientist per year have been worked out for the years 2002-0. Publication per scientist is generally in the range of about 2-6 for various institutions. The Aggregated Average impact factors per paper for all institutions have been in the range of 2.3, while some institutions have shown values of the order of 3.3 with an average output of 6 papers per scientist. DST has been examining correlations between budget support and average outputs per scientist on a nation wide basis. Preliminary data indicates that a budget support of about Rs 45-50 per scientist is likely to provide optimum results for the country. In planning process for the eleventh plan period for autonomous institutions, an output-input correlation has been taken into account by the Department of Science and Technology.

2.2.2 Support for Pharmaceutical Research and Development

The Department of Science and Technology has been entrusted with the responsibility of promoting and supporting Drug and Pharmaceutical Research in the country through a special drive during the Xth Plan period. This objective has been fulfilled by creating National Facilities in the field of Regulatory toxicology, Proteomics, Pharmacokinetic Evaluation, Biosafety Facility both at level 3 and level 4 at various national academic institutions etc.

Collaborative research and development work was supported in institutions like NCL, CDRI, IICT, and University of Hyderabad etc with the participation of leading industries like Lupin, Bharat Serum, BE Ltd, Natural Remedies, Sudershan Biotech etc. In all 82 projects were supported under the Xth Plan which include national facilities and research projects (collaborative as well as for Loan applications) on diseases like AIDS, TB, Diabetes, Leucoderma etc.

The important feature of the scheme included initiation of research work in Siddha and Ayurvedic medicines both for human and veterinary purposes. R&D efforts have resulted in 6 product patents – filed both in India and abroad , 13 process patents and synthesis of over 250 New Chemical Entities (NCEs) resulting in around 25 lead molecules. Around 7000 molecules already existing in various national Laboratories were screened for their efficacy for various diseases under various projects .

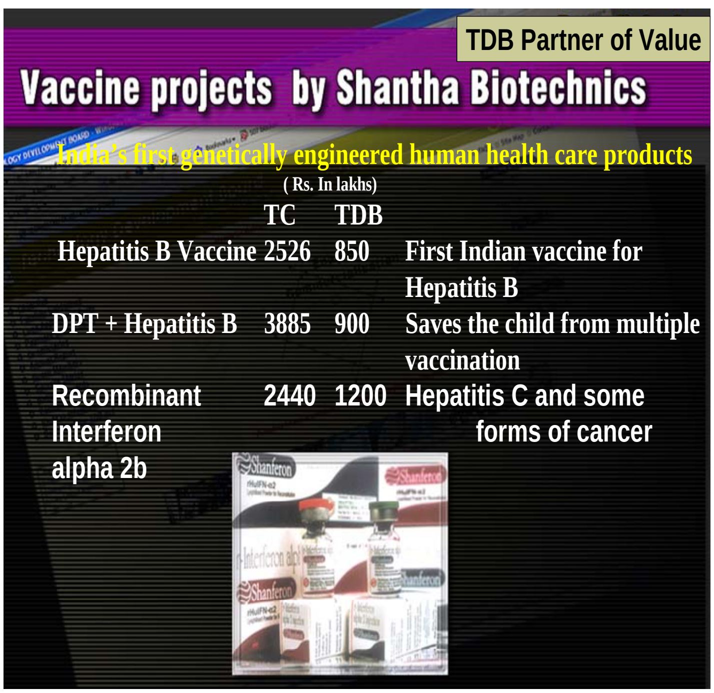
The programme was reviewed by the Expert Group headed by Prof Sukhatme. The Group appreciated the efforts of the Department for setting up state-of-the art facilities in the country to facilitate R&D efforts of the scientists and initiating research and development work in allopathic as well as AYUSH systems of medicines. The group commended that the Programme has been able to bring in private contribution to the tune of Rs 150.00 crores for Drug & Pharma research. This program has emerged a good example of Public-Private Partnership model in research and development.

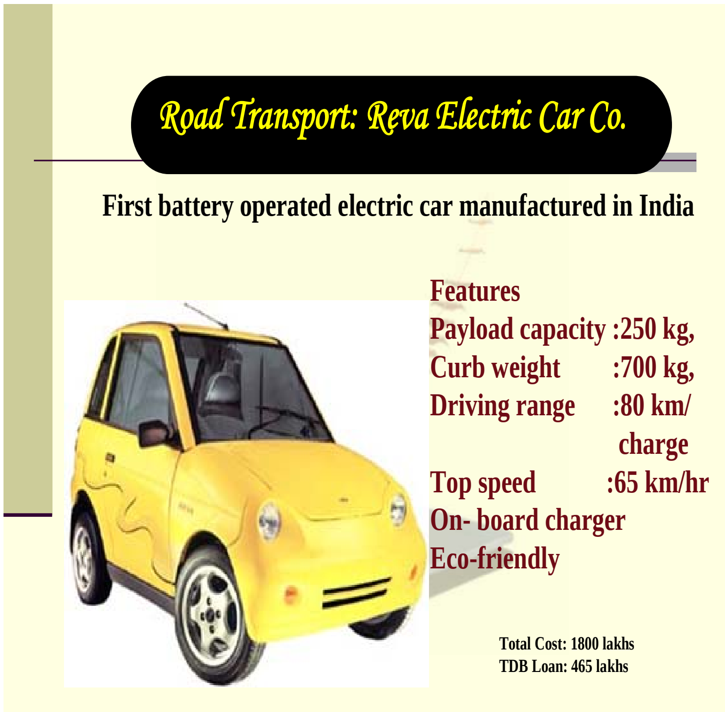
2.2.3. Technology Development Board

Technology development Board is a new experiment for India in supporting technology ventures through special funding schemes. Total of 154 projects have so far been supported under TDB. More than 54% of the projects enrolling for support under TDB have been drawn from mostly health and engineering sectors. Definite trends emerging from the active enrollment of various sectors of growth have been analyzed. Some successful technology ventures supported under TDB mechanism have won the National Technology Day Awards during the last five years.

Some notable examples of projects succeeding for the country are a) vaccines from Shantha Biotech, b) health care products from Bharath Biotech, c) Rewa Battery operated Car and d) Indica care from Tata motors


TDB's most important Private partner
Bharat Biotech International Limited - II
The company has set up a plant for production of Streptokinase, a specific activator for myocardial infarction and a life saving drug, with a production capacity of 2 million doses per annum
The company released the product 'Indikinase' in October, 2003 and is the first company in India to manufacture Streptokinase through recombinant route.
(In Rs./ Lakhs)
Total cost of Project – 1221
TDB Loan Assistance - 325


TDB Partner of Value
Vaccine projects by Shantha Biotechnics
India's first genetically engineered human health care products
(Rs. In lakhs)
TC TDB
Hepatitis B Vaccine 2526 850 First Indian vaccine for Hepatitis B
DPT + Hepatitis B 3885 900 Saves the child from multiple vaccination
Recombinant Interferon alpha 2b 2440 1200 Hepatitis C and some forms of cancer



Further studies are being undertaken to revitalize the TDB mechanism for higher impact and spread effects.

2.2.4. Science communications

The Department of Science and Technology has been actively spreading the excitement of careers with science among younger population of India with a view to attract talents for career with science. The include the organization of various events including a) National Children's Science Congress, b) National Teacher's Science Conference, c) Steer the Big Idea – DST – CII collaborative program, d) Year of Physics, planet earth etc, e) scientific awareness programs in 579 districts and f) management of Vigyan Mail

2.2.5. International cooperation

The Department of Science and Technology has been the coordinating agency for the country on S&T cooperation with other countries. Several new programs have been launched during the tenth plan period. They are a) Indo-Israel Industrial R&D Cooperation with US $ 1 million per year contribution from GOI b) Indo-Russian Technology Centre with US $ 1 million / year contribution from GOI c) Indo-UK Science and Innovation Council with an equal matching grant of 6.5 8 million pounds, d) Indo-Russian S&T Cooperation in cutting edge areas with US $ 75 million contribution from GOI e) Indo-Canadian S&T Cooperation in cutting edge areas with US $ 1 million / year contribution from GOI, f) New Programme with : Canada; Columbia; Iceland; Mozambique; Switzerland; USA g) establishment of Joint Bilateral Centres of Excellence in the areas of Non-ferrous Metallurgy, Biomedical Technology and Lasers & Accelerator.

The ongoing cooperation with France overseen by Indo-French Centre for Promotion of Advanced Research has been further strengthened. Major outputs of the cooperation have been a) 69 Projects yielding 160 exchange visits, 100 research papers and b) 6 Workshop (Statistical Physics, NMR Application, Materials, Infrared Lasers, Pharmacogenetics, Prevention of Biomedical Risks)

The ongoing partnership with USA has been enabled under Indo-US S&T forum. The forum conducted large number of programs which include a) 18 Workshops / Symposia/Round – table held in India and USA and b) 8 other events like for example Frontiers in Science and Engineers, Public-private Partnership in R&D, establishment of Joint Thematic Centres, about 500 Joint Research Projects Supported and Joint S&T Workshops (50 Nos.).

Under International cooperation program DST has supported a) 100 Fellowships / Training Opportunities (ICTP, Lindau, ILTP, JSPS, IRTC (Germany) etc.), b)

Technology Exhibitions with Canada and c) Global Conference on "India R&D 2005 – The World's Knowledge Hub of the Future".

New Intergovernmental Agreements Signed/concluded

During 10th Five Year Plan period, inter governmental Agreements for Cooperation in S&T were signed with 16 countries which included Canada, China, Colombia, European Union, Islamic Republic of Iran, Republic of Iceland, Italy, Laos, Mozambique, Republic of Korea, Serbia and Montenegro, Sudan, Sweden, Switzerland, Thailand, and USA. Further, the detailed protocols on IPR were also signed with Canada, Israel, USA and Switzerland. It may be added that the agreement with USA which could not be signed in last 15 years due to non agreement between the two sides on IPR protocol, was signed in October, 2005 with a detailed IPR protocol. In addition, MOUs were signed with many agencies including Maryland State, DST-SAFEA; DST-NSFC; DST-CAS; INSA-SFI etc. At present, India has signed/concluded Inter Governmental Agreements with 66 countries as per list given at Annex-I.

Renewal of Programmes of Cooperation (POCs)

During the 10th Plan, under bilateral programmes, suitable mechanisms were established with conclusion and implementation of Programmes of Cooperation (POCs) with Argentina, ASEAN, Australia, Bangladesh, Belarus, Brazil, Bulgaria, China, Cuba, European Union, France, Germany, Hungary, Indonesia, Islamic Republic of Iran, Israel, Italy, Japan, Kazakhstan, Malaysia, Mexico, Myanmar, Nepal, Poland, Republic of Korea, Romania, Russian Federation, Singapore, Sri Lanka, South Africa, Syria, Thailand**,** Tunisia, Ukraine, UK, USA, Uzbekistan and Vietnam.

New Joint R&D Centers Established:-

While the existing joint R&D centers were continued to be supported, 8 new Joint Centers were set up with active cooperation with some of the bilateral partner countries. Each of these centers is located at an Indian or foreign institution around existing capabilities and infrastructure for optimal utilization of resources both financial and physical. These centers are basically meant for facilitating focused and integrated interaction/collaboration between Indian and partner country institutions in identified fields of mutual interest. The new joint centers established during the 10th Plan are as follows:-

- Indo-French Center on Organic Synthesis, IISc, Bangalore
- Indo-French Laboratory for Solid State Chemistry (Flask), IISc, Bangalore
- Indo-Russian Centre for Ayurvedic Research, Moscow
- Indo-Russian Centre for Gas Hydrate Studies, NIOT, Chennai
- Indo-Russian Centre for Earthquake Research, IMD, Delhi
- Indo–French Institute of Mathematics, Mumbai
- Indo-Russian Centre for Biotechnology, Allahabad

- BIMSTEC Centre for Weather and Climate, NOIDA (virtual)

BIMSTEC Centre for weather and Climate, established as a follow up to the announcement made by the Prime Minster of India during BIMSTEC Summit held on 30-31st July, 2004 in Bangkok, Thailand, is functioning at the moment in virtual mode from NCMRWF, NOIDA. However, India is proposing to announce establishment of BIMSTEC Center in physical mode during forthcoming BIMSTEC Summit to be held in India in February, 2007. Thus, requiring major funding for the establishment of the Center.

Access/Utilization of Major International Research Facilities

Indian scientists were assisted and supported in accessing/utilizing the following international research facilities for conducting experiments in the fields of crystallography, condensed matter physics, high energy scattering, solid x-ray spectroscopy, nuclear resonance scattering, magnetic Compton studies, etc, and received advanced training at international research facilities such as:

- CERN **(Geneva)**
- ELETTRA **(Italy)**
- Sp Ring-8 **(Japan)**
- KEK Accelerator (**Japan**)
- National Laboratory for High Energy Physics (Japan)
- Synchrotron Radiation Sources Beam line facility Novosibirsk, (**Russia**)
- FAIR **(Germany)**
- Fermi lab **(United States)**
- Synchrotron Light Source (**Singapore)**

Fellowships / Training / International exposures to young scientists:

The young scientists from India were assisted by providing Doctoral, postdoctoral and other research fellowships instituted jointly with some of the partner countries/agencies Similarly, Russian young scientists were provided fellowships to work in Indian Institutions. The following fellowships were made available:-

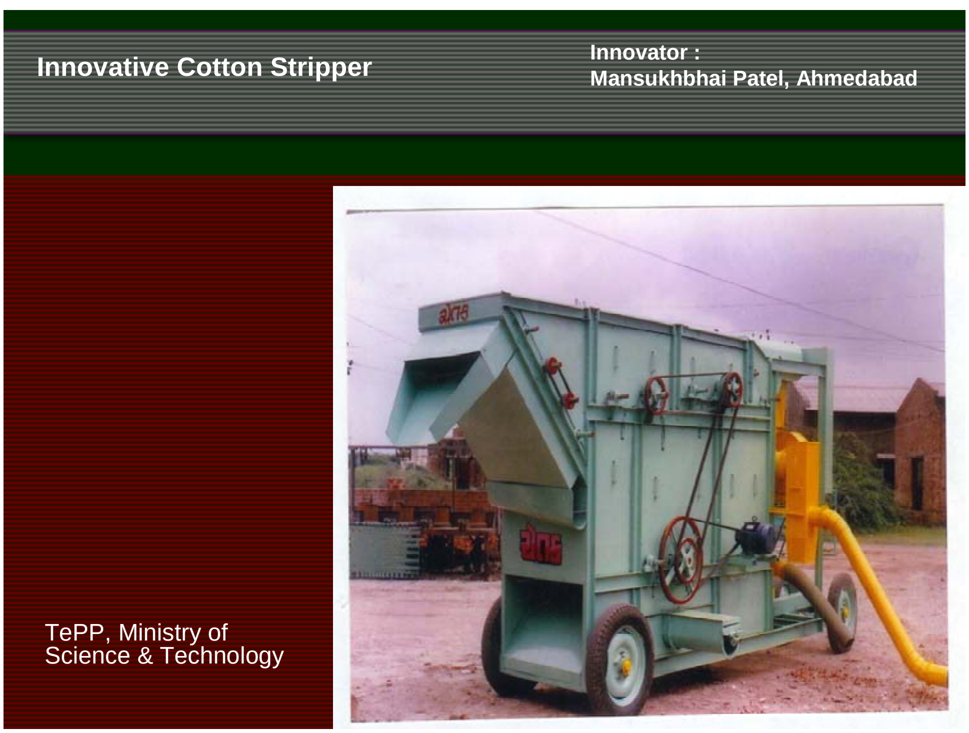
- Japan Society for the Promotion of Science (JSPS)
- Science & Technology Agency (STA), Japan
- International Centre of Theoretical Physics, Trieste (ICTP)
- ILTP Fellowships for Russian Scientists

In addition, participation of young doctoral students is mandatory in the projects given under DST-DAAD programme.

2.2.6 Technology and Entrepreneurship Development

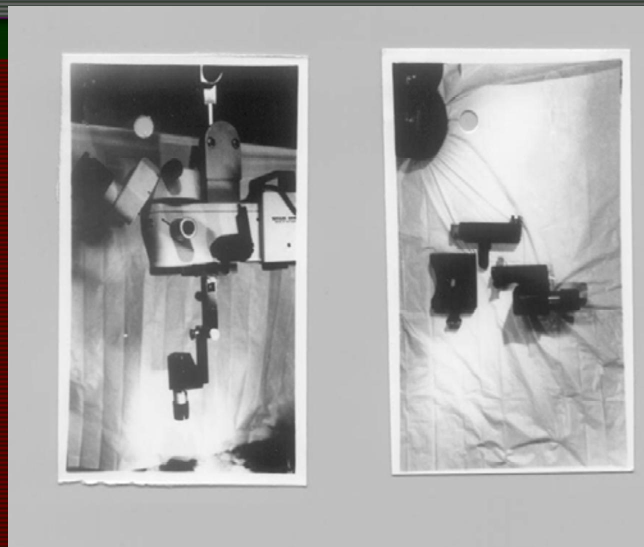
The Department of Science and Technology has been active promoter of entrepreneurship development initiatives based on technology led incubators. Some important initiatives of DST during the tenth plan period have been a) Technology Business Incubators (TBIs) promoted at IITs, IIMs, NITs, NID, ICRISAT, etc. in the areas of ICT, BT, Design, etc, b) Over 150 tenants incubating various technologies/products, c) Collaborative programmes launched with EU & World Bank, d) 10,000 Micro enterprises promoted at 40 locations in the country, e) Skill development programme for 35,000 persons to enable them to become self reliant for their livelihoods, f) 3 centres launched in PPP mode under SKILLS project of UNDP for skill training at Chennai and Bangalore, g) Entrepreneurial awareness created among 1,00,000 S&T students, h) 5000 teachers trained for promoting entrepreneurship, i) 45 academic/technical institutions supported to establish entrepreneurship development cell.

Some important outcomes have been gained from the TePP programs implemented jointly by the Department of Science and Technology along with the Department of Scientific and Industrial Research. Some indicative examples are a) innovative cotton stripper, b) diagonal inverter for operation microscope, c) bullock operated generator, and d) fire fighting Robot



Diagonal Inverter for Operation Microscope

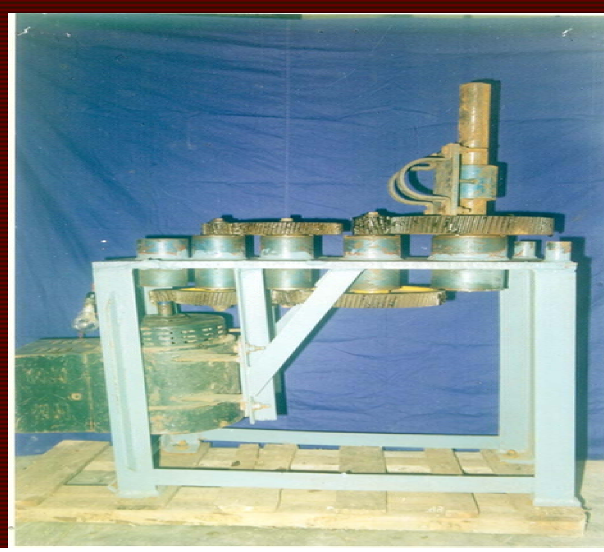
Innovator :
Dr. S.C. Gupta, New Delhi



TePP, Ministry of
Science & Technology

Bullock Operated Generator

Innovator :
R. S. Singh, Varanasi



TePP, Ministry of
Science & Technology

Fire fighting 'ROBOT'

Innovator :
Pranvendra Kumar Rao, Lucknow

TePP, Ministry of
Science & Technology

2.2.7 Science and Society programs

Science- Society programs of DST have formed flagship activity of the Department. There have been several science demonstration projects working with NGOs. These projects have been varied in nature. Primarily the focus of the projects undertaken under Science society programs has been referencing of technologies to the social contexts in which the technologies need to perform.

The State Councils have been set up in all the States and Union Territories and a very strong networking has been done during the 10th Plan. This involved regional meetings of Southern Region States at Bangalore and Northern Region States at Jammu. National consultations were held on the theme "Integrating Science & Technology into the Development agenda of States and Formulation of Mega projects in the 11th Plan in India" at Delhi : at Hyderabad on " S&T interventions in addressing problems of contamination of drinking water and water scarcity" and on "Strategy for identification and mapping of sectoral areas for S&T intervention" at Kolkata.

In order to evolve specific S&T based development programmes for Himalayan region states, an interaction meeting was organized at Itanagar. In addition, the performance of various S&T Councils was reviewed by the Scientific Advisory Council to the Prime Minister (SAC-PM) at Bangalore in December, 2005.

The State S&T Programme has contributed significantly towards replication of technologies developed in various national institutions such as the water purification technologies in the States of Rajasthan, Andhra Pradesh, Gujarat, West Bengal and all the eight North Eastern States; plastic and hospital waste handling technologies of Plasma incineration developed at Institute of Plasma

Research, Gandhinagar demonstrated in Andaman and Nicobar Islands, Goa, Himachal Pradesh and Sikkim. Similar examples included energy generation based on micro-hydel, bio-diesel etc. at various locations.

This scheme was reviewed by the Expert Group under the Chairmanship of Prof. Sukhatme. The group appreciated the approach followed by the Department and expressed satisfaction over the achievements of the scheme during the 10th Plan.

State Science & Technology Programme

Strengthen State S&T Councils through :

- **Location-specific R&D and demonstration projects in Water Purification, Rural energy & Environment Protection etc.**
- Financial Support for Core S&T manpower and infrastructure
- Encourage initiatives through promoting information exchange

Some region specific project with success includes applications of water purification technologies. The need for technologies for safe drinking water on a national priority basis has been recognized.

State Science & Technology Programme

Water Purification

Iron Removal Plant in NE States

Hand pump attached defluoridation plant in Rajasthan, Andhra Pradesh, Karnataka & U.P.

Desalination Plant in Rajasthan, Gujarat & Andhra Pradesh

2.2.8 National Mission on Bamboo Applications

The Department of Science and Technology has been implementing a National Misssion on Bamboo Applications since tenth plan period. There have been several important technology leads under the mission. These include a) composites, b) construction materials c) gasifier feed stock materials. Some of the important technology leads gained have been summarized and some housing constructions carried out already presented below.

National Mission on Bamboo Applications

- **Composites/Flooring Boards unit entered production**
- **Clustered 48 house rehabilitation project completed at Wardha**
- **Packages of practices developed for biotic shelter belts**
- **Nagaland Foods commenced commercial production Of processed bamboo shoots**
- **Cones, chunks, slivers and shreds prodn. commenced at Luit Valley Food Products, Jorhat**
- **Establishment of 2x1 Mw thermal gasifier is on schedule**
- **Mobile gasifiers developed.**
- **Development and documentation carried out for bamboo based orthotic and prosthetic application**
- **Bamboo Network Programme launched**

PREFAB SHELTER FOR HIGH ALTITUDE AREA, KARGIL

2.3 Directional changes during Tenth Plan with an Impact on DST

2.3.1 Formation of Earth Commission: Government of India has formed Ministry of Earth Sciences under which an Earth Commission is planned. The commission would oversee such activities which include operational programs like weather forecasting and meteorology. Therefore, merger of IMD, National Center for Medium Range Weather Forecasting(NCMRWF), Indian Institute Tropical Meteorology, at Pune and some field related operational activities being carried out under DST. On account of the formation of Earth Commission, some changes in the planning process for the eleventh plan program have become necessary. Seismology mission will need to be implemented through the new ministry rather than DST. Therefore, the budget exercise of DST has suitably been modified.

2.3.2. Formation of National Science and Engineering Research Board: One of the most important flagship programs of DST has been the research support under SERC mechanism. This has been a successful unit of DST . The Scientific Advisory Council to the Prime Minister (SAC-PM) has recommended that a new and autonomous body, namely the National Science and Engineering Research Foundation (NSERF), be established to significantly enhance the level of basic research funding available to raise India's research capabilities to internationally competitive levels. Given the stratification in terms of the strengths and capabilities of various academic and research institutions in the country, promotion of basic research in the country requires two distinctly different, though obviously interdependent measures. One to widen and strengthen the base of scientific research in the country by capacity building in schools, colleges and universities and, the other, to enable and facilitate the capable scientists in various institutions to undertake ambitious and internationally-competitive projects. In order to launch this two-pronged strategy, it has been decided that the existing SERC mechanism within DST will cover the task of spreading the R&D base in universities and colleges and the new autonomous body will focus on building excellence in research and development for gaining global competitiveness in the immediate future. A proposal to establish a new Science and Engineering Research Board along the SAC-PM's recommendations is under inter-ministerial discussion among various departments of the Government of India. The Board is likely to be formed shortly. Formation of such the Board is expected to strengthen DST in more than one way. DST is panning to undertake many new initiatives in fostering talent and innovations, in development of technology intelligence systems for building evidence based proactive S&T policy build up for public policy support, intensification of technology development processes, expansion of science-society programs as well as in forging international cooperation related activities. The formation of the Board is likely to open opportunities for inducting new talents and support staff.

Chapter 3

Perspectives for the Eleventh Plan Program of DST

3.1 Planned Interventions for Rejuvenation of Indian S&T Systems

3.1.1 Talent Supply Chain Problem: One of the most serious challenges facing the S&T systems in the country during the eleventh plan period beyond arises from the low entry of talent into the S&T streams. Unless the supply chain of talent being attracted to science education and research is strengthened urgently, India could face a major challenge. DST needs to play a critical part.

3.1.2 Investment Limitations in S&T: A compelling need for increasing the R&D investments from current level. Need for increasing the fund allocation for S&T by 400% over the tenth five year plan allocation has been felt. The proposal of DST for a larger outlay for the eleventh plan is, therefore, motivated by an analysis of national competitiveness and need.

3.1.3 Delivery Efficiency for Resources: Current delivery mechanisms for release of funds seem to call for prolonged times, as long as 12-16 months. All efforts to reduce the time demands to less than 4 months would be required. DST is in the process of speeding up internal processes.

3.1.4 Strengthening Institutional Frameworks: Although university sector has been the major recipient of funds for research, the absorption capacity and the rate of absorption require to be strengthened. DST has planned some suitable readjustments in the FIST program for empowering the university sector.

3.1.5 Quantification of Outcome and Impacts: Support of the public policy for S&T systems in the global economy is closely liked to the outcome of research and development on the economic growth engines as well as on public opinion of science as judged from societal benefits accruing from research and development. Therefore, a secure mechanism of assessing and quantifying the outputs and outcome of research and development and investments into science and technology on economy and inclusive growth of rural lifestyle is considered necessary for gaining support of public policy to science and technology.

3.2 Changes in Plan Approaches

DST is developing a suitable mechanism and structure for monitoring, in real time, the outputs and outcome of S&T and measurement of proportions of technology-led growth of GDP of India. DST, has planned during the eleventh plan that a certain percentage of R&D support be directed towards coordinated programs involving multiple agencies and disciplines with super ordinate goals and targets. DST has thus far adopted mostly bottom up models for planning. During the eleventh plan a balanced mix of both bottom up an top down models are envisaged. Nano Technology Mission is one of the examples of such programs that need to be developed using a different model of planning. There already are MoUs with the Department of Atomic Energy and the Department of Biotechnology to jointly launch and fund major programmes in areas of mutual interest.It is also proposed to have similar arrangements with some of the other Ministries in areas of growth related sectors and those of immediate relevance to the national needs like,Textiles,Petroleum,Energy,Drug and pharma,ICT,etc.

DST has also planned to vacate some areas of research in light of the formation of The Ministry of Earth Sciences. Programs on Earth sciences such as seismology mission, weather forecasting, medium range modeling as intra departmental activities will be vacated. Shedding of programs based on internal evaluation is a planned step.

3.3. Proactive Preparation for Private-Public Participation

Public –Private partnership has already emerged a critical need for enhancing the resource support for R&D. Innovative schemes to seed and support R&D in private systems also may also have to be developed. Targeted innovations in technology would form a major step in the emerging pattern of global research. DST, therefore, will prepare proactively the S&T system in the country in some select domain areas which are most suited to private-public partnership. DST has been able to seed such partnerships in Pharmaceutical sector during the tenth plan period. Further deepening is planned during the eleventh plan program. This model will receive considerable emphasis in implementing the Nano Science and Technology on a Mission mode and other Emerging Technologies.

3.4 Deepened International Cooperation

International cooperation of India will play an important part. It will be based on strategies and win-win formula. Technology diplomacy being the way forward, the preparedness of DST as the coordinating agency for international cooperation on S&T needs to undergo major transitions. Technology synergy programs with nations embracing India in S&T cooperation will require a funding facility for matching their contributions. The eleventh plan budget of DST will include a certain lump sum provisions for technology synergy programs with a provision to match the contributions of partnering countries. Technology acquisition fund with global models of dispensation is considered. The support of world bank for the generation of Technology Acquisition fund is under consideration. In several frontline areas of research like high energy physics, which are only done using major world facilities, it is proposed to mobilize all available strength in the country and participate in such research ventures in a meaningful and concerted fashion. For this, active coordination with DAE is envisaged and a formal structure has already been established in the form of a MoU.

3.5 Science and Technology Programmes for Socio-economic development

3.5.1 National Consultation Processes for Planning the Interventions: Public opinion of science and technology in India as evidenced from India Science Report is favorable. Such a favorable opinion demands that the S&T system is able to make tangible and traceable contributions to water-, energy-, and nutritional security. The eleventh plan of DST will include impact making programs on water and energy security. At a National consultation meeting held in September 2006 at New Delhi, a declaration has been signed among the representatives of various States that coordinated programs be mounted in areas of water, energy and solid waste management. A case has been made for initiating network projects sharing common objectives and sharing of funds.

3.5.2 Science and Society Programmes: Science and Society programme of DST is widely acclaimed. It has served as an outreach activity of the department for pilot interventions of successful technologies. There is a merit and need to expand the scale and increase the impact of the science and society programmes undertaken by the Department. A proposal to establish a separate Foundation for actively engaging the Non Governmental Organizations in spreading the outreach of the successful experience is under consideration. New technology delivery mechanisms for rural India are essential. This activity may need to be undertaken as a joint inter-ministerial program during the XIth plan period. The more inclusive growth targeted in the approach paper of Planning Commission is feasible only if technologies suited to low investment potentials of rural India were innovated and delivered. A revisit followed by a mission mode action program in some specific sectors is envisaged as a part of the XIth plan programme of DST.

3.5.3. Special Component Programmes: Activities planned under this programme are based on a scale expansion model of the ongoing activities.

3.5.4. Tribal Sub plan: Special programmes suited to the North Eastern Region are being added to the ongoing activities of the department. This work pertains to the commitment of the department to participate more aggressively the inclusive growth model of the country through the S&T led interventions.

3.5.5 S&T Entrepreneurship Development: The S&T Entrepreneurship development activities of the department have included many approaches and initiatives. Recent review of the programmes indicates some successful examples, which have attracted global attention. There is a proposal to more aggressively link the initiatives of the DST on S&T Entrepreneurship to global funds and International cooperation programs during the XIth plan period.

3.5.6 S&T Communication and Popularization: S&T communication and popularization activities have led to some exciting lead initiatives. Children Science congress, International children science congress, innovation among youth and many other initiatives of DST have gained wide acceptability and perceived value among the stake holders. These activities require scale expansion for wider impact. Impact assessment of the ongoing initiatives followed by restructuring of increasing the impact is planned.

3.6 Need for Synergies with Socio economic ministries and State S&T Progammes

Some R&D initiatives of DST require that the department partnered with the concerned line ministries and the departments of science and technology in various state governments. DST plan to work in networked fashion. The Eleventh plan of DST considers inclusion of departures from the previous plans in some areas based on specific needs. Some specific programs which will benefit using NMITLI type planning and Top down models of implementation are envisaged.

3.6.1 Teaching of Science in Schools and Colleges in collaboration with Education Departments in the Center and States: The Department of Science and Technology considers that the most critical intervention necessary is one of an inter-ministerial effort to strengthen the teaching systems used for imparting science in schools. New mobile laboratories, teaching aids, teacher mentoring programs, special programs for science motivated youth as well as girl children are required. DST plans to work with the various state governments and state S&T councils in conducting special programmes for science education and educators.

3.6.2 Technology programs in Collaboration R&D Institutions of Other Departments: DST recognizes the need to work closely with the R&D institutions affiliated to several socio-economic ministries. Total of 54 R&D institutions under the control of various socio-economic ministries have been recognized. DST plans to assist in strengthening the R&D institutions affiliated to other socio-economic ministries by establishing linkages with the respective domain knowledge institutions under the ministry of science and technology during the XIth plan period. Some important examples for such program participation are in the areas of clean coal technology, steel, petroleum and energy sector.

3.6.3 State Science and Technology Programmes in Key Areas: Region specific technology interventions in the areas of water, energy, solid waste management, value added utilization of regional and local resources have been planned. During the XIth plan period, the DST plans to coordinate with other departments and assist in the preparation of state S&T visions under a partnership model.

3.7 Survey of India: Modernization and Re-Engineering

Survey of India enjoys brand equity in the area of Geo-spatial products. In the wake of new map policy of India, Geo-spatial products have gained market value in the consumer market. The sub-department requires an urgent package for modernization of its physical, human, market and intellectual capitals. There is now a proposal to re-engineer the department to meet the emerging challenges and opportunities emanating out of the new map policy and growing market for Geo-spatial products estimated at about Rs.5000 crores per annum. Technology infusion, capacity building and leadership development have been planned. A special one time package for modernization of the department along with the formation of new entities to render SOI user-focused is envisaged during the XI^{th} plan period.

3.8 NATMO

National Atlas and Thematic Mapping Organization is engaged in the core business of developing map products. The organization is organically linked to the development value addition technologies for the primary products of Survey of India. The modernization package of SOI will also bring about the organic linkages in the planned programmes of NATMO.

3.9 Autonomous Institutions

DST supports a total of 15 R&D centered institutions and two other technology bodies' viz. National Accreditation Board for Laboratories(NABL) and Technology Information, Forecasting, Assessment Council(TIFAC). Recent review has shown that many of the autonomous institutions being supported by deliver science and technology outputs which are comparable to some of the best global bench marks. A systematic study is being made to relate the minimum budget support required for matching outputs in the form of publications and intellectual products matching the global bench marks. The plan of DST during the XI^{th} plan is to invest in autonomous institutions selected on the basis of performance and assist them to attain global best standards in science and engineering. This initiative of DST will assist the country to plan the supply side interventions on a national scale.

A study of impact assessment of TIFAC and NABL is planned. The proposed study will form a decision tool to shape the future structure and programmes of the two organizations. TIFAC is being developed into an policy body for developing technology foresight and strengthening the innovation infrastructure of the country.

NABL plans to expand the scale and enlarge the reach and spread in some specific areas. NABL foresees possibilities for strengthening the biomedical device areas and emerge the National apex body for implementation of standards.

During the XI^{th} plan period, DST plans to initiate five autonomous S&T institutions in some important and nationally critical areas. Glaciology, molecular materials, pre-competitive research institute for computer sciences are some areas, where India would need R&D capacities. Need for National initiatives for R&D in these areas have been felt. DST has been directed to develop such autonomous centers of research and development in these areas. DST plans to propose total of five autonomous S&T institutions during the XI^{th} plan period.

3.10 Professional Bodies

DST has been the main funding agency for some of the most important professional bodies and academies in Science and Engineering. This responsibility is expected to continue and widen into some interface areas of natural and social sciences during the XIth plan period.

3.11 Schemes from the Tenth Plan

3.11.1 Seismology: In the wake of formation of the new Ministry of Earth Sciences, DST does not feel it appropriate to host the mission mode program into the XIth plan period. In view of the importance of the area with respect to increasing the preparedness of the country in mitigating the damages caused by natural disasters, DST plans to participate in the program through basic research and pre-cursory studies in the chain of autonomous institutions and academic centers. Depending upon the role advised and sought by the new Ministry of Earth Sciences from DST, the department would dovetail its programs on seismology.

3.11.2 Bamboo Product Mission: A new board for the implementation of the technology leads gained from the Bamboo Application Technology Mission has been proposed. Several interesting technology leads for the commercialization of bamboo products have been gained during the tenth plan period. An active propagation of the successful leads in the construction, energy, consumer product and other related sectors has been planned. This mission has entered into an interesting propagation phase and the XIth plan programs are expected to be delivered through a special delivery mechanism.

3.11.2 Synergy projects: Synergy projects initiated during the tenth plan period have led to new models for mounting inter-disciplinary areas employing knowledge networks. This model is gainful for initiating research and development in new and strategic areas. These projects offer scope for initiating programs in cross border area like energy, environment, national security etc. These projects under the management of the Principal Scientific Advisor serve special purposes and employ special models. These programs would bear a provisional budget at the same level as the previous five year plan.

3.11.3 Pharmaceutical Research and Development Fund: Since the establishment of the Drug and Pharmaceutical Research program, this fund is not being proposed for continuation during the XI^{th} plan period

3.11.4 Information Technology: The applications of information technology in organizational management and automation of the internal processes of governance would be covered in this head.

3.11.5National Training Programme for Scientists and Technologists: The program aims at the capacity building within the S&T organizations and institutions. This needs toe emerge an ongoing activity with a focus on talent renewal and renovation.

3.11.6 Drugs and Pharmaceutical Research: True public-private partnership is emerging in the area of pharmaceutical research and development. With India gaining an opportunity to compete in the global market for pharmaceutical products, the scheme would merit further enabling mechanisms for a more vibrant public-private partnership to emerge in research and development in one of the key sectors of growth.

3.11.7 National Mission on Nano Science and Technology: The proposal to mount a National mission on nano science and technology is under inter ministerial consultation process. This mission is expected to reach criticality during the XIth plan period.

3.12 New Schemes proposed for the XIth plan

Total of five new proposals have been made by the Department of Science and Technology. They are a) water technology program, b) National Campaign for Talent Fostering and Innovation Building, c) innovation clusters, d) Security Technology Initiative and e) Creation of mega science facilities for basic research.

3.12 1. Water Technology Initiative: The focus of the projects proposed by DST is in design and development of low cost solutions for domestic use of technologies for safe drinking water. Since quality is the main consideration of safe drinking water research, such technologies which employ nano materials and filtration technologies are being focused. The initiative would include also the pilot testing of a credible number of products and referencing of selected technologies to the social contexts of the application regions.

3.12.2 National Campaign for Talent fostering: A new program under the title "Innovations in Science Pursuit for Inspired Research (INSPIRE) is proposed by the DST to attract and foster talent in scientific research. A separate scheme is being proposed. The scheme draws benefits from the previous experience in the education sector, but aims to expand the scale to gain critical size and mass.

3.12.3 Innovation clusters: Whereas the education and industrial infrastructure in the country are developing in parallel, there is a need to develop an innovation infrastructure to link knowledge products to the generation of wealth. Competitiveness innovation clusters are emerging in global platform. Numerous success stories of such innovation clusters benefiting the academy and industrial sectors have been reported. It is necessary for India to mount such an initiative under an effective public-private partnership model in areas where the trade and advantages have already been established and the clustering processes are evident. Evidence based selection of the sectors and locations for innovation clusters will be essential.

3.12.4 Security Technology Initiative: Internal security is a subject of modern civilizations in many countries. A science and technology initiative in the area of security is essential. This technology would involve a careful selection and symbiosis of many disciplines. A knowledge and innovation network and carefully designed initiative is considered necessary. Since DST enjoys the benefit of linkages with a vast network of institutions, it has already made a preliminary attempt to the structure and implement the national initiative. A new national program is being proposed using the NMITLI type model.

3.12.5 Mega Facilities for Basic Research: Basic research in the country has been depending upon mega and capital intensive facilities created by other countries. This practice has led to asymmetries in credit sharing. Further, Indian expertise to build advance scientific instruments and devices does not get fostered outside the strategic areas of research where technology denial forces building of capacities. DST along with DAE has identified areas where an effective partnership of the two departments can bring about an effective capacity building in the university and academic sector fro building mega facilities for basic research. An MoU signed between DST and DAE and minutes of the recent meeting held in Indore on the inter-departmental programs are presented in Annexure

Chapter 4

Definitions of Goals, Directions, Objectives and Deliverables of Plan of DST for the XIth Plan Period

4.1 Programs for Attraction of New Talents

It is imperative that Indian science and technology system is able to attract talents. Indian science establishments are unable to attract talents for the pursuit of science currently. Innovative mechanisms are required for improving the supply chain management of talent pool. A special Scheme titled "Innovation in Science Pursuit for Inspired Research" (**INSPIRE**) has been developed. The main features of proposed scheme, INSPIRE, are

- Innovation funding in schools (one million young innovators)
- Summer camp with Science icons (for high performers)
- Assured opportunity schemes for proven talent force
- Retention of talents in public funded research through PPP

4.2. Assured Career Opportunity Schemes in Science and Technology Sector

Science and technology may offer psychic income to those seeking such special attributes, but there is a need for also providing assured opportunities to talented youth for career 'with science'. There may be a need to create at least 1000 new blood positions under plan mode in the research and development sector during the next five years. These positions would need to be supported with R&D funding support for five years. These positions may be available for competitive bidding by Universities as well as institutions in under both public and private funded modes. Current plans of India towards, expansion, inclusion and excellence will demand that career opportunities are expanded in the S&T sector. Currently, about 6500 people in India are graduating annually with doctoral degrees. Estimates reveal that about 2000 of such doctorates with specialization in non- science areas need to seek careers outside science and technology. For an inclusive growth of India in sectors where excellence is critical, expansion of career opportunities is essential. Science and technology department needs to champion for such an initiative by gaining public policy support for S&T.

4.3 Creating An Innovation Culture

India has emerged as a land of ideas. The conversion of ideas into innovation demands the establishment of mechanisms through which the ideas can be tested and experimented with. Our children in the age group of 10-17 need to be facilitated in experiencing the joy of innovating, if they are to be attracted to the study of science. Our current structures in research and development functions are such that a person turns nearly 30 years old by the time career entry is gained. The joy of experiencing innovation needs to be rooted early. A mission to reach at least one million young people to experience the joy of enquiring into science is necessary.

4.4 Fostering Excellence and Creativity

Breeding centers and mechanisms for fostering excellence demand special efforts. Mentoring is an essential part of development processes in research. Doctoral research programmes demand such mentoring measures. A scheme to attract gifted youth in the age group of 15-18 to summer camps, where they rub shoulders and receive mentoring from the icons of the world of science is one mechanism of fostering excellence. Such a mechanism will need to be embedded in the vast talent pool of India. May be a project involving top 1% of our school leavers in a summer camp with a vast pool of Nobel Prize winners and icons of science in the world will form one form of fostering creativity in science. We will need a foundation to foster creativity and excellence among our children by presenting them a critical sized group of role models. Our S&T departments need to develop a mechanism for nourishing the root of S&T supply streams, if they wish to reap the fruit of excellence.

4.5 Developing a Super Grid for Attracting Talent to Science and Technology Landscape

India is vast and diverse. The talent pool is spread out. We will need a live and strong grid and network to link the well- intentioned national programs with the target groups. We do have a State S&T Council mechanism. Departments of Science and Technology embedded within the State machineries and the Centre need to be effectively networked into a fully functional grid of support system to deliver innovative S&T initiatives. DST, for instance, has many novel programs. The size and scale over which these programs need to be spread would need a different support grid involving also the departments of science and technology in the States and the S&T Councils.

4.6 Retention and Fostering of Talent and Excellence

Special efforts are required to retain talent and excellence in the S&T streams. Our decision processes and operational methods do not provide enabling mechanisms to function non-linearly. Science and Technology demand a significant level of non-linear processes. The current S&T ecology does not seem to provide either physical income with career opportunities matching other service sectors or psychic income derived from uninhibited pursuits of passion with science. The S&T ecology may need to be de-bureaucratized to feasible levels in the framework of the Indian governance system. There may be a need for innovating, and other mechanisms for providing flexible pay and perks for S&T groups. An effective interplay of private sector would be required for the public institutions in attracting and retaining talent in S&T streams. PPPs will need to lay the main foundation from which excellence may be fostered in future in S&T landscape.

4.7 Deepening of Support Systems For Basic Science

4.7.1 Strengthening Research and Development Support Mechanisms: The Research and Support Development Support Mechanisms will be strengthened by launching the two pronged strategy mentioned earlier. The SERC of DST shall endeavor to widen and strengthen the base of basic research through appropriate HRD measures and building up of research capabilities of the academic sector. Necessary resources, in-house infrastructure and suitable changes in the procedural mechanisms will be made available to ensure both quality and speed in the SERC processes. The proposed Science and Engineering Research Board will provide the funding and fund-delivery mechanism for undertaking major, internationally-competitive and front-ranking projects. Nano mission, Pharma Technology programs initiated during the tenth plan period will require added funding. These have been built into the plan separately. These missions will also function with an inbuilt overseeing and implementation structure and mechanism.

4.7.2 Special programs for rejuvenation of research in University and Academic Sector: Several national committees have strongly advocated for special programs for rejuvenating research capabilities in the university and academic sectors through special assistance programs. A need for top-down approaches for rapidly revitalizing the S&T capacities in the academic sector has been expressed at various platforms. The mandate and function of DST demand that the department enrolls into such time bound programs and deliver the outputs on mission mode during the XIth plan period. A different approach for making supply and delivery side interventions has been recommended by the scientific community. DST assumes those roles as a natural responsibility and function.

4.8 Technology Development Programs For Technology-led Growth Paths For GDP

4.8.1 Quantification of role of technology in National Growth process: GDP growth of India is currently buoyant. However, there are no reliable estimates of the percentage of growth of GDP, which is led by applications of science and technology. The linkage between the supply systems of S&T-led outputs and demand systems for applications of technology is not strong in many non-strategic sectors. There is now a need to make conscious attempts to estimate and increase the technology contributions to the GDP growth of India. A measurement system is required for India. DST has proposed to commission such a cell as an in-house unit.

4.8.2 Assisting National growth Agenda in Agriculture through technology support: Agriculture forms an important element of the growth engine. However, the share of agriculture in the GDP growth is estimated at $<2\%$ per annum. There are plans and targets within the Government to raise the share of agriculture sector to 4.0% in the GDP growth paradigm of India during the next few years. This is possible only if new technologies are added to the agriculture sector with dramatic results on land, labour, water and system productivities. It should be possible to relate high technology to serve the common man involved in agriculture. Spatial Data Infrastructure along with necessary microzonation could provide valuable insight to the farmers. Advanced information on rainfall, monsoon, agronomical data, watershed management systems and measures for increasing substantially the efficiency of the use of water in agriculture should reach the people when needed. Weather science and water saving technologies could form two important elements. Majority of operational and other technological aspects of earth science will be implemented through the new ministry. DST will be involved in S&T support systems in the universities in Earth science through Extra mural support and Survey of India related services.

4.8.3 Technology support systems for Growth Engines of Manufacturing Sector: The manufacturing sector has registered significant growth in the last few years. The percentage contributions of the manufacturing sector to the GDP growth are significant. A large percentage of growth in the manufacturing sector is, however, through the Small and Medium Enterprise segment. Manufacturing in such segments is driven by access to materials and market forces. The level of value addition to materials through technology in such segments is limited to 5-7%. Technology and innovation-driven manufacturing should be able to add values to materials by 15-20% and 25-30% respectively. Our manufacturing systems should adopt best manufacturing practices. Value addition through technology should increase the income of the people. Both volume and value of employment will become important. Technology should be used gainfully to increase the value of employment.

In some sectors of high economic growth potentials such as drug and pharmaceuticals, textiles, and chemicals on the one hand and emerging areas like biotechnology and nano technology for advanced materials on the other, it should be possible for the Indian S&T system to quantify the scope and opportunities to provide a technology-led growth path. Perhaps the S&T system should target doubling the technology contributions to growth in such sectors by 2010.

4.8.4 Technology support for the Services Sectors: Indian GDP growth is enabled by developments in the services sectors like Information Technology and BPOs. On the one hand, there is a mushrooming of colleges. On the other, the services sector is languishing for want of appropriately skilled people. Now, there are discussions regarding finishing schools. Perhaps, applications of new educational technologies and training systems can help in accelerating the skilling of people to suit the needs of the services economy, which creates large scale employment in the private sector.

4.8.5 Need for Private-Public Partnership: Generation and utilization of technology are currently not integrated adequately in most sectors of growth. A technology partnership needs to be developed among our public funded R&D institutions and industries. The role of technology-led growth can be enhanced only if the public and private partnerships are vibrant. PPPs should involve identification of common objectives, co-investments and co-generation of values to both S&T institutions and the private sector enterprises. New models such as the one launched by the Council of Scientific and Industrial Research through New Millennium Indian Technology Leadership Initiative (NMITLI) is a good model. We need to enlarge the scope and scale of such programs under various PPP models.

4.9 Technology Diplomacy: in Nation Building

4.9.1 Gaining leaderships through Technology-led Diplomacy: The world order is changing. Trade advantages polarize the nations. New alliances and groups of Nations are being formed based on economic indicators. Technology-led growth of economy is the global model of developed nations. Balancing political and economic freedoms of nations has brought technology-led diplomacy to the center stage in international cooperation. India needs to leverage technology-led diplomacy in international cooperation. For several developing countries, India is a role model for science and technology-based growth. India can play an enabling role for many nations.

4.9.2 Technology Synergies for Promotion of Innovation Cultures: There are several developed nations which target the young population of India for the growth of their own science and technology systems. Other nations are targeting Indian's young population for developing their science. India can not remain a supply system talents alone. It is possible for India to develop educational and S&T enterprises based on successful global models of twinning capacity building in S&T landscape. This process needs to be based on win-win formula for both nations. Our strategy for international cooperation needs to be based on mutual gain and complemental strength. Bold initiatives to attract Indian Diaspora for building active research schools in frontier areas by providing critically sized R&D grants is another way of building international cooperation in a sustained manner with mutual gain for both nations.

4.9.3 Technology Acquisitions under S&T Cooperation for Faster Growth: There are nations from which India may stand to gain and receive in certain sectors of development. Balancing overall growth of India in much needed sectors of economic activities cannot be based on total self-reliance in everything. Re-inventing and reverse engineering models of growth are not sustainable in modern India. In such domains, India would need to develop strategic partnerships with other nations after appropriate cost benefit analysis.

Energy-, water-, eco- and nutrition-security of India would call for large global models of S&T cooperation. Then there are areas of research like high energy physics, nuclear physics, accelerator physics and technology, etc. which are manifestly international in character. Suitable collaborative projects by mobilizing the national strengths in these areas will be evolved and funded in coordination with sister agencies like DAE.

4.10 Technology Outreach For Inclusive Growth of Rural India

4.10.1 High Technology for benefit of all: India and China, with large population, would need essentially an inclusive model of growth. Any paradigm growth model risks social stratification of rural environments. Appropriate technology and rural technology are terms employed to refer such elements of technologies which demand lower investments and decentralized use. They do not mean that technology systems required for use in villages and inclusive growth of large communities can be devoid of high science and technology. China has adopted an innovative model for spreading technologies to villages. We may need to learn from our past experience and integrate from the successful experience of China through 'Scope' like program where 2 million foot soldiers have been engaged in spreading technology systems to 170 million people. We have good models; but we need to expand the scale and reach the benefits of high technology to all, whether living in urban or village centers. Innovations are required to enroll corporate sectors in spreading the applications of high technology benefits to the breadth and width of the country. A Foundation under one of the S&T departments would be required to be established to increase the reach of technology to villages. Development process through applications of S&T should be rooted in our villages, if the public faith and interest in S&T systems need to be enhanced. India Science Report does reveal that Indians trust in science. They also believe in technology. How to benefit those who trust in science and believe in technology is a challenge that needs to be converted into an opportunity.

4.10.2 Water and Energy Technologies: In selection of areas for a time-bound action by S&T departments to reach the benefits of their efforts, one needs to adopt a selective approach. In the selection process, one needs to exercise high discretion. Some of those areas which are of concern to a vast majority of population must gain higher priority over other areas. Water and energy security of the nation form two ideal areas for the S&T landscape in the country to provide a protective cover through a combination of incremental , systemic and leap-frog innovations. This would call for convergence of minds. S&T plan of DST needs to include coherence, synergize and cohesiveness work. These are required for providing a dramatic effect of DST on India sooner than later in areas of fundamental needs like water and energy.

4.11 Grand Challenge Programs

The Department of Science and Technology has planned key programs of grand challenges to be explored and developed during the eleventh plan period. These programs will be developed using best models of Indian S&T system.

4.11.1 Science of Human Cognition: DST proposes a new program initiative on Science of human cognition using a knowledge network. Under this model, an effort to link traditional Indian systems of bio feedback including yoga and the modern tools of measurements of interactions of brain, mind, behavior and consciousness using modern scientific methods is planned.

4.11.2 Security Technology Initiative: DST proposes a major high science based network initiative to develop new tools and techniques to recognize pre-emptively people with terrorist intent. The objective of the effort will be counter terrorism.

4.11.3 Rural Technology Delivery Mechanisms: DST proposes to establish a new foundation and mechanism to increase the outreach of technology and deepen the social contract of S&T. DST would focus on spreading technologies suited for domestic use for ensuring the safety of drinking water with a spread effect.

4.11.4 Mega Science Support: DST proposes to collaborate with Departments of Atomic Energy and other science departments in the creation of mega science programs and facilities in and out of the country to improve the access of advanced global research facilities like Synchrotron, ILC,ITER,FAIR,SKA etc to the university and academic sector.

4.12 Objectives of Plan Programs of DST for the XIth Plan Period

The Eleventh plan objectives of programs under Department of Science and Technology are broadly grouped as

- To facilitate the formation of a National Science and Engineering Research Board with functional autonomy
- To participate in the formation of Earth commission by enlarging the scope of IMD, NCMRWF, IIPM and some operational activities relating to earth sciences
- To launch and commission an intensive Nano science and technology mission mode program
- To strengthen research and developmental activities undertaken in Autonomous institutions and create new centers in five select areas of national priority
- To expand science communication and Vigyan Prasar functions to commission mission mode National Innovation Campaign among young learners
- To lead a joint initiative of center with state functionaries as a super grid for science promotion
- To enlarge the national program on technology development for select industries including Pharmaceutical research and Development
- To establish a new cell for technology intelligence and S&T policy building
- To revitalize the programs of Technology Development Board and Technology Information, Forecasting and Assessment Council
- To enable modernization of Survey of India through a mission mode program
- To partner socio economic ministries in the areas of new energies, petroleum, environment, textile, pharmaceuticals, leather and coal in research and development support and link S&T systems for addressing the needs of global change programs

4.13 Eleventh plan deliverables from programs of The Department of Science and Technology

Deliverables are

- National Science and Engineering Research Board
- Enabling 33% of the Autonomous institutions to global standards of S&T output indicators through a well balanced budget support per scientist
- Nano science and Technology mission building capacity in the emerging area in at least 25 public funded institutions and 25 industries building PPP to mobilize about 25% of the budget needs from the industrial sector
- Launch of Five new autonomous S&T institutions in areas like ,Molecular materials,Glaciology,ICT,drug and pharma,and Textiles.
- Creating innovative experience among one million school children and mentoring by icons of global science in 45,000 children

- A super grid of science network in all states and regions of the country
- Modernization of Survey of India
- Foresight Unit for Science and Technology for Evidence based Policy formulation
- Ten fold expansion of activities and programs under TDB, International cooperation program , TIFAC
- Participation in a Pan-India Initiative for anthropogenic emission measurements and mitigation
- A water technology mission for safe drinking water in at least 100 locations as proof of concept
- Launching of Security Technology Initiative for improving internal security
- Establishing a National Foundation for Technology for Rural Enterprises and Employment, TREE with defined targets for the Eleventh plan period
- Evidence based interventions and Quantification of technology growth potentials to GDP growth in select three industrial sectors and technology proving exercises in three select industrial sectors

Chapter 5

Supporting S&T Programs

5.1 Science and Technology Plan for India

Science and Technology plan for the country for the XIth plan period has received inputs from various expert groups in addition to those constituted by the various departments. In view of the increasing concerns and the public opinion that Indian competitiveness in the areas science and technology, science and engineering academies, Scientific Advisory Committee to the Cabinet, Scientific Advisory Council to the Prime Minister and other high science bodies have been making important proposals for rapidly gaining for India a positional strength. Some of the proposals made have large bearing on the XIth plan initiatives of the Department of Science and Technology. Therefore, it is likely that several support programs in addition to those contained in the proposal of the Department of Science and Technology may need to be considered by the Planning Commission. Some such support programs in which the department of Science and Technology could participate meaningfully and serve the role of implementing agency have been listed here for further consideration.

5.2 Massive Interventions in the University and Academic Sector

University forming the root of the scientific research in the country, it may be necessary to make more massive interventions in the university sector than what has been projected in the XIth plan proposal of the Department of Science and Technology. DST recognizes that these initiatives would need to be implemented in close collaboration with Ministry of Human Resource Development. DST offers to enroll itself in the support programs for the university sector in addition to what is already planned by the department.

5.3 Support to Science Academies

DST has proposed a level of support to the science academies on the basis of sustainability of the ongoing initiatives. However, there is a need to launch new programmes for fostering existing talent in the scientific community. DST foresees a proactive role for the department in supporting the project mode actions of the academies which play an important part in supporting excellence in research.

5.4 Schemes for Teachers and Research Students

One of the important aspects of the proposal of DST for the XIth plan period is in the area of science education and teaching. The department does propose a number of initiatives for attraction of talents to study and careers with science. The department proposes to play some supporting roles with the education sector in conducting motivational programs for teachers in science. In these activities, DST proposes to work with the education sector.

Chapter 6

Summary and Plan Proposals

Sl no	Name of the Scheme/Project/Programme	Proposed XIth-plan Outlay (in crores)
1	Research and Development Support (including Board/Foundation)	8,000
2	Technology development Programme	550
3	S&T Programme for Socio-economic Development	
3.1	Science and Society	150
3.2	Special Component Programme	50
3.3	Tribal Sub plan	50
3.4	S&T Entrepreneurship Development	280
3.5	S&T communication & Popularisation	240
4	International Cooperation	450
5	State Science and Technology Programme	160
6	Survey of India (Modernization package)	1,000
7	NATMO	20
8	Autonomous Institutions	
8.1	IACS	265
8.2	Bose institute	185
8.3	RRI	120
8.4	IIA	240

8.5	**IIG**	**170**
8.6	**SCTMIST(Incl.National Biomedical devices regulatory Authority)**	**350**
8.7	**BISP**	**95**
8.8	**SN Bose institute**	**95**
8.9	**ARI**	**90**
8.10	**WIHG**	**90**
8.11	**JNCASR**	**180**
8.12	**TIFAC**	**350**
8.13	**Vigyan Prasar**	**40**
8.15	**ARCI**	**310**
8.16	**NABL**	**50**
8.17	**CLCR**	**35**
8.18	**ARIES**	**85**
8.19	**New Planned Autonomous Institutions in areas Of Molecular Materials,Glaciology,ICT,Textiles etc**	**200**
	Total Autonomous Institutions	**2,950**
8.20	**Professional Bodies**	
8.20.1	**INSA**	**45**
8.20.2	**Indian Academy of Sciences**	**28**
8.20.3	**Indian Science Congress Association**	**13**
8.20.4	**INAE**	**14**
8.20.5	**NASI**	**21**

8.20.6	**Other professional bodies and symposia etc**	**25**
	Total Professional Bodies	**146**
9	**Technology Management Project**	**22**
10	**Schemes introduced during the Xth plan**	
10.1	**National Bamboo Application Mission**	**300**
10.2	**Synergy Projects**	**50**
10.3	**Information Technology**	**22**
10.4	**National Training Program for scientists and Technologists**	**10**
10.5	**Drugs and Pharmaceuticals Research**	**1,400**
10.6	**National Nano Technology Mission**	**1,000**
11	**New Schemes Proposed in XIth plan**	
11.1	**Water Technology Programme**	**300**
11.2	**National Campaign for Talent Fostering and Innovation Building**	**1,300**
11.3	**S&T Innovation clusters**	**500**
11.4	**Security Technology**	**200**
11.5	**Creation of State of Art Mega facilities for Basic Research on National Scale**	**150**
	Total plan	**19,300**
	Provisions for support programs listed in Chapter 5 are not included. Wherever possible inclusions from the DST proposal will be synergized with other national efforts	

Chapter 7

MAJOR ACHIEVEMENTS DURING 10TH FIVE YEAR PLAN

7.1 RESEARCH AND DEVELOPMENT SUPPORT

SERC (Science), SERC (Engineering), Coordinated Programmes in Earth and Atmospheric Sciences, Opportunities for Young Scientists (OYS), IRHPA (Intensification of Research in High Priority Areas) continue to be the backbone of basic research in the country. The hallmark of these programmes supporting basic research is that they cut across disciplines and institutions. The only criterion for providing support has been the content of scientific investigation to be pursued. Such an open-ended system is an absolute must for support of basic research and the "DST/SERC" programmes have managed to keep this character intact over a 30 year long period. These programmes must be continued, strengthened and provided greater manpower and technological wherewithal as mentioned at the end of this Section under General Recommendations.

These programmes have also maintained a very fair and transparent system of peer-review through Programme Advisory Committees which instils lot of confidence among scientists.

The other distinguishing feature of SERC has been to start and consolidate research in the country in a number of areas. In its 30 year long history, there are a number of such examples. To mention a few viz the entire area of structural biology research. The unstinted support to several leading groups has led to the growth of a strong and internationally competitive community in the country. Similarly, DST/SERC consciously promoted research in neurobiology which led to a sizable community culminating in the formation of a new centre on brain research. The research programme on chronobiology in the country has been sustained mainly due to the support provided by DST. This list can be made very long. However, these examples are enough to illustrate the fact that DST/SERC has been able to champion the cause of several important areas of research in the country and those areas owe their existence to the support provided by DST. This has been possible mainly because of the open-ended nature of the DST/SERC system which is the life-line of any basic research funding mechanism.

It is useful to list a few other examples which not only strengthened areas of research, but also established major facilities for research. The Plasma Physics Programme at PRL, Ahmedabad was initially supported under IRHPA. It went on to become the Institute for Plasma Research at Gandhinagar under DST with an indigenously designed tokamak for plasma research. Later, when the Superconducting Steady-State Tokamak (SST) project came, IPR moved over to DAE. And, today, in addition to the SST, it would be also leading India's participation in the International Thermonuclear Experimental Reactor (ITER) project in France. It will not be a hyperbole to say that, but for the initial push provided by DST, plasma research in the country would not have achieved the kind of confidence-levels and visibility that it did. Similarly, though the Pelletron Accelerator at IUAC, New Delhi was established by UGC, the entire range of facilities there for materials research using swift heavy ions owes its existence to sustained funding by DST over 10 years. Sustained support to the NMR Facility at TIFR, Mumbai has enabled Indian biologists and chemists to maintain their competitive edge over a very long period.

Several prestigious international collaborative projects like the CMS and ALICE projects at CERN, Geneva are also being handled by the SERC Division because major funding for hardware is involved. DST/SERC has, over the years, evolved a very useful functional relationship with the Department of Atomic Energy which has culminated in a DAE-DST MoU for jointly undertaking research programmes of mutual interest.

In summary, the DST/SERC has been the mainstay of basic research in the country, especially in the academic sector, and all the programmes mentioned above need to be continued.

On the output side, about 60% of SERC projects fall into the Very Good to Excellent category when monitored by the peer-review Committees, 30% in Good category and the remaining in the Satisfactory category with a miniscule fraction in the Poor category. This only shows that the peer-review of the projects has been effective.

Various PACs have identified a large number of very good and ambitious projects/programmes to be taken up during the XI Plan.

WOS-A (Women Scientists Scheme-A)

This is a very novel programme, the first of its kind in the world, to enable women scientists to re-enter mainstream research after break/s in their career due to family responsibilities. It is heartening to see that majority of the women scientists supported so far fall into the 35-45 age group which shows the need for such a scheme. Over 100 projects have been supported every year and, in the absence of such a scheme, we had been losing this group of active researchers all these years.

This is an important gender-sensitive programme and must be augmented. We only need to be careful while monitoring such projects, especially with regard to assessing the level of commitment of a women scientist to get back to research after break/s in her career.

Nano Science and Technology Initiative and Nano Science and Technology Mission (Nano Mission)

Responding to the worldwide explosion in research activities in the area of Nano Science and Technology, DST, under the SERC umbrella, started the Nano Science and Technology Initiative (NSTI) in October 2001. So, effectively, these activities coincided with the X Plan period.

The support provided so far has been, understandably, mostly for basic research projects (~ 100 in number) and building up of sophisticated research infrastructure by way of establishment of 17 units/centres on nano science and nano technology. Close to Rs. 80 crore have been spent so far and the programme has started resulting in good papers and competitive work in the area. One of the projects has also resulted in a US patent and the technology has been taken up by a US company.

DST has already formulated an ambitious plan for enhancing these efforts by establishing a Nano Science and Technology Mission (Nano Mission) with an allocation of Rs. 1000 crore during 2006-2011. This is under consideration for funding at the apex levels in Government and the Mission is expected to be launched shortly. The Nano Mission, as expected, would look at promotion of Nano Science and Technology in a comprehensive fashion. Apart from basic research and human resource development, it is planned to lay considerable emphasis on technology development and commercialization utilizing public private partnerships. It is also planned to synergize the efforts being made by various government agencies and industry through well-laid consultative and decision-making structures.

Ramanna Fellowships

This new Scheme wherein Principal Investigators who have produced excellent results in their ongoing projects shall be able to get financial support for maintaining their core research activities in an uninterrupted fashion. It will, at least for performing investigators, solve several problems encountered during the gap between sanction of two successive projects.

The path-breaking feature of this scheme of granting a fellowship to even employed investigators. Though the amount of fellowship is very modest, this shows a big conceptual advance in the Government system and puts in place a reward scheme for performing investigators.

FIST (Fund for Improvement of S&T Infrastructure in Higher Educational Institutions) and SAIF (Sophisticated Analytical Instrument Facilities) schemes have done a yeoman service to the scientific community in the country by providing enabling research instrumentation and infrastructure to a large number of institutions.

FIST has been uniformly acclaimed to be a very good initiative by DST. It has helped remove equipment obsolescence in a big way in university departments and also helped upgrade the teaching laboratories at the post-graduate level. This programme must be strengthened.

KVPY (Kishore Vaigyanik Protsahan Yojana)

This flagship programme of DST to attract young school and college-going students towards sciences has become a sought-after scheme and also a benchmark for other such schemes in terms of quality of selection, its nurturing mechanisms and the quantum of scholarship provided.

USERS (Utilization of Scientific Expertise of Retired Scientists)

Considering the depleting reserve of research manpower in the country, it has been emphasized in several forums that the expertise of superannuated scientists must be conserved. This is a very useful scheme to utilize the expertise of retired scientists to write book/s monographs, etc. and must be continued.

PFA (Partial Financial Assistance)

This is a very popular scheme of DST supporting a large number of scientists and research students to attend conferences, seminars, schools, etc. abroad. It is an important aspect of research career to be able to disseminate ones findings among leading peers and to interact with them. Intellectual interaction is important for fostering scientific creativity.

Seminar/Symposia Scheme

This is also a very popular scheme which partially supports a large number of conferences, etc., publication of some important journals like Current Science and a number of prestigious professional bodies. This scheme must continue. The new initiatives proposed during the XI Plan also seem reasonable and funds should be provided to launch them.

Swarnajayanti Fellowships, Ramanujan Fellowships and JC Bose Fellowships are the most prestigious fellowships that DST has for the most meritorious among scientists.

The recently announced Ramanujan Fellowship has broken a new ground by throwing open these fellowships to even foreign nationals. The JC Bose Fellowships have further built upon the beginning made by Ramanna Fellowships and allowed for attractive fellowship amount to employed scientists over and above their salary. Both these fellowships have an attractive Contingency grant and the recipients have the flexibility to spend it as per their research needs.

NSTMIS (National S&T Management Information System)

This is a very important activity, but is currently going on at a modest level. Apart from collecting and collating data regarding the national and international science and technology scenario, it should also start predicting trends of research in the country vis a vis the international scenario. This will provide important input for policy formulation.

7.2 TECHNOLOGY DEVELOPMENT PROGRAMMES

7.2.1 TECHNOLOGY SYSTEMS PROGRAMME

The objective of the programme is to promote development of technologies and technology based systems indigenously. The programme aims at application of advanced R&D to solve socio- economic needs and improve performance of traditional technologies. The programme also aims to enhance technological capabilities of the country especially in frontier technologies.

I. TENTH PLAN

A. <u>Activities</u>

During the Tenth Plan the scheme is being effectively utilized to develop systems both in the areas of modern technology as well as traditional technology. Attempt has been made to identify and implement application of advance technology for solving socio-economic problems in a cost-effective manner. The technology issue faced by the specific sectors of the industry, particularly small and medium enterprises are being effectively addressed to facilitate development of appropriate and globally competitive technologies. Specifically, following programmes have been undertaken during the Tenth Plan.

- Technological Application for solving socio-economic problems such as, water contamination, rural energy etc.
- Introduction of advanced technologies to traditional crafts etc., particularly surface engineering technologies to enhance value of traditional products.
- Technologies for distress diagnostics, industralised building systems and seismic protection in the structures.
- Information and communication technology for rural applications
- Molecular electronics devices including conducting polymers
- Use of straight vegetable oil and bio-fuels as an alternative to conventional fuels.
- Waste utilization, re-cycling and management with specific reference to plastic waste, electronic waste and hospital waste.
- Development of gyrotron for indigenous application.
- Technology Upgradation in unorganized the small scale sector of glass industry.

B. Achievements

During the Tenth Plan the scheme has been effectively utilized to develop systems both in the areas of modern technology as well as traditional technology. Attempt has been made to identify and implement application of advance technology for solving socio-economic problems in a cost-effective manner. The technology needs of the specific sectors of the industry, particularly small and medium enterprises was effectively addressed to facilitate development of appropriate and globally competitive technologies. Some of the important areas which were taken up for technology development relate to following:

i) **Water purification :** This area was given focused attention under the programme and various technological options were explored for removal of containments from drinking water. Specifically, an Integrated Technology for Arsenic Removal from Drinking Water (1000 ltr/day) using microbial cum adsorption route was taken up for development. The technology is undergoing field trials in the state of Chhattisgarh. In order to address the problem of salinity in drinking water, development of Two Stage Sea Water Desalination Unit (1000 ltr/per hr) based on indigenous membrane technology was taken up. Development and upscaling of iron removal plant for water treatment was also taken up based on ceramic membrane technology. Development and field-testing of adsorption technology based arsenic removal systems based on newer adsorbents was also taken up. In order to reduce the energy requirement for water purification and improve efficiency and effectiveness of entire system, a hybrid membrane based desalination –cum ceramic membrane pre-treatment technology was also taken up for development for treatment of river water.

ii) **Decentralised Energy** : In order to meet the ever increasing need of energy as well as to make provision of this basic necessity in remote locations, attempt was made to develop innovative technologies to tape the potential of micro-hydro in various parts of the country. Bio-fuels hold considerable promise to augment the supply of fossil fuels. Development of Straight Vegetable Oil Operated Village Electrification Plant (20 Kw) was taken up and the technology developed has been replicated in four states.

iii) **Glass Technology:** In order to develop a realiable pot for melting of glass, Development of Glass Melting Pot was taken up. The life of the pot was enhanced to 55 days from 15 days. Construction of gas fired Glass Melting Day Tank Furnace capable of melting 1000 kg Soda Lime Glass at 1450ºC was also supported to meet the specific requirement of Firozabad Glass Industry. Development of bio-fuel production plants and mapping of effects of straight vegetable oil on engine performance was also taken up to explore the feasibility of using Straight Vegetable Oils (SVOs) for certain specific stationary applications.

iv) **Information and Communication Technologies:** In order to promote application of Information and Communication Technologies to meet the needs of rural parts, development of low cost broadband access system for last mile connectivity having application for providing rural and remote connectivity was taken up. Development of cost effective set top boxes for Internet access on television was another activity that was taken up under the programme.

v) **Miscellaneous Technologies:** Under the programme, various technology initiatives related to development of Pesticides Detection kit for specific commonly used pesticides, development of Gold Analyzer for Non-Destructive, Transportable, Quick and Accurate Gold Analysis and development of material for carbon aerogel for development of state of art aerocapacitors were also successfully taken up.

7.2.2 Achievements in Joint Technology Development Projects with Socio-economic Ministries

1. The IS-STAC, DST has played a pro-active role in revival, reconstitution of various STACs by giving them guidelines about terms of reference of committees, project funding and by contributing financially and technically in selected R&D projects. Under the scheme, IS-STAC has launched Joint technology Projects (JTPs) to provide thrust to promotion of research in the areas concerning the Ministries/Departments.

2. Under the scheme, specific support is expected to be provided by DST for activities which can be demonstrated on industrial scale through research & development efforts and are conducive for strengthening of technological capabilities in the country. The energy & environment concerns have added a new dimension to the development projects in socio-economic sectors. For achieving such linkages with industry, a priority is being given to Research, Development and Demonstration (RD&D) projects relevant to the concerned sectors in these areas. Support has also been provided in other areas also.

3. Major examples of achievements during 10^{th} Plan include Joint Technology Project on Development of Column Flotation Technology for Industrial Applications, Energy Efficient Metal-Metal Composites, Increased Utilization of Indigenous Coal Resources, Helium Extraction and monitoring, Thrust to Energy R&D and Energy Conservation, Air Pollution Monitoring and CO2 Sequestration research. Thrust has been given by organizing Workshops and Interaction meetings with the participation of various Stakeholders. Industrially oriented R&D for steel sector was supported to study various tolerable Indian non-coking coal sources with the aim of maximizing the usage of domestic non-coking coal in the COREX process at Jindal Vijaynagar Steel Limited jointly by Min of Steel and DST. Specific mention needs to be made about the initiatives like National Helium Conservation Program; National Facility for Semi Solid Forming (NSSF) for Aluminum & Composites at IISc., Bangalore and Aluminum Foam Development at RRL Bhopal (under joint technology project with Ministry of Mines); Clean Coal Technology Initiative: Coal Washing Studies using Vorsyl Separator/ Falcon Separator and In-situ Coal Gasification (under

joint technology projects with Ministry of Coal); Development of Process for Advanced Hot Dip Coated Products using HDP Simulator as a National Facility.

4. Indicative list of Joint Technology Projects with participation of Socio-economic Ministries

- Extraction of Magnesium through MAGNETHERM Process – DST, (Mines) - National Metallurgical Laboratory (NMl), Jamshedpur
- Development of cost effective and Energy Efficient materials for mining industry – DST, (Mines) – Regional Research Laboratory, Bhopal
- Development of Column Flotation Technology for Industrial Application – DST, (Mines) – HZL, Udaipur; RRL, Bhubaneswar; NML, Jamshedpur
- Industrial Applications of Vorsyl Separator– DST, (Coal) – Regional Research Laboratory, Bhopal
- Study of various tolerable Indian non-coking coal sources with the aim of maximizing the usage of domestic non-coking coal in the COREX process – DST, (Steel) – M/S JVSL, Bangalore; IISc., Bangalore
- Advanced Process Control and Optimization Technology for mineral processing plants – DST, (Mines) – Tata Research Development & Design Center (TRDDC), Pune and HZL, Udaipur
- Studies on production of alloyed pig iron/cast iron and low alloy steel/stainless steel using chromite overburden – DST, (Mines) - M/S MECON, Ranchi
- Development and Testing of STATCON - Dynamic Voltage Regulator (STATCON - DVR) – DST, (Power) - Department of Electrical Engineering, IIT, New Delhi
- Evaluation of Process variables in continuous scale bio-oxidation of complex sulfide ore/concentrate of Ambamata/Sikkim – DST, (Mines) – Regional Research Laboratory, Bhubaneswar
- Pilot Enrichment Plant for Helium from hydro-thermal sources and Helium Purification Center – DST, (DAE) - Saha Institute of Nuclear Physics (SINP), Kolkata and Variable Energy Cyclotron Center (VECC), Kolkata
- De-ironing of Eastern Ghat Bauxites – DST, (Mines) – Jawaharlal Nehru Aluminium Research Development & Design Centre (JNARDDC), Nagpur
- Development of Pressure Swing Adsorption Technology for purification of crude helium and design estimates for pilot plant Phase-I – DST, (DRDO), Indian Institute of Petroleum (IIP), Dehradun
- Scale-up of Engineering Design for PSA based helium purification Phase-II (DST) - Indian Institute of Petroleum – DST, (IIP), Dehradun and Engineers India Ltd. (R&D Center), Gurgaon
- Radon/Helium Monitoring in Thermal Springs (DST) – Department of Physics, Guru Nanak Dev University, Amritsar
- National Facility for Semi Solid Forming Aluminum and its Composites at IISc., Bangalore – DST, (Mines & DRDO) – Department of Mechanical Engineering, Indian Institute of Science (IISc.), Bangalore.
- Development, Demonstration and Dissemination of Protective Technologies : Biodegradable Emulsion for Food Security and Prevention of Waste of Perishable Food Items by Extending their shelf Life – DST, (Rural Development, MoEF) - Department of Chemistry, IIT, Delhi

- Production of alloyed pig iron and low alloy/stainless steel from the Chromite Over burden – DST, (Mines) – M/S MECON, Ranchi
- Baseline Environmental Survey of Domiasiat and adjacent areas, Meghalaya – DST, (BRNS) – North Eastern Hill University(NEHU), Shillong
- High Resolution Seismic Survey for Exploration and Mapping of Anomalous Zone in Mining Regime with a view to Analyze their stability High Resolution Seismic Survey for Exploration and Mapping of Anomalous Zone in the Mining Regime with a view to Analyze their stability – DST, (Mines) - National Institute of Rock Mechanics, Kolar
- Seasonal behavior of atmospheric pollutants and surface ozone at road site in Delhi – A pilot study (DST) – Center for Atmospheric Sciences, IIT, Delhi
- Recovery of Values from Wastes from Base Metal Industry – DST, (Mines) – Regional Research Laboratory, Bhopal
- Recovery of Tungsten from Tungsten Alloy Swarf - DST, (Mines) – Regional Research Laboratory, Bhopal
- Simulation assisted development of Al-metal foam through liquid metallurgy route for engineering applications – DST, (Mines) – Regional Research Laboratory, Bhopal
- Exploration of Helium from hot springs (Himachal Pradesh, Assam, Orissa) and Development of Infrastructure for Gas Collection at Tantloi (Jharkhand)-DST, (DAE) – Saha Institute of Nuclear Physics (SINP), Kolkata
- Pilot Scale Smelting and pre-feasibility studies on nickel-chromium cobalt bearing magnetite ores from Nagaland for an economically viable plant – DST, (Steel, Mines) - National Metallurgical Laboratory, Jamshedpur and Directorate of Geology & Mining, Govt. of nagaland
- Application of Vorsyl Separator for Recovery of Clean Coal from Middlings and Rejects – DST, (Coal) – Regional Research Laboratory, Bhopal and Central Mine Planning & Design Institute Ltd. (CMPDIL), Ranchi
- Pilot Plant for Production of Grade-A Helium from Natural Gas - DST, (ONGC, DAE) - Saha Institute of Nuclear Physics(SINP)/Variable Energy Cyclotron Center(VECC), Kolkata.
- Underground Coal Gasification and its Utilization for Power Generation Studies in Lignite Deposits of Rajasthan (Phase-I) – DST, (Coal), Neyveli Lignite Corporation
- Monitoring of Geo-chemical Precursory signals for seismic events (DST) at Jammu & Kashmir and Andamon- Nicobar Islands - Saha Institute of Nuclear Physics(SINP)/Variable Energy Cyclotron Center(VECC), Kolkata.
- In depth Study on Identification of Deep underground Aquifers and their suitability for carbon dioxide sequestration – DST, Global Hydro geological Solutions, New Delhi
- Helium Isotopic (3He/4He) Ratio as Precursory signal to Earthquake – A National Facility – DST, Saha Institute of Nuclear Physics(SINP)/Variable Energy Cyclotron Center(VECC), Kolkata.

<u>Working Group Recommendations for 11th Plan: For Socio-economic Ministries</u>

i) The PAN-INDIA programmes will be introduced for integration of S&T with socio-economic growth agenda. Specific programmes will be taken up through participation of STACs in Techno-economic and Socio-economic Ministries as the case may be.

ii) **The Investment for Implementation of_PAN-INDIA programme will be made as follows**

- The S&T allocations for different Ministries will be increased to 2-5% of the total budget of the Ministry
- The PAN-INDIA programme will be taken up to be supported jointly in key sectors along with DST and adequate provisions will be made for this.
- The Ministries should strengthen their Institutes to reduce disparity with other S&T institutions, The Ministries that do not have their own adequate number of institutions should consider innovations such as creation of virtual R & D Centres.
- Keeping in view the need to support large-scale projects allocation in DST for STAC programme should be enhanced for the XI Plan as 5% of its total budget allocation with appropriate manpower strengths.

An amount of Rs 200.cr is year marked

<u>For State S&T Councils</u>

The state councils of Science & Technologies seem to be restrained by the lack of expertise and fund as presently R&D funds are distributed only among Central R&D institutes. It is therefore, imperative that some corpus or core funds are ear-marked for the State Councils so that they would be free to take up R&D projects based on the needs of their State. It is recommended that

- Central R&D institute must interact individually with each State Council to present the concepts and technologies developed by them in order to identify which concepts and technologies suit a particular State. They could also assist the State Councils to identify and develop mega projects towards development of the States. This interaction is virtually missing at present.
- The State Councils must meet twice a year to exchange the ideas and share expertise. The Regional Meetings of the Councils should also be promoted to develop cross-boundary projects.

A Joint Resolution was signed by all State S&T Councils in the Annual meeting held on 18-19 September 2006. In this four specific themes of technologies viz. a) for safe drinking water, b) for decentralized power generation, c) for decentralized solid waste management, d) for remunerative utilization of regional and local natural resources have been identified. A strong plea has been made by various State Governments and S&T councils that the budgetary allocations be raised and a provision of Rs 5000.00 cr. be made for various States to make a competitive bidding for planned S&T interventions.

7.2.3 INSTRUMENT DEVELOPMENT PROGRAMME (DST)

Instrumentation is one of the major areas of Science & Technology which makes a great impact on vital sectors of national activities such as education, scientific research, industry, agriculture, medicine and health etc. The Department of Science & Technology (DST) has been promoting the area of Instrumentation through its Instrumentation Development Programme (IDP) with the objective of strengthening indigenous capability for research, design and development of instruments in the country leading to their indigenous development and production, continuous updating of the technology to keep pace with technology improvements taking place globally, and innovations in the area of Instrumentation.

Programmes are evolved and projects are supported under IDP for research/design/development and for innovations in different areas of instrumentation which are identified from time to time. The identified areas are Analytical, Medical, Environment Monitoring & Pollution Control, Test & Measuring, Food Processing, Geo-scientific, Agri-electronic Textiles, Leather Instrumentation and Sensors. The projects at various R&D organizations country are in progress. IDP Division also provides support for Training Programmes on Repair & Maintenance of Bio-medical instruments for Hospital Doctors/Technicians in various parts of the country, industrial instrumentation, food processing, Textile instrumentation and medical instrumentation etc.

7.2.4 National Good Laboratory Practice (GLP) Compliance Monitoring Authority

The **National Good Laboratory Practice (GLP) Compliance Monitoring Authority** was set up in the Department of Science and Technology through a Cabinet decision in April, 2002. GLP is a quality system, evolved by **Organization for Economic Co-operation and Development** (OECD) under which **non-clinical safety studies** are conducted on **chemicals** for their submission to regulatory authorities e.g. Drugs Controller General of India. The Authority provides **GLP compliance certification** to the test facilities, which are involved in conducting safety studies on chemicals (viz. industrial chemicals, pharmaceuticals, veterinary drugs, pesticides, cosmetic products, food products, feed additives, etc.) in accordance with **OECD Principles of GLP**.

The National GLP Compliance Monitoring Authority functions through an Apex Body, which has Secretaries of concerned Ministries/Departments, Director-General, CSIR and the Drugs Controller General of India as its members with Secretary-DST as its Chairman. This Apex Body is responsible to ensure that the National GLP Programme functions as per OECD norms and Principles and it achieves OECD-recognition, so that India acquires full member status in OECD. The Apex Body has set up a Technical Committee on GLP, which is a recommending body, to help the National GLP Compliance Monitoring Authority in evaluating the competence of test facilities on the basis of the inspections organized by the GLP Secretariat.

The Indian GLP Programme has empanelled experts, with prescribed qualification, experience and training (as approved by the Technical Committee), for assessment of test facility as its GLP inspectors. The inspectors evaluate the technical competence of the applicant laboratory in all respects for its compliance to GLP. The Authority has conducted two Training Courses for GLP inspectors with the help of OECD experts. As a result, we have trained GLP Inspectors in the country from various Government organizations to conduct GLP inspections of applicant test facilities

A National Coordination Committee on OECD Test Guidelines Programme has been constituted and National Coordinator for OECD's Test Guideline Programme has been nominated. This committee comments on the new /revised OECD Test Guidelines to enable active participation of the country in carrying out research/ developing draft OECD guidelines. Head, GLP Programme has been appointed as National Coordinator for OECD's Test Guidelines Programme and he attends meetings of the OECD's Test Guidelines Programme.

The Programme has also constituted a Legislation Committee, with participation from different Government Departments/ Ministries to prepare a draft Legislation on GLP in the country.

A. Tenth Plan

I . Activities

a) Setting up of the National GLP Compliance Monitoring Authority under the administrative control of Department of Science and Technology after Cabinet's Approval
b) Prepared documents such as guidelines, rules, procedures, brochure, application forms etc. on Indian GLP Programme.
c) Gazette Notification for commencement of GLP Programme

d) Constitution of Apex Body (GLP Authority) and Technical Committee on GLP

e) Scientific and administrative staff from the existing strength of Department of Science and Technology placed for work in the GLP Programme.

II. Achievements

a) Inspected Twelve (12) test facilities for examining the procedures followed by them and their adequacy for adhering to the GLP Principles.
b) GLP compliance certificate awarded to six (6) test facilities
c) Organized Training Courses for GLP Inspectors (Two in number)

d) Organized awareness workshops, seminars, symposiums on GLP in different parts of the country (14 in number)
e) Organized Training Course “Good Laboratory Practice in the Indian Context” for Test facilities in the country (One in number)
f) Launched the web-site of Indian GLP Programme www.indiaglp.gov.in. The web-site is being continuously updated.
g) Attended the meetings of the Working Group of OECD and OECD’s Test Guidelines Programme- Five in number (Head, National GLP Programme has been nominated as an Observer to the Working Group of OECD National Coordinator for OECD’s Test Guideline Programme).

7.2.5 Natural Resources Data Management System (NRDMS)

Objectives

- Demonstrate and promote the use of Spatial Data Management Technologies for micro level planning under diverse terrain conditions
  - Provide software support for data management, modeling and operation research
  - Promote R & D in spatial data technology
  - Technology Transfer & Capacity Building of potential users
  - Forge linkages with the users at different levels

- Provide S&T inputs for framing Policies related to Spatial Data Management Technologies

- Develop & Demonstrate pilot scale spatial infrastructure and provide research support to National Spatial Data Infrastructure.

- Documentation and dissemination of emerging technologies to the potential users.

- Capacity building and training.

Achievements during 10th Plan (2002-07)

- NRDMS Database Centers were set up in States of Uttaranchal, J&K, Assam, Karanataka, Nagaland, and Rajasthan.
- Second phase of “Hydrology of Small Watershed” programme with focus on capacity building of PIAs launched. Few R&D projects were supported.
- A sub programme on “Geo Spatial data mining” has been initiated.
- Development of data clearing house for NRDMS programme and specifically for “Hydrology of small watershed” sub programme completed.
- Under Bio go database and ecological modeling for Himalayas, Spatial Database for three micro watershed in HP has been developed on 1:25,000 scale for land capability and irrigability classification. For Uttaranchal study area, few R&D projects have

been initiated to undertake detailed studies for two micro watershed.

- Integration of these spatial databases to generate application oriented scenarios such as watershed management plan, land use, socio economy for decision makers were undertaken.
- Mission Mode Project on Landslide Hazard Mitigation in Uttaranchal initiated. Few R&D site specific projects supported to the concerned agencies. Border Roads Organization and PWD, Uttaranchal are associated with the projects as user agencies.
- Landslide Hazard Zonation Atlas was completed.
- Development of Early Warning System for Landslide being evolved.
- A book on “Landslide: A perception and initiatives of DST” published.
- Validation of preventive control measures in few selected landslide sites have been adopted.
- A web based HIV Sentinel Surveillance System developed.
- Project on ‘semantic interoperability’ and ‘web-enabled object – oriented databases’ launched.
- Two blocks have been undertaken under PURA Programme to develop the methodology for physical connectivity model.
- Neighbourhood mapping programme has been made operational in 20 schools in District Almora. It has been upscaled in other parts of the country i.e. Jhansi, Manipur, Nagaland and Jaunpur.
- In the wake of Great Tsunami occurred in December, 2004, six site specific projects focusing on ground water assessment, large scale risk mapping and topographical erosional aspects were supported. The final products of these projects have been brought out in the form of a book entitled “Geomatics in Tsunami”.
- In order to develop wave propagation model in GIS environment, a site in Nellore District (AP) was selected for ALTM survey to validate the model.
- As a part of capacity building and training more than dozen workshops/ training programmes have been conducted and organized to demonstrate the applicability and efficacy of NRDMS final products in local area development and planning.
- **International Collaboration:**

  i) Implemented Indo Norwegian Project on “Geohazards – Tsunami and Landslides”.

7.3 DRUGS AND PHARMACEUTICALS RESEARCH PROGRAMME

The broad objective of the “Drugs and Pharmaceuticals Research Programme” (DPRP) is to promote R & D in the Drugs & Pharmaceuticals Sector with the aim of enhancing capabilities of the Indian Drugs and Pharmaceutical industry towards development of new drugs by synergising the strength of national institutions and drug industry for discovery and introduction of new drugs .

Achievements

During this Plan (10th) **so far 82 projects have been** sanctioned out of which 42 are collaborative projects (Industry –Institution) , 22 projects are from Pharma companies for provision of soft Loan and 18 projects are in the form of National Facilities **.**

Details are given under three separate headings listed below.

I) **SUPPORTING RESEARCH PROJECTS IN PHARMA SECTOR**
(Collaborative as well as Loan applications) :

During the 10th Plan, vigorous efforts were made to continue generating (in a pro-active mode) research projects and financially supporting these towards new drug development for diseases endemic to India like AIDS, Leprosy, Malaria, Kala azar (Leishmaniasis), Amoebiasis, Skin disorders like Leucoderma, Psoriasis, Gastrointestinal disorders like Diarrhoea and Cholera, Diabetes, Parkinson's Disease, epilepsy, acute respiratory infections and Hypertension etc.

Various R&D projects have been supported during the tenth plan in areas of research which would lead to new drug development for the following broad areas of diseases namely **Malaria , Cancer, Rheumatic Arthritis, Bacterial infections, Fungal infections ,Amoebiosis, Coronary Heart Disease, HIV/AIDS, Tuberculosis, Glaucoma, Leishmaniasis, Alopecia, Leucoderma, Asthma, Dengue, Cataract, Diabetes Mellitus, Dementia , Osteoporosis, neuro-degenerative disorders , Japanese Encephalitis besides metabolic and respiratory disorders etc .**

Besides the projects supported in the tenth plan which were disease based other projects related to i**ndigenous novel-diagnostics** for detection of HIV/AIDS and **New Drug Delivery systems** for Tuberculosis using nano-technology were supported .

Out of the **sixty four research projects (R&D) supported** during the 10th Plan **, thirty eight are related to Modern System** of Medicine , **Eighteen projects are plant-based** i.e Ayurvedic products- their scientific validation/ standardization, while **one project is related to Veterinary product** ,another one to a **marine product** besides a project on **herbo-Mineral product** and **four projects are related to Siddha** products , **besides one project on Unani drug** .

ii) **SETTING UP OF NATIONAL FACILITIES FOR FURTHERING R&D ACTIVITIES IN PHARMA SECTOR**

Eighteen National Facilities in areas of relevance to R&D for new drug discovery both related to Modern System of Medicine as well as Indian System of Medicine have been financially supported under the programme at different Institutes which are as follows :

1. At NIPER , Chandigarh

i)"National Centre for Safety Pharmacology " at Deptt of Pharmacology & Toxicology , National Institute of Pharmaceutical Education and Research **(**NIPER) , Sector 67 , SAS Nagar , Mohali 1600 62

ii)"Regulatory Toxicology: Development of GLP certified facility for Toxicological Screening of New Chemical entities" at National Institute of Pharmaceutical Education and Research **(**NIPER) , Sector 67 , SAS Nagar , Mohali 1600 62

iii) "National Facility on Pharmacoinformatics" at National Institute of Pharmaceutical Education and Research (NIPER), SAS Nagar, Mohali-160 062, Punjab.

iv) " Establishing National Centre on Bio availability" at National Institute of Pharmaceutical Education and Research (NIPER), SAS Nagar, Mohali-160 062, Punjab.

2. At CDRI , Lucknow

v) " Establishing National Facility for Pharmacokinetic and metabolic studies" at Central Drug Research Institute (CDRI), Chattar Manzil Palace, Post Box No. 173, Lucknow – 226 001.

4.12.1 vi) "National Facility for Regulatory Pharmacology and Toxicology" at Central Drug Research Institute, Chattar Manzil Palace, Post Box No. 173, Lucknow – 226 001.

3. At CCMB, Hyderabad

vii)"Clinical Research Facility to Develop Stem Cell Technologies & Regenerative Medicine" at Centre for Cellular and Molecular Biology(CCMB**),** Hyderabad.

4. At IICT, Hyderabad

viii) “National Facility for Combinatorial Natural Products” at Indian Institute of Chemical Technology (IICT), Hyderabad

ix) “National Facility for analysis of herbo metallic products” at Indian Institute of Chemical Technology (IICT) , Hyderabad.

5. At Calcutta

x) “National Facility or Advanced Proteomics and Protein Research and Development of Biomarkers, Drugs and Therapeutic Proteins” at Indian Institute of Chemical Biology (IICB**)**, 4 Raja SC Mullick Road, Jadavpur , Kolkatta-700 032.

xi) “Pharmacokinetic Evaluation of some novel fixed dose combination drug formulations” at Bioequivalence Study Centre, Department of Pharmaceutical Technology, Jadavpur University, Kolkatta.

6. At Bangalore

xii)“National Facility for screening drugs and their biological effects for Cancer, AIDS, and Malaria”at JawaharLal Nehru Centre for Advanced Scientific Research (JNCASR) , Bangalore.

xiii)“Facility for therapeutic and prophylactic intervention strategies against human and animal bio-safety level-3 (BSL-3) Pathogen endemic to India” at Department of Microbiology and Cell biology, Indian Institute of Science, Bangalore 560012.

7. At Delhi

xiv) “Infrastructure and capacity building for Clinical Trial Registration” at National Institute of Medical Statistics (NIMS)” New Delhi-110029.

xv) “ Setting up National Facility for Genomic services to assist in Drug Discovery” at Institute of Genomic and Integrative Biology (IGIB), University Campus, Mall Road, Delhi-110 007.

8. At Pune

xvi). “Maximum containment facility (BSL4), A National infrastructure for Research on highly Pathogenic Viruses” at National Institute of Virology (NIV), Pune.

9. At Mumbai

xvii). "National Facility for Preclinical Reproductive and Genetic Toxicology" at National Institute for Research in Reproductive Health **(**NIRRH) Jehangir Merwanji Street, Parel, Mumbai.

10. At Thanjavur

xviii). "Central Facility for Pre clinical Studies for Research in Indian System of Medicine (Ayurveda and Siddha" at CARISM**,** SASTRA Deemed University, Thanjavur.

iii) **INTERACTION MEETS & WORKSHOPS**

Under the programme , efforts have been made for popularizing the DPRP scheme of DST by participating in Exhibitions and by conducting interaction Meets , Seminars , Brain Storming Sessions(BSS) and workshops .

7.4 S&T PROGRAMMES FOR SOCIO-ECONOMIC DEVELOPMENT

7.4.1 Science and Society Programme

Background:

The Societal programmes of the Department of Science and Technology primarily aims at reaching technology to the weaker sections of the society so that they derive benefit in terms of enhanced income, reduced drudgery and in general an improved quality of life. Apart from successful technology packages developed through societal programmes, these programmes have also demonstrated the successful interface between S&T based voluntary organizations, R&D and Technology Institutions. This has helped to evolve a successful system of technology transfer for sustainable livelihood generation.

Major Schemes operational in Science and Society Division

1. Science & Society Programmes
2. Science & Technology for Women
3. Tribal Sub-Plan
4. Special Component Plan for the Development of Scheduled Caste

Major Programmes under the scheme:

1. Science & Technology for Rural Development (STARD)
2. Science & Technology for Weaker Section (STAWS)
3. Young Scientists Programme (Societal)

Objectives:

1. To promote research, development and adaptation of technology for improving quality of life of weaker sections, women and rural people.
2. To motivate Scientists for applying their knowledge and expertise to problems of weaker communities and rural poor.
3. To strengthen the existing institutions, field groups, NGOs etc. involved in research and application of innovative S&T solution; and.
4. To motivate scientist and technologists for applying their expertise to problems in the rural areas.

7.4.2 Science & Technology for Women

During the period 2003 –2006, 130 projects were supported in technology areas such as value added products from the medicinal and aromatic plants, women's health and nutrition, NRM intensified micro enterprise activities, sustainable utilization of natural resources of Kerala, small scale fish culture, muga culture, fodder and fodder seed production, appropriate techniques for waste land development, plant based attractants for honey bees, value added products of Rock bee honey and wax and integrated farming system development. Two Coordinated programmes have been were initiated in the area of fodder & animal feed in 12 different agro-climatic regions of the country with technical back up from Indian Grass land and Fodder Research Institute, Jhansi. Development of prevention and intervention strategies for nutrition related non–communicable disorders among post reproductive period women with technical back up from All India Institute of Medical Sciences. 10 Women Technology Parks with an aim to showcase technologies developed specially developed for women have been set up in different agro – climatic zones of the country. Around 100 women scientists had been provided fellowships under the WOS-B programme for projects aimed at R&D in societal problems. A task Force for Women in science has been set up with an aim to formulate interest of women scientists and appropriate measures to promote and encourage women to take up scientific and technological profession. 8 distinguished personalities have been conferred with the National award for women's development through application of Science and Technology.

7.4.3 Tribal Sub-Plan (TSP)

During the Plan period from 2002-2006, over 100 inter-disciplinary projects of multi-sectoral nature having innovative S&T components have been taken up in the areas of farm & non-farm sectors, horticulture and processing techniques, sustainable agricultural practices, health and sanitation, NTFP, medicinal plants, animal husbandry etc. These projects have been implemented in different parts of the country focusing on appropriate and cost effective technology modulation and transfer, based on location specific needs/conditions

- Dairy cattle improvement through scientific breeding plan and artificial insemination

- Introduction and testing of post harvest technologies for value addition of organic wild products in trade
- Cost effective design & development of a manually driven washer pump to lift water from open water sources.
- Up-gradation of technological know-how among tribal women for improvement of cocoon productivity and crop sustainability in sericulture

7.4.4 Special Component Plan for the Development of Scheduled Caste (SCP)

During the first four years of the 10th Plan, 95 projects have been sanctioned in the following areas:

- Sericulture, alternative vocation for income generation, small-scale scientific rearing of small animals such as goat, poultry and pig, sustainable utilization and value addition of natural resources, mechanized processing of bamboo furniture and product applications, diversified cropping systems, agro- technology for improving the land use, fisheries, cultivation of horticultural produce by using organic/bio-fertilizers, value addition in banana fibers, etc.

- Some projects which have made visible impact on the well being of the poor scheduled caste population are:-

  In a coordinated programme on Functional Capability Development, under Special Component Plan for Scheduled Caste" (SCP) an innovative income generation programmes is being implemented in four states of the North East. The main aim of the programme is to expose the younger generation to possibilities of technology- based production units. In these projects only those technologies have been taken up which have acceptability and market. The following activities were taken up: 1. **Manipur** - Spinning and weaving of cotton, silk and woolen textiles, Kauna Grass mat manufacturing and development and dissemination of developed technology of Lion Looms and shuttle frame looms. 2. **Tripura** - Lion looms for weaving and also improved frame looms, Bamboo related and Bee Keeping based income generation. 3. **Arunachal Pradesh** - Lion looms, improved frame looms, spinning of cotton and silk yarn. 4. **Assam –** Improved technologies for Eri and Muga silk yarn. This programme is coordinated by Tamalpur Anchalik Gramdan Sangh.

- A project on skill up-gradation for silk reelers in Karnataka and other sericulture States of India" is being implemented jointly by Karnataka State Sericulture Research and Development Institute (KSSRDI), Bangalore and Asian Institute for Development (AIRD), Bangalore, 20 persons have been trained in modern Sericulture technologies in each State.

- In another project skill development training is being imparted in manufacture of hydraform brick manufacturing by utilizing raw materials such as mud, fly ash, gypsum, cement and industrial wastes. The unit is environmentally friendly as produces no air/water pollution. Fly ash brick (Hydra form bricks) technology provides wider scope for cost reduction in construction and protecting environment by reducing industrial waste. The technology has provided a tremendous scope for entrepreneurship wherein trained youth can produce blocks in various shapes and sizes viz. paving blocks, reinforcement blocks, conduit blocks and plain blocks by using simple customized tools.

- Fishery development project in the fifty hamlets of Mulavukad and Vallarpadom Islands in Kerala State has been taken up. Under this project 100 existing wells have been cleaned. Cages for fish and pen culture ponds have been developed using local resources. Water harvesting kit has been fabricated in consultation with SS Engineering College of Science and Technology. The kit has a capacity to collect 35 to 40 thousand litres of drinking water in a year that is sufficient to meet the drinking needs of an average family for a year without any roof harvesting devices. Youth are being trained in repair and modification of hand- driven pump developed by Centre for Water Resources Development and Management, Kozhikode to suit the project area. In this project artificial reefs are also built with locally available materials by adopting traditional methods. The other important area of intervention is mangrove plantation. Seedlings are first grown in bamboo sticks and then transplanted to marshy land. This method has a much more survival rate of mangrove.

7.4.5 National Science & Technology Entrepreneurship Development Board (NSTEDB)

The role of technology in creating, sustaining and growth of enterprises has undergone a major change in the last decade. The businesses are becoming more global, knowledge driven and technology focused. This has necessitated change in the skill sets needed to be a successful entrepreneur in the technology domain. With its large S&T human resource India has been a major contributor to the global knowledge work force. At the same time Indian contributions to the knowledge entrepreneur arena have a potential for increase. The National Science & Technology Entrepreneurship Development Board (NSTEDB) has been trying to convert the knowledge worker to knowledge entrepreneur since its inception. NSTEDB has been trying to infuse the spirit of entrepreneurship amongst the S&T persons for promotion of technology based start-ups on one hand and at the same time has also been involved in developing innovative skills and micro-enterprises at the grass root level.

Achievements during the 10^{th} Plan

The major achievement of the Board has been that a system and methodology for promotion of knowledge based and technology driven enterprises has been put in place in some of the top notch institutions of higher learning, this mechanism by the name of Technology Business Incubator (TBI) now exists in 45 institutions. The institutions include some of the IITs, IIMs, NID, NITs, etc. The system now has matured and is organically linked to similar mechanisms across the globe for sharing of best practices, exploration of new markets, infusion and validation of new ideas and technologies, etc. Realizing the significant role played by such knowledge based start-ups the Finance Minister in his budget speech (2006-07) has announced to provide enabling concessions to them.

A number of initiatives were taken during the 10^{th} Plan to increase the inflow of S&T persons in the arena of entrepreneurship and to convert the knowledge worker to knowledge entrepreneur for creation of wealth and jobs These initiatives started from spreading awareness about entrepreneurship, developing skill sets through training and nurturing of ideas through business plan competitions. About 5000 teachers were trained for taking the message of entrepreneurship to the students. In order to support the teachers training curriculum and methodologies were continuously created and updated. Approximately one lakh students were exposed to the nuances of entrepreneurship. Approximately 11000 S&T persons were trained to be techno-entrepreneurs through the training programmes supported by NSTEDB. A web portal and an e-zine covering all aspects of entrepreneurship development and enterprise creation was created and updated regularly during the 10^{th} Five Year Plan. This portal receives about one lakh hits per month. In order to encourage working professionals of S&T background and to attract them to entrepreneurship a distance learning programme titles Open Learning programme in Entrepreneurship (OLPE) was supported.

One of the gap areas identified during the 8^{th} Five Year Plan was absence of real high end skills amongst the Indian public at large and thus hindering their entry into self employment and entrepreneurship. Accordingly, based on the felt need a programme of skill training in emerging technology areas was put in place during the 9^{th} Plan. This programme was found very effective in creating self and wage employment opportunities and was strengthened with UNDP support during the 10^{th} Plan. This programme has been taken up by some of the State Governments on their own for replication. More than 1.25 lakh jobs have been created through this initiative so far. Nine thousand micro enterprises have been created through the initiative of the micro-enterprise development programme targeted at less developed regions of the country.

The reach of the programmes supported by NSTEDB is fairly wide spread. During the 10^{th} Five Year Plan NSTEDB was able to cover all the States and UTs of the country through its programmes.

7.4.6 Rashtriya Vigyan Evam Prodyogiki Sanchar Parishad (RVPSP)

- Training in S&T Communication (Long term and Short term): Several programmes conducted, spread across the length & breadth of the country, to train a cadre of science communicators.
- Field based projects in S&T Communication including annual Children's Science Congress, an activity which is now conducted in each & every district of India; Teachers' Science Conferences involving hundreds of teachers from all parts of the country; celebration of National Science Day in most of the States in February each year; Voluntary Blood, Organ & Tissue Donation programme, training master resource persons in Science behind so-called miracles; *Jathas*, Public Debates, etc. on popular science issues, and so on.
- Development and dissemination of S&T communication software Audio, Video, CDs, Films, Books, Slide-sets, posters, Calendars, Year Planners, etc. to spread awareness.
- Vigyan Mail – An exhibition-on-wheels, a unique train which had 12 specially designed coaches showcasing India's achievements and capabilities in science & technology, which halted at 27 stations during its 72 days run in 2005 and attracted over 15 lakh persons.
- R&D Projects on S&T, Research journals, Newspapers & Newsletters on popular science in English, Hindi and regional languages supported.

- International collaboration in S&T communication initiated with INTEL, in collaboration with CII, to promote innovation amongst children besides facilitating participation of school students in international innovation fairs.
- Year of Scientific Awareness 2004- A major initiative involving most of the above mentioned activities which touched about 20 crore people in each & every nook & corner of India. Several types of software developed and distributed countrywide. Subsequently many initiatives launched in the newly identified sectors.
- International Year of Physics 2005- Over 200 Master Resource Persons in various activities in Physics trained who subsequently reached out to thousands of students. The Parishad will continue to support the activities.
- A nationwide Water Resources & Eco-system Management programme launched in 2006 under the eco-water literacy campaign which has now taken concrete shape and will continue to be supported.
- Planning & preparation for Planet Earth Programme (2007-09) in full swing. Workshops held with the prospective associates and partners.
- Felicitating UNESCO-Kalinga Award winners and Kalinga Chair.
- 'IRIS' an International Innovation Fair being held at Delhi in 2006 and is proposed to be made a regular event.
- National Science Communication Awards: increase in no. of awards to six from initial two, significant hike in prize amount and increase in number of applicants.

7.5 INTERNATIONAL S&T COOPERATION PROGRAMMES

The International S&T Cooperation Programmes are aimed at complementing and supplementing national efforts of doing world class R&D in different areas of national priority at competitive cost and in most efficient manner. The Cooperation activities are implemented through various types of modes of cooperation which include bilateral mode; regional cooperation mode and multilateral cooperation mode. During 10th Five Year Plan, Bilateral Cooperation activities were implemented through inter governmental agreements signed with 67 countries. Regional cooperation activities were implemented under the aegis of mechanisms such as SAARC, BIMSTEC, ASEAN, IOR-ARC and multilateral activities under STEPAN, UNESCO, TWAS,NAM S&T Centre and IBSA Cooperation. In addition, support and facilities were extended to Indo-US S&T Forum; Indo-French Centre for Promotion of Advanced Research (IFCPAR) and NAM S&T Centre.

During the 10th Five year plan, the focus of International S&T Cooperation Programmes was primarily aimed at providing the Indian scientists and engineers the following opportunities:-

- To share their R&D efforts and excitement with fellow researchers in partner countries**;**
- To gain access to research facilities abroad which are not available in the country;
- To share research cost and output;
- To gain from each others experience;
- To participate in mega science research projects;
- To participate in major international research facilities ;
- To demonstrate Indian S&T capabilities;
- To create world class facilities/centers of excellence/ joint centers.

However, in the last 2 years of the 10th five year Plan, activities/programmes aimed at encouraging and promoting public private partnership through various modes of cooperation such as technology platforms and tech summits and support and encouragement to pre commercial R&D were initiated. While tech summits were organized with Russia, Canada. These activities were organized with close collaboration with the Confederation of Indian Industry (CII). A similar tech summit is being planned with participation of ASEAN countries during 2006. Technological expositions were also organized with Belarus (2003) and Ukrain (2004).

In addition, for promoting India's image as an emerging knowledge power and to show case its progress in R&D in frontier areas of S&T, India R&D 2005; the world's knowledge hub of Future was organized in 2005 in collaboration with Federation of Indian Chamber of Commerce and Industry (FICCI). Experts from more than 70 countries participated in the event.

Pre commercial R&D initiative known as India Israel Initiative on Industrial R&D was started during 2005. Many more countries including Canada, Australia, US, UK , Japan have shown interest in initiating similar activities with India. Thus, while focusing support to basis and applied sciences, efforts were made to evolve programmes and activities aiming at pre-commercial R&D and Public Private Partnership.

Types of Activities supported:

The activities supported during 10th Five Year Plan included Exploratory missions of scientific delegations; Exchange visits of scientists for collaborative work and information exchange; Joint Workshops; Fellowships/training /study visits for Indian scientists abroad and foreign scientists in India; Development and implementation of joint R&D programmes, joint projects and Collaborative R&D programmes; support to Indian scientists to access major international facilities abroad; establishment of Joint centers of Excellence; Joint preparation of the state of the art reports; support to pre commercial R&D on selective basis.

Summary of Achievements during 10th Five Year Plan

Achievements made/outcome under International S&T Cooperation Program during 10th Five Year Plan period are summarized in the Table given below:-

Sl. No	Activity	Achievements
1.	New Agreements signed	17
2.	POCs signed/renewed	35
3.	Joint R&D Projects	~ 1000 projects supported
4.	Exchange visits	~ 6000 visits supported
5.	Joint Workshops	~ 150 workshops
6.	Joint Research Papers	~ 1500 Research papers
7.	Co-authored books/monographs	~ 20
8.	New Joint Centres of Excellence	~ 10
9.	Promotional Centre	1
10.	Fellowship to India	~ 25
11.	Fellowship abroad	~ 175
12.	Lindau Fellows	125
13.	Ph.D Awarded	~ 200+
14.	International Events / Exhibition	12

15.	Project based visit of STIOs to India	20
16.	MOUs signed	10

7.6 STATE SCIENCE AND TECHNOLOGY PROGRAMME

Objectives:

- To strengthen State Council for Science & Technology to promote state S&T activities.
- To provide catalytic support for S&T demonstrate projects, replication projects, location specific research and state specific studies and surveys.

Achievements:

During the 10^{th} plan, the activities of the programme were substantially enhanced and programmatic phase initiated in Ninth Plan was enlarged. As a result of pro-active efforts made during the plan period, following results were obtained:

a) **Network of State S&T Councils**:

Active interaction was continued with State S&T Councils and Departments of all the states. In addition to core support, states were encouraged to avail of programmatic support available from DST.

b) S&T demonstration projects

Under this programme, technologies developed by national labs as well as by State S&T Councils were encouraged for field trials, demonstration and replication. Some of the major achievements were in the following areas:

- **Plastic and hospital waste management system:**

Four plastic and hospital waste disposal demonstration plants based on indigenously developed plasma incineration technologies were set up at ecologically fragile locations having high tourist influx at Goa, A&N, Himachal Pradesh & Sikkim.

- **Water purification technologies**

In order to demonstrate effectiveness of indigenous technologies for removal of contaminants from drinking water with a view to provide safe drinking water, following technologies were successfully demonstrated:

- One demonstration plant based on ceramic membrane based iron removal from water was installed at Tripura..

- A sea-water desalination plant based on 2-Stage desalination process development indigenously was installed in Nelmudar village (Ramnathapuram district), Tamil Nadu.

- A community deflouridation plant of 25 ltrs/minute capacity based on Activated Alumina Technology was developed and demonstrated at Moondli Village in Rajasthan.

- Pilot demonstration plant for treatment of hard/brackish water based on indigenously developed Reverse Osmosis Technology was successfully installed at Uttarlai Airforce Station, Barmer. The plant has been running successfully and providing pure drinking water to inhabitants of air-base as well as nearby villages.

- **Other Technologies:**

- A demonstration building unit showcasing solar passive housing technology developed by HP State S&T council was constructed at Manipur to facilitate replication of technology.

- A sericulture demonstration plant has been established in J&K, adapting better silk yielding technologies, under guidance of scientists from IICT, Hyderabad

c) **Mapping of sectoral areas for S&T interventions**:

In order to plan and prioritize State S&T activities so that they accrue maximum benefit to people, an exercise for mapping of State S&T needs, was initiated for identification of problems requiring S&T intervention.

d) **Impact on State S&T policies**:

State S&T Councils of various states have been quite effective in making an impact on State polices. To illustrate, the state of Himachal Pradesh has been successful in prescribing guidelines related to use of solar passive housing techniques and water conservation structures in buildings exceeding certain sizes. Various states such as Madhya Pradesh, Punjab, Uttaranchal, Uttar Pradesh etc. have formulated their S&T/biotechnology policies.

7.7 SURVEY OF INDIA

Significant Achievements during the 10th Plan

1. Digitization of maps on 1:250,000 and 1:50,000 scales completed for the entire country. Out of the 5067 sheets, 3780 sheets have been updated and the remaining maps will be updated by mar 07.
2. Procurement of 80 DGPS, 30 Digital Levels, 90 Total Stations, 210 Tablet PCs integrated with GPS provided to all GDCs of SOI. 200 more Tablet PCs with GPS are being procured during current FY.
3. A village Information System (VIS) has been established for the entire country, except the NE States. The system is being extensively used by the Planning Commission for monitoring the Plan Schemes.
4. Large scale maps of 7 metros on 1:4,000 scales have been prepared and awaiting clearance from MOD. Similarly large scale maps for Most of the State capitals is in hand.
5. GIS maps for all 70 cities and towns of Uttaranchal State have been prepared.
6. Election Commission has been provided with geo-referenced digital GIS maps for all Parliamentary and Assembly Constituencies of the country. Election Commission is also being provided with large scale maps of Metros for preparing voters list. Pilot project is on in Ahemdabad.
7. Modernization and expansion of Tide Gauge Stations(TGS) Network has been carried out and 36 Tide Gauge Stations with online communication system are to be put in place shortly. Presently real time data from 9 TGS is being received by SOI.
8. One Printing Machine and one Map Publishing System have been procured and one more printing machine will be procured during the current financial year.

Significant Developments during 10th Plan relevant to the 11th plan

1. New National Map Policy announced in May, 2005. 3,200 Open Series Maps (OSMs) are ready for being put in public domain.
2. National Spatial Data Infrastructure (NSDI) has been created. SOI will provide topographic database (base layer) for the NSDI.

7.8 NATIONAL ATLAS & THEMATIC MAPPING ORGANISATION

During Xth Plan, NATMO took up several new projects in addition to the continuing project as a spill-over of the earlier plans. These projects are related to the requirement of thematic maps and atlases in the country. As a result, the revision of National Atlas of India and other atlases were carried out and the new projects on the preparation of the atlas of the three new states, i.e. Chhattisgarh, Jharkhand and Uttaranchal were taken-up. While former two atlases are near completion, the atlas of Uttaranchal has already been published and released in the year 2003. The atlases for the remaining part of the original states of Madhya Pradesh, Uttar Pradesh and Bihar have also been taken up and they are likely to be completed within a year or so. Further, NATMO took active role in National Spatial Data Infrastructure (NSDI) and Village Information System (VIS) related activities. The most important achievement of this Plan is the development of the technology for the preparation of the atlases for the Visually Impaired. Other important projects completed or in near-completion are (a) National Atlas of India, 2nd ed., (b) National School Atlas, (c) Satellite Atlas of India, (d) District Planning Map Series, (e) State Atlases, and (f) Primary School Atlas.

7.9 National Mission on Bamboo Application :

Objectives

Development and scaling up of bamboo based economic activities in the country to enable enhanced economic opportunities, employment generation, entrepreneurship, exports and the environment protection. The thrust areas of the Mission include-

(i) Knowledge and information gathering and dissemination

(ii) Technology development and validation

(iii) Demonstration and promotional activities for bamboo based value added products and applications

(iv) Standard setting and testing of materials and products

Support to entrepreneurial projects and the commercialization of technologies.

Achievements:

Wood Substitutes	• Development of new composite material-glass-bamboo hybrid sandwich composites as well as flattened bamboo boards for different applications. • Revival of three closed plywood units based on bamboo as a raw material with a production capacity of more than 2 million square feet per annum • Establishment of two bamboo flooring units of more than 150,000 m2 per annum capacity.
Building & construction	• Development of low-cost, prefabricated community toilet block, and housing systems, using bamboo, bamboo-jute, bamboo-glass fiber sandwich and composite materials • 127 pre-fab bamboo composite based shelter units developed and erected for different functional requirements of earthquake resistant, high altitude, high wind and tsunami affected areas. • Prototype development of innovative structures, utilizing bahareque (Latin America) style construction • Construction of high end and architecturally complex structures, using Colombian techniques of mix of materials, joinery, treatment and network of load bearing elements in Delhi. • Develop processes for treatment as well as BIS standards for bamboo based construction and structural material

Agro-processing	• Technology packages developed for processing of shoots for the market, at different scales of activity-from 200 TPA to 2000 TPA-ERG • Demonstration of low cost technology packages for processing edible shoot for community/ cluster level, using low cost heat sealing equipment and simple packaging techniques for shelf life from 4-9 days-ERG • Establishment of a 1100 TPA units for processing/packaging of bamboo shoot, to be established at Jorhat.
Craft & small enterprise	• Establishment of a mechanized commercial processing of whole bamboo furniture in Nagpur. • Development and demonstration of technology for application of natural colorants on bamboo and bamboo products (IIT Delhi) • Establishment of a three units of 300 tonne per annum capacity stick making units • Technology validation and setting up of bamboo mat-acrylic molded utility product manufacturing unit of 3000 square feet/shift • Setting up of a manufacturing unit of mechanized craft and utility items-first of its kind in the country • Setting up of a 3.5 lakh square feet per annum capacity Venetian blind making unit
Industrial applications	• Development and demonstration of technology for bamboo charcoal kilns of 2tonne/batch/3 day cycle capacity • Process technology developed for activated carbon-development of semi-commercial scale plant. • Technology for bamboo based torrification developed to enhance storage life of flowered bamboo and to provide high calorific clean fuel to rural and industrial applications • Establishment of 1 Mwe equivalent bamboo based gasification unit at HPC, Naogaon and Silchar • Technology validation and product development using bamboo fiber reinforced thermoplastics • Technology validation for bamboo fiber production through pulping and non-pulping route and development of its application for non-woven, hygiene applications and wound dressings
Bamboo Machinery & products, Process Technology	• Design & Development of four indigenous lines of bamboo processing machineries including primary and secondary processing machineries • Development of sliver mechanized equipment capable of producing 0.6-0.9 mm slivers to support mat making and craft sector • Prototype development, testing and field testing of bamboo composite based for tea pallets • Bamboo based packaging boxes for Alphonso mango prototyped, developed and market tested
Support &	• Market and product survey for edible bamboo shoot

Linkages	• Survey of flowering area using satellite imageries and ground truthing • Development of maturity marking systems for bamboo cultivation • Development of draft standard for whole bamboo and bamboo composites. • New publications on propagation, cultivation and preservation. • Demonstration of package of practices for edible bamboo shoot, flyash mycorrhiza soil amendment, river bank protection and thorny perimeter fencing. • Coordinated locational trial of commercially important species of bamboo at nine regional locations as well as trial for Tissue Cultured plants vis-à-vis vegetatively multiplicated plants. • Setting up of vegetative four multiplication nurseries for quality plant material production using selected plus germplasm and sand beds

7.10 Synergy Projects:

Objectives :

The Scheme "Synergy Projects" of O/o PSA to GOI has targeted to achieve the objectives of studies, pilot projects and development efforts that can nucleate or catalyze large multi-disciplinary projects or help in networking institutions whose work has a common objectives but the efforts are currently fragmented. They are more in the nature of evolving projects in response to urgent national S&T needs, as perceived from time to time, and this response has to be quick. Some of the projects undertaken by O/o the PSA to GOI relate to improving S&T environment in the country are:-

- Improving S&T Environment in the Country
- Enhancing Academia-Industry Interaction
- Energy and Water
- Rural Technologies
- National Security

Achievements

The following projects have been successfully completed :-

i) Measures of Impact of S&T in India : Agricultural and Rural Development.

ii) Analysis of Indian Patenting Activity in International and Domestic Patent System.

iii) **Measures of Progress of S&T in India : An Analysis of the Publication Output in Science & Technology.**

iv) A National Energy Map for India- Technology Vision – 2030.

v) Development of GaAs-Epitaxial Multijunction Quantum Well Infrared Photodetectors (QWIPS) – Phase I.

vi) Preparation of a Road Map for Oil Spill Management for India.

vii) Promotion of information security through the formation of the Society for Electronic Transactions and Security (SETS) under the Societies Registration Act, 1860.

viii) Development of a Bulk Encryption Unit and a Secret Algorithm.

ix) Modeling of Fluidized Bed Coal Gasifiers.

x) Development of a Readout Integrated Circuit (ROIC) for an 8X8 QWIP array.

xi) Development of Explosive Detector based on the Ion Mobility Spectrometry Technology.

xii) RuTAGs has been established in Uttaranchal, Tamilnadu and also in Assam for the North-eastern State.

xiii) Following projects are under implementation in the automotive sector :-

a) Pilot project on Telematics : Vehicle Tracking and Control Systems at Koyembedu Bus Terminus, Chennai.
b) Intelligent and Interactive Telematics using emerging wireless technologies.
c) Low cost engine management system for small engines (2 wheeler/ Autorickshaw).
d) Light weight automobile body components (Hydroforming and Tailor Welded Blanks)

xiv) Ground Water Recharge Zones and flow Characterization using Isotope was Hydrology Techniques was successfully completed in the state of Uttaranchal.

No. Prn.SA/ADV/SC/2006
Government of India
Office of the Principal Scientific Adviser to the Government of India

311, Vigyan Bhawan Annexe,
Maulana Azad Road,
New Delhi 110011
Dated: 11th May, 2006

OFFICE MEMORANDUM

Subject : Constitution of Working Group under the Steering Committee on Science on Technology for the Formulation of Eleventh Five Year Plan (2007-2012).

Planning Commission has constituted a Steering Committee on Science and Technology for the Formulation of Eleventh Five Year Plan (2007-2012). To assist the Steering Committee and to finalize its recommendations, a Working Group is being constituted for Department of Science & Technology. The composition and terms of reference of the Working Group would be as follows :

I. Composition

Sr. No.	Name, Designation and Organization	
1.	Secretary, Department of Science & Technology	Chairman
2.	Prof. M.R.S. Rao, JNCASR, Bangalore	
3.	Prof. M. Vijayan, Honorary Professor/ Distinguished Biotechnologist, IISc., Bangalore	
4.	Ms. Swati Piramal, Nicolas Piramal India Ltd., Mumbai	
5.	Prof. A.K. Sood, IISc., Bangalore	
7.	Dr. T.K. Chandrasekhar, RRL, Trivandrum	
9.	Dr. G. Sundararajan, Director, International Advanced Research Centre. for Powder Metallurgy and New Materials (ARC-I), Hyderabad	
10.	Dr. S. P. Sukhatme, Former Chairman, Atomic Energy Regulatory Board, Mumbai	
11.	Dr. Harsh K. Gupta, Former Secretary, Department of Ocean Development	
12.	Dr. V. Sumantran, Former Executive Director, Tata Motors Ltd., Pune.	
13.	Dr. S.K. Joshi, Vikram Sarabhai Professor, NPL, New Delhi	
14.	Dr. Kota Harinarayan, Emeritus Scientist, NAL, Bangalore	

15. Dr. A. Patwardhan, TIFAC, Delhi

16. Mr. Jayasimha Sriram, Signion Systems Pvt. Ltd., Hyderabad.

17. Mr. D. Raghunandan, Centre for Technology Development, Delhi

18. Shri H.K.Mittal, Adviser, DST, New Delhi — Member Secretary

II. Terms of Reference

1. To review and assess the progress made by the various Central S&T Departments/ Agencies during the Tenth Five Year Plan identifying the achievements, weaknesses/ shortfalls and gap areas.

2. To suggest plans and programmes of the various Central S&T Departments/ Agencies based on the policy, approach, thrust and priorities of the S&T Sector for the Eleventh Five Year Plan taking into consideration the concept of Zero-based budgeting, convergence of various ongoing schemes including weeding out of the schemes which are no longer relevant and completion of ongoing schemes on a priority basis and also to suggest an optimum outlay for the S&T Sector, comprising, the ongoing commitment and new programmes proposed to be undertaken, keeping in view the overall resource position in the country.

3. The Chairman may co-opt members for specific task.

4. The expenditure on TA/DA in connection with meetings of this group would be met by the concerned department.

5. The report of the Group would be submitted by 15th July, 2006.

(S. Chatterjee)
Adviser

***Copy forwarded to*:**

1. Chairman, all members and Member Secretary of the Working Group.

2. Dr. V.L. Chopra, Member (S&T and Agriculture), Planning Commission, Yojna Bhawan, New Delhi

3. Dr. P.K. Biswas, Advisor (S&T), Planning Commission, Room No. 213, Yojana Bhawan, Sansad Marg, New Delhi

(S. Chatterjee)
Adviser

Annexure-II

F.No.1(1)/2006-PC
Government of India
Ministry of Science & technology
Department of Science & Technology
Plan Coordination

Technology Bhawan
New mehrauli Road
New Delhi-110016

Date: 24th January 2006

ORDER

Sub: Constitution of Expert Committees for Evaluation of Plan Schemes of DST and Formulation of XIth Five Year Plan

In order to evaluate Xth Fiver Year Pal Schemes of the Department and formulation of XIth Five Year Plan proposal, it has been decide to constitute six Expert Committees. The Composition of the Expert Committees for consideration of various plan schemes is as under:-

Plan Schemes: R&D Support; Nano Science & Technology Mission; Synergy Projects; National Training Programme for Scientists & Technologists; and Other professional Bodies, Seminar, Symposia

Prof. M Vijayan, IISc, Bangalore – Chairman
Dr G Sundararajan, ARC-I, Hyderabad
Prof AK Barua, IACS, Kolkata
Dr T Ramasami, CLRI, Chennai
Dr P. Asthana – Convener

Plan Schemes : Technology Development Programme; Drugs & Pharmaceuticals Research, State S&T Programme

Dr SP Sukhatme, Ex-Chairman, AERB, Mumbai - Chairman
Dr Varprasad Reddy, Shanta Biotech, Hyderabad
Dr G Bhubaneswar, SCTI, Thiruvananthapuram
Prof DV Singh
Dr KV Raghavan, Former Director, CLRI, Chennai
Er NS Tiwana, Punjab S&T Council
Dr Laxman Prasad – Convener

Plan Schemes : Autonomous Institutions & Professional Bodies, Bamboo Mission

Dr P Rama Rao - Chairman
Dr Indira Nath
Prof SK Tandon, Delhi University
Dr ML Munjal, IISc, Bangalore
Dr SE Hasnain, VC, Univ. of Hyderabad
Dr B Harigopal – Convener

Plan Schemes : S&T Programmes for Socio Economic Development; Technology Management Project – SKILLS; and Information Technology

Prof. SK Joshi - Chairman
Dr Dinesh Awasthi, Director EDII, Ahmedabad
Dr Madhu Pant, Director, Bal Bhavan
Dr Anil P Joshi, HESCO, Dehradun
Mr HK Mittal - Convener

Plan Scheme : International S&T Cooperation

Dr Kota Harinarayan, NAL, Bangalore -Chairman
Dr S G Dhande, Director, IIT, Kanpur
Dr W Selvamurthy
Dr SK Brahmachari, Director, IGIB, Delhi
Shri YP Kumar - Convener

Plan Schemes : Science Based Services (SOI, NATMO, IMD & NCMRWF), Seismology Mission

Dr Harsh K Gupta, Ex-Secretary, DOD -Chairman
Dr BL Deekshatulu, University of Hyderabad
Dr SM Kulshreshta, Ex-DG, IMD
Dr UC Mohanty, IIT Delhi
Mr AJ Kurian - Convener

4. Terms of Reference of the Expert Committees:-

(i) Evaluate the plan schemes and submit recommendations within 3 months from the date of constitution for continuation/discontinuation of the schemes during the XIth Five Year Plan period.
(ii) Recommend modifications, if required, in the existing schemes.
(iii) Provide inputs for formulation of XIth Five Year Plan proposal of DST.

5. Tenure of the Committees:

Tenure of the Committees will be till the formulation of the XIth Five Year Plan proposal of the Department .

6. Payment of TA/DA and Honorarium

The expenditure of the Committee members on TA/DA for attending meetings will be met from the Plan Scheme(s) being handled by the Convener of the Expert Committee. Honorarium of Rs.500/- per day will be paid to the Members of the Committees for attending the meetings.

(Dr B K Shukla)
Scientist F

To:-

1. All the Conveners of the Expert Committees.
2. PPS to Secretary, DST.
3. JS(A)/JS(F)/COA.
4. All HODs of DST
5. IFD

Recommendations of the Expert Committees for Evaluation of Plan Schemes of DST and Formulation of XIth Five Year Plan

1. R&D Support; Nano Science & Technology Mission; Synergy Projects; National Training Programme for Scientists & Technologists; and Other professional Bodies, Seminar, Symposia

Prof. M Vijayan, IISc, Bangalore – Chairman
Dr G Sundararajan, ARC-I, Hyderabad
Prof AK Barua, IACS, Kolkata
Dr T Ramasami, CLRI, Chennai
Dr P. Asthana – Convener

Recommendations of the Expert Committee

After considering the X Plan activities and achievements and the XI Plan projections placed and presented before the Committee, the following recommendations were made.

SERC (Science)
SERC (Engineering)
Coordinated Programmes in Earth and Atmospheric Sciences
Opportunities for Young Scientists (OYS)
IRHPA (Intensification of Research in High Priority Areas)

The above programmes continue to be the backbone of basic research in the country. The hallmark of these programmes supporting basic research is that they cut across disciplines and institutions. The only criterion for providing support has been the content of scientific investigation to be pursued. Such an open-ended system is an absolute must for support of basic research and the "DST/SERC" programmes have managed to keep this character intact over a 30 year long period. These programmes must be continued, strengthened and provided greater manpower and technological wherewithal as mentioned at the end of this Section under General Recommendations.

These programmes have also maintained a very fair and transparent system of peer-review through Programme Advisory Committees which instills lot of confidence among scientists. Over a long 30 year period, the DST/SERC system has never attracted any criticism for the fairness of its peer-review system and for the faithfulness of the Secretariat to technical decisions taken by peer-review committees. It is no mean achievement and DST needed to be complimented for this feat. This aspect needed to be zealously guarded and secured so that the scientific community continues to repose faith in the fairness of DST/SERC system.

The other distinguishing feature of SERC has been to start and consolidate research in the country in a number of areas. In its 30 year long history, there are a number of such examples. To mention a few, let us start with the entire area of structural biology research. The unstinted support to several leading groups has led to the growth of a strong and internationally competitive community in the country. Similarly, DST/SERC consciously promoted research in neurobiology which led to a sizable community culminating in the formation of a new centre on brain research. The research programme on chronobiology in the country has been sustained mainly due to the support provided by DST. This list can be made very long. However, these examples are enough to illustrate the fact that DST/SERC has been able to champion the cause of several important areas of research in the country and those areas owe their existence to the support provided by DST. This has been possible mainly because of the open-ended nature of the DST/SERC system which is the life-line of any basic research funding mechanism.

It is useful to list a few other examples which not only strengthened areas of research, but also established major facilities for research. The Plasma Physics Programme at PRL, Ahmedabad was initially supported under IRHPA. It went on to become the Institute for Plasma Research at Gandhinagar under DST with an indigenously designed tokamak for plasma research. Later, when the Superconducting Steady-State Tokamak (SST) project came, IPR moved over to DAE. And, today, in addition to the SST, it would be also leading India's participation in the International Thermonuclear Experimental Reactor (ITER) project in France. It will not be a hyperbole to say that, but for the initial push provided by DST, plasma research in the country would not have achieved the kind of confidence-levels and visibility that it did. Similarly, though the Pelletron Accelerator at IUAC, New Delhi was established by UGC, the entire range of facilities there for materials research using swift heavy ions owes its existence to sustained funding by DST over 10 years. Sustained support to the NMR Facility at TIFR, Mumbai has enabled Indian biologists and chemists to maintain their competitive edge over a very long period.

Several prestigious international collaborative projects like the CMS and ALICE projects at CERN, Geneva are also being handled by the SERC Division because major funding for hardware is involved. DST/SERC has, over the years, evolved a very useful functional relationship with the Department of Atomic Energy which has culminated in a DAE-DST MoU for jointly undertaking research programmes of mutual interest.

In summary, the Committee has no doubt that the DST/SERC has been the mainstay of basic research in the country, especially in the academic sector, and all the programmes mentioned above need to be continued.

On the output side, about 60% of SERC projects fall into the Very Good to Excellent category when monitored by the peer-review Committees, 30% in Good category and the remaining in the Satisfactory category with a miniscule fraction in the Poor category. This only shows that the peer-review of the projects has been effective.

Various PACs have identified a large number of very good and ambitious projects/programmes to be taken up during the XI Plan. Those documents have been attached as appendices. The Committee feels that most of those programmes are well thought out and sufficient resources should be made available to realize them so that DST/SERC programmes make a quantum jump during the XI Plan period.

The Committee will only like to add that, in addition to those well-identified programmes, DST/SERC system must always have the flexibility and resources to launch a new area of research and support any individual scientist for some new idea which may emerge suddenly and could not be thought of at this moment. It is this flexibility which is the lifeline of basic research funding and DST/SERC system must always have it, as in the past.

The Committee strongly feels that there is nothing seriously wrong with the SERC system. Some of the recent criticisms have been due to some operational problems and they need to be addressed immediately. Some suggestions have been made in the General Recommendations below.

WOS-A (Women Scientists Scheme-A)

This is a very novel programme, the first of its kind in the world, to enable women scientists to re-enter mainstream research after break/s in their career due to family responsibilities. It is heartening to see that majority of the women scientists supported so far fall into the 35-45 age group which shows the need for such a scheme. Over 100 projects have been supported every year and, in the absence of such a scheme, we had been losing this group of active researchers all these years.

The Committee feels that this is an important gender-sensitive programme and must be augmented. We only need to be careful while monitoring such projects, especially with regard to assessing the level of commitment of a women scientist to get back to research after break/s in her career.

Nano Science and Technology Initiative and Nano Science and Technology Mission (Nano Mission)

Responding to the worldwide explosion in research activities in the area of Nano Science and Technology, DST, under the SERC umbrella, started the Nano Science and Technology Initiative (NSTI) in October 2001. So, effectively, these activities coincided with the X Plan period.

The support provided so far has been, understandably, mostly for basic research projects (~ 100 in number) and building up of sophisticated research infrastructure by way of establishment of 17 units/centres on nano science and nano technology. Close to Rs. 80 crore have been spent so far and the programme has started resulting in good papers and competitive work in the area. One of the projects has also resulted in a US patent and the technology has been taken up by a US company.

DST has already formulated an ambitious plan for enhancing these efforts by establishing a Nano Science and Technology Mission (Nano Mission) with an allocation of Rs. 1000 crore during 2006-2011. This is under consideration for funding at the apex levels in Government and the Mission is expected to be launched shortly. The Nano Mission, as expected, would look at promotion of Nano Science and Technology in a comprehensive fashion. Apart from basic research and human resource development, it is planned to lay considerable emphasis on technology development and commercialization utilizing public private partnerships. It is also planned to synergize the efforts being made by various government agencies and industry through well-laid consultative and decision-making structures.

The Committee feels that DST should follow-up further on these steps already taken and start the Nano Mission at the earliest.

Ramanna Fellowships

The Committee greatly appreciates launching of this new Scheme wherein Principal Investigators who have produced excellent results in their ongoing projects shall be able to get financial support for maintaining their core research activities in an uninterrupted fashion. It will, at least for performing investigators, solve several problems encountered during the gap between sanction of two successive projects.

The Committee also notes with satisfaction the path-breaking feature of this scheme of granting a fellowship to even employed investigators. Though the amount of fellowship is very modest, this shows a big conceptual advance in the Government system and puts in place a reward scheme for performing investigators.

This scheme must continue and should be fine-tuned and made more attractive during the XI Plan.

FIST (Fund for Improvement of S&T Infrastructure in Higher Educational Institutions)
SAIF (Sophisticated Analytical Instrument Facilities)

Both these schemes have done a yeoman service to the scientific community in the country by providing enabling research instrumentation and infrastructure to a large number of institutions.

The SAIF programme, must be provided enough funds to phase out and replace obsolete equipment. In addition, it should be enabled to add to its list more contemporary instrumentation. Also, it should strengthen its users training activities.

FIST has been uniformly acclaimed to be a very good initiative by DST. It has helped remove equipment obsolescence in a big way in university departments and also helped upgrade the teaching laboratories at the post-graduate level. This programme must be strengthened. The Committee, however, feels that it should keep its current focus on building research infrastructure and capabilities and not get overburdened with educational responsibilities which, though extremely important, falls into the domain of other agencies.

KVPY (Kishore Vaigyanik Protsahan Yojana)

This flagship programme of DST to attract young school and college-going students towards sciences has become a sought-after scheme and also a benchmark for other such schemes in terms of quality of selection, its nurturing mechanisms and the quantum of scholarship provided.

While this scheme should continue, there is a need to look at ways to enhance the retention of students in sciences and also to achieve a critical mass of such KVPY fellows.

USERS (Utilization of Scientific Expertise of Retired Scientists)

Considering the depleting reserve of research manpower in the country, it has been emphasized in several forums that the expertise of superannuated scientists must be conserved. This is a very useful scheme to utilize the expertise of retired scientists to write book/s monographs, etc. and must be continued. The rate of honorarium for such scientists, viz. Rs. 10,000/- pm, needs to be revised. A mechanism must be put in place so that the quantum of honorarium gets periodically revised with salary revision of other classes of research personnel.

The Committee also feels that the DST provision of allowing superannuated scientists to have research projects (with provision of honorarium) after standard peer-review is an excellent provision. Not very many agencies have such a provision and it must be continued.

PFA (Partial Financial Assistance)

This is a very popular scheme of DST supporting a large number of scientists and research students to attend conferences, seminars, schools, etc. abroad. It is an important aspect of research career to be able to disseminate ones findings among leading peers and to interact with them. Intellectual interaction is important for fostering scientific creativity. This scheme must be continued.

The Committee, however, strongly feels that DST (and also other agencies) should grant full travel support and funds for registration, etc. so that scientists do not have to unnecessary approach several agencies for one single travel. This causes immense hardship to the scientists and uncertainty till the last stage when he/she should ideally be preparing for his talk during the conference.

DST should also allow international travel under its research projects. After all, the projects are chosen after such a rigorous peer-review. It is important that the work of such investigators gets international attention and recognition.

Seminar/Symposia Scheme

This is also a very popular scheme which partially supports a large number of conferences, etc., publication of some important journals like Current Science and a number of prestigious professional bodies. This scheme must continue. The new initiatives proposed during the XI Plan also seem reasonable and funds should be provided to launch them.

Swarnajayanti Fellowships
Ramanujan Fellowships
JC Bose Fellowships

These three are the most prestigious fellowships that DST has for the most meritorious among scientists.

The recently announced Ramanujan Fellowship has broken a new ground by throwing open these fellowships to even foreign nationals. The JC Bose Fellowships have further built upon the beginning made by Ramanna Fellowships and allowed for attractive fellowship amount to employed scientists over and above their salary. Both these fellowships have an attractive Contingency grant and the recipients have the flexibility to spend it as per their research needs.

In view of the new benchmarks set by the JC Bose fellowships, it may be necessary to review the amount of Swarnajayanti fellowship.

These schemes should be continued and strengthened during the XI Plan period.

NSTMIS (National S&T Management Information System)

The Committee feels that this is a very important activity, but is currently going on at a modest level. Apart from collecting and collating data regarding the national and international science and technology scenario, it should also start predicting trends of research in the country vis a vis the international scenario. This will provide important input for policy formulation. In order to achieve this, DST should considerably strengthen this activity.

Training Programme for Scientists and Engineers

The Committee feels that this is a very important initiative taken by DST in the X Plan. It would supplement the scientific training of scientists employed in DST and other government organizations with necessary administrative, financial and science policy-related knowledge and skills and enable them to do their science management job and serve the scientific community in the country even better. The training programmes had been carefully developed for junior, medium and senior level scientists and three reputed organizations like IIPA, New Delhi, ASCI, Hyderabad and NIAS, Bangalore had been entrusted with the task of running the training programmes. The international training component following the national-level training was also an imaginative step to enlarge the outlook of these scientists involved in management of R&D programmes.

The Committee strongly feels that these programmes should be continued in the XI Plan and the courseware should be continuously improved based on the feedback from trainers and participants.

Synergy Projects

The Committee feels that the PSA's Office, which is running this programme, has chosen such areas which have immense practical and economic significance for the country. In order to achieve tangible results in a reasonable time, it was necessary to pool all the expertise in the country. The PSA's Office, because of its nodal position, has been able to achieve the same. This is quite significant and a novel initiative during the X Plan. These Synergy Projects deserved to be continued in the XI Plan period also as per the plan submitted by the PSA's Office.

General Recommendations

The Committee strongly feels that R&D schemes of DST have done a great service to the scientific community of the country. There is nothing basically wrong with the decision-making processes of SERC and other schemes and their sanctity should be maintained.

The only major problem with these schemes is that the turn-around time for obtaining grants has increased considerably over the years and is currently, on an average, close to one year for a normal project. It is important to hasten the funding process. The major reason behind the delay is overloading of the system with ever increasing number of schemes, ever increasing number of projects, ever increasing complexity of projects and responsibility of spending ever increasing budgets with no commensurate increase in the scientific staff strength of the Department and poor leveraging of IT tools. It is important that whenever a new programme is started, provision for sufficient scientific and support staff is made. And, complete automation of the DST project management system has become extremely urgent.

In addition, the scientific Divisions need to be granted greater financial autonomy or delegated greater financial powers so that routine decisions can be taken at the programme management level itself.

Regarding XI Plan, very good plans have been proposed in different areas of research and are available in the Appendices. The Committee would only like to flag a few specific items and issues. They are as follows:

- In the XI Plan period, various PACs have tried to align their research interests towards development of new sciences.

- Additional high intensity photon sources have become an absolute necessity for doing world-class work in several areas ranging from structural biology to new materials. This must be made available at the earliest.

- It has become urgent to stop further depletion of staff from university departments by strengthening the university system. Universities have to be the mainstay of open-ended basic research.

- Freeze on hiring imposed on even national labs is greatly damaging the R&D system of the country. R&D is scientist-centric and if no new manpower is hired, the R&D system will cease to generate new knowledge. Freeze on hiring must not be imposed on scientific institutions.

2. Technology Development Programme; Drugs & Pharmaceuticals Research, State S&T Programme

Expert Committee

1. Prof. S.P. Sukhatme	Chairman
2. Prof. D.V.Singh	
3. Dr. G. Bhuvaneswar	
4. Dr. N.S.Tiwana	
5. Dr. Laxman Prasad	Convenor

The committee recommended the following:

i) The committee expressed its satisfaction over the achievements in the 10th plan.

ii) The committee advised that specific activities/products/processes may be identified by each group for which technology is proposed to be developed based on the felt needs.

iii) The committee felt that conscious efforts should be made to ensure that the technologies developed are put to use. This would require consideration of demand potential in addition to the felt need. Attempt should be made to associate industry in the development process. Technology interventions may also be planned for industry clusters.

iv) Conscious effort should be made to avoid duplication of efforts in the identified niche areas vis-à-vis activities being undertaken elsewhere.

v) Focused attention should also be given for development of systems required for health care. A workshop/brain storming session may be organized for the purpose.

vi) Based on achievements of 10th Plan as well as the projected activities, the committee recommended the continuation of the programme in the 11th plan with a total outlay of Rs. 75 crores.

vii) The group recommended creation of autonomous authority under GLP programme.

viii) Under the NRDMS activities, it was felt to develop mechanism to involve various states to make the programme more effective.

ix) The group advised DST to work out mechanism for periodic upgradation of facilities to ensure parity with global standards.

x) In the state Science & Technology programmes it was felt that sizable demonstration was required to make an impact of Science & Technology intervention of the lives of the people.

3. Socio-economic Development Schemes; Technology Management Project (SKILLS Project of UNDP); and Information Technology

Expert Committee:-

Prof. SK Joshi - Chairman
Dr Dinesh Awasthi, Director EDII, Ahmedabad
Dr Madhu Pant, Director, Bal Bhavan, New Delhi
Dr Anil P Joshi, HESCO, Dehradun
Mr HK Mittal - Convener

1. S&T Programmes for socio-economic development need to be continued from 10th Five Year Plan to 11th Five Year Plan.

2. New programmes are necessary because of changes that have taken place in the economy during the past few years.

3. Instead of spreading too thin, the socio-economic development programmes are required to be implemented in focused manner.

4. Importance must be given to sectors which are crucial not only for 11th Five Year Plan but beyond 11th Plan. Societal programmes must take up large scale technology demonstration programmers in the sectors like water and energy.

5. Service sector is suffering for want of appropriately skilled people. New educational technologies and training systems may be evolved to suit the needs of service economy. Experience gained through the SKILLS project may be useful to expand this activity.

6. There is a need to expand the scale of socio-economic development programmes to reach the benefits of high technology to all, whether living in urban or rural areas.

7. An appropriate mechanism e.g. a Foundation, may be established to increase the reach of technology to villages.

8. To build scientific temper among the masses, large scale programmes on science and technology communication needs to be taken up.

9. Innovation and entrepreneurship related programmes are required to be expanded to a critical level to encourage knowledge based and technology driven enterprises.

10. Use of ICT at all levels in the Department is required to be enhanced for effective delivery and monitoring of various schemes.

11. In order to expand the programmes, besides enhanced allocation, new delivery mechanisms and innovative approaches need to be adopted.

12. To handle the expansion of the schemes additional manpower must be provided for effective utilization of the resources.

4. International S&T Cooperation

Expert Committee:

Dr Kota Harinarayan, NAL, Bangalore -Chairman
Dr S G Dhande, Director, IIT, Kanpur
Dr W Selvamurthy
Dr SK Brahmachari, Director, IGIB, Delhi
Shri YP Kumar - Convener

The Expert Committee constituted by the Department to evaluate the achievements made under the program during 10th Five Year Plan and to formulate 11th Five Year Plan Component for the activity met under the Chairmanship of Dr. Kota Harinarayana on 4 occasions. It also collected feedback from Chairmen and members of various PACs on the program as well as collected inputs from aided and other autonomous institutions under the Department. The Expert Committee recommended the following approach for the 11th Five Year Plan.

1. A good degree of success has been achieved under the International S&T Cooperation Programmes during 10th Five Year Plan through sharing of knowledge and information, providing access to sophisticated facilities to Indian scientists and engineers, sharing of resources, developing joint R&D projects in areas of basic and applied science and technology, providing opportunity for training and fellowships, development of joint R&D centers etc.

2. Efforts have also been made in last two years of the 10th Plan to focus attention on applied and pre-commercial R&D and organization of technology summits etc.

3. More dynamism is required to be inducted in the programmes during 11th Plan. This could be achieved through change in mind set, attitude and approach, by attracting foreign researchers to India, increase in out reach of activities etc. so that India could assume leadership role and position itself as a developed nation.

4. Strategic partnerships with select countries (~15) are recommended for technology led cooperation. Cooperation with other countries could be based on geo-political and other advantages for the country.

5. Dual approach is recommended for 11th Five Year Plan. About 40% of the funding may be devoted to bottom-up approach benefiting individual scientists/groups. 60% of the funding, however, should be directed on top down approach for mega projects both in

areas of basic sciences as well as in socially relevant areas such as transportation, energy, water, environment, disaster mitigation/preparedness, health etc.

6. Support to applied and industry oriented R&D activities with adequate involvement of industry is strongly recommended.

7. A Budgetary support of Rs. 1500 crore is recommended for 11th Five Year Plan. It should be supplemented with enhanced and appropriate manpower support. Decentralization of decision making must be resorted to.

8. Establishment of 50 Joint R&D Centers and other R&D Centers of Excellence including in engineering design and engineering product development areas is recommended for providing technological support to industrial enterprises in important sectors of economy.

9. The number of post doctoral fellowships from India should be increased substantially to attract bright and young minds from different parts of the world to work in Indian institutions. Thus, it is proposed to institute 500 fellowships for Indian scientists and 100 fellowships for foreign researchers per year.

10. The role of science counselors should be redefined and at least 15 science counselors be posted abroad one in each strategic partner country.

11. Similar to Lindau meet in Germany, an interactive meet of bright Indian students with icons of Indian science and Nobel Laureates from different parts of the world should be organized every year for motivating and encouraging young children to opt science as career. Selected young students from partner countries may also be invited to participate in the event.

12. To sensitize academic, R&D and industry people about the possibilities, potential and opportunities offered by international S&T Cooperation and collaborations, it is recommended that every year an annual meet may be organized. The aim is to expose Indian Academia/R&D/Industry to the opportunities available through international cooperation.

Indo- French Centre for Promotion of Advanced Research: The Activities of the Indo-French Centre for Promotion of Advanced Research has been strengthened during 10th Plan. Major output of the cooperation have been a) 69 joint Projects involving 160 exchange visits , 100 research papers and b) 6 workshops (Statistical Physics, NMR Application, Materials, Infrared Lasers, Pharmacogenetics, Prevention of Biomedical Risks). The activities of the centre are further proposed to be strengthened during 11th Five Year Plan.

Indo-US S&T Forum: The Indo-US S&T Forum conducted large number of programmes during 10th Five Year Plan which included a) 18 joint workshops/Symposia, and round tables held both in India and USA and b) 8 other events like Frontiers of Science, Frontiers of Engineers, Public Private Partnerships in R&D , catalyzing establishment of joint centres, fellowships, exploratory visits etc.

5. Science Based Services (SOI, NATMO) Seismology Mission

Expert Committee:

Dr Harsh K Gupta, Ex-Secretary, DOD -Chairman
Dr BL Deekshatulu, University of Hyderabad

Dr SM Kulshreshta, Ex-DG, IMD
Dr UC Mohanty, IIT Delhi
Mr AJ Kurian - Convener

Survey of India

1. Creation of Digital Topographic Database on 1:10,000 scales for the entire country and 1:2,000 scale for urban areas. Once this is achieved, planned development will become systematic. This is a very mammoth task and will require substantial investment in manpower, equipment and technology. The approximate projection for this activity will be about Rs.3,000 crore, spread over 7 years. This includes Rs.415 Crores for aerial photography for the entire landmass of the country (20,40,000 sq. km of unrestricted area @ Rs.1,000/- per sq. km. on 1:15K scale, and 2,00,000 sq. Km. of urban area on 1:8K scale @ Rs.2100/- per sq. km.), Rs.1.27 Crores for Block Adjustment, Rs.401.56 Crores for Feature Extraction, Rs.1878.85 Crores for Field Verification, Rs.79.56 Crores for Database updation, and Rs.68.46 Crores for GCP Library.
2. Capacity Building for NSDI: SOI shall play a pivotal role in building and maintaining NSDI. This is an entirely new activity with the Union government approving NSDI in June, 2006. The investment required is to the tune of Rs.43 crore spread over the entire Plan Period.
3. Geodetic Research: Geodesy, gravity, magnetic measurements, crystal movement studies form the basis of topographical mapping. Modern research inputs are required to be kept towards this work. The inputs proposed include Very Long Baseline Interferometery, National Museum, and Geodetic Research Centre and will require an investment of Rs.45 crore spread over 5 years.
4. Airship is an extremely new initiative. In essence, it is an unmanned airship, which is quasigeostationary to act in multidisciplinary functions in real time telecommunication relay, weather observer, surveillance platform etc.

NATIONAL ATLAS & THEMATIC MAPPING ORGANISATION

The major approach of the Organisation for the XIth Plan is to shift from producing printed maps and atlases to provide map-related services to the country with modern technology. NATMO has to shift from analogue mode to digital mode. Convergence of technologies is an important component for the XIth Plan.

The other objective of the plan is to take up new challenges during its Golden Jubilee and to consider the market requirement and also to provide services to the people. Accordingly, the Golden Map Service was initiated for its implementation in the XIth Plan. It is likely to boost to NATMO for absorbing the digital technique and communication technology in the field of thematic map making. On the other hand, the flagship activity of the organisation, i.e. the preparation of the National Atlas of India, is also proposed to be web-based. Hence, the 3rd Edition of the National Atlas of India will be web-enabled and will take up issues of current national interest. The other focus of the XI plan will be for the preparation of large-scale thematic maps. With the availability of detailed data and the technology to handle the same, it is possible to undertake detailed thematic maps on larger scale.

On the whole, the focus of the XIth Plan for the organisation will be based on convergence of technologies, detailed thematic maps and web-enabled services. This will definitely lead to prepare maps and atlases or the digital data on priority issues and to provide access to such information to common people through communication and web technologies.

Considering the above approach, following projects (with estimated cost) have been proposed here:

		Estimated Cost (Rs. In Crores)
(1)	Golden Map Service	Rs. 22.76
(2)	Development of Digital Cartographic base for Large-scale Thematic Mapping	Rs. 20.71
(3)	Web-based National Atlas of India	Rs. 03.82
(4)	Mapping for Low-vision Persons	Rs. 05.42
(5)	Development of Infrastructure	Rs. 33.00
Total Cost		Rs. 85.71

Regarding the cost of the remote sensing data, which is a major cost of the first two projects, it is proposed that NATMO should join hands with Survey of India and work out a business model where SOI will provide geo-referenced satellite data for generating products and services. This will reduce the cost of the proposed projects substantially and generate revenues for NATMO and SOI. On the account of remote sensing data only, there will be a reduction up to Rs. 5 crore. Further, there will a common datum and data base between the two major cartographic organisations in the country. This will also synergise the working of the two organisations.

Executive Summary

This report provides a quantitative and qualitative analysis of the progress of Indian S&T, as reflected in its publications output reported in mainstream national and international journals. The main objective of the present report is to examine the status of S&T in the country, its strong and weaker areas of research, quantity & quality of research output, and dynamics of research across institutions, sectors, geographical regions and subjects. Such a study may prove useful for Indian science planners & policy-makers for gaining macro insights into the country's S&T system.

This study is based on India's S&T papers indexed in *Science Citation Index - Expanded Edition (SCIE)* of *Web of Science* database. Besides, it has also looked at the India's contributions reported in other international multidisciplinary databases, such as *SCI, SCOPUS,* and *PASCAL*, in addition to international subject databases, such as *Chemical Abstracts, INSPEC, COMPENDEX, PubMed,* and *CAB Abstracts.* The 11 years (1993 to 2003) cumulative publications and citations output data of different countries covered in the *Essential Science Indicators* of Thomson-ISI database were also used for international comparison.

While examining the status and progress of Indian S&T, this study also identifies the factors underlying its growth, stagnation and decline. It also examines India's position vis-à-vis select developed and developing nations, in terms of its research output, citation visibility, economic status, strength in education & training, and financial & manpower resources devoted to S&T.

The report describes the broad features of India's S&T, in terms of size & growth of its publications output, type of institutions participating in S&T research, their pattern of research output, concentration & scattering of institutional productivity, performance across institutions, sectors, geographical regions and subjects, type of collaboration, and measurement of publications quality in terms of average impact factor and citations per paper. It also profiles four different S&T sectors — the Universities & Colleges, mission-oriented R&D, Institutes of National Importance, and Industry — respectively in terms of publications size & growth characteristics, the role of their constituents, contributions across subjects, quality of research efforts, pattern of collaboration in research, and quantitative & qualitative assessment of research in major participating institutions.

The major findings of the study are as follows:

Science and technology (S&T) in the country is on the rise and heading towards faster publications growth

As reflected in the publications indexed in international multidisciplinary subject databases, India's publications growth rate has been relatively much faster in the recent years. As compared to 2.51% annually during 1985-2005, it more than doubled (5.4%) annually in 10 years (1995-2005), and quadrupled (10.1%) in the recent five years (2000-2005). India's publications indexed in *Web of Science* have grown from 14405 papers in 1990 to 28603 papers in 2005. Its annual output is estimated to touch 38,000 papers by 2010, as per forecast made based on last 15 years data. India's subject-wise publications growth rate (as reflected in international subject databases) has been higher than its overall publications growth in multidisciplinary databases. In engineering sciences (*COMPENDEX*), its annual publications growth was 15.8% during 1993-2003, but in last five years (1999-2003) it was still faster, 17.3%. In medical sciences (*PubMed*), it was 13.2% annually during 1995-2004, and in the last five years (2000-2004) it was 15.7%.

India along with China leads the developing countries in S&T research output in majority of the subject fields

India tops in publications productivity among developing countries in four subject fields, based on its cumulative publications output during 1993-2003 (*Web of Science* data). Its rank in world's publications output and percentage-wise contribution in each subject is as follows: Agriculture (4^{th}, 5.63%), Plant & Animal Sciences (8^{th}, 3.13%), Energy & Environmental Sciences (11^{th}, 1.97%) and Biology & Biochemistry (14^{th}, 1.51%). It ranked 2^{nd} in publications productivity amongst developing countries, following China in Materials Science (8^{th}, 3.56%), Chemistry (8^{th}, 3.62%), Physics (9^{th}, 2.26%), Geosciences (11^{th}, 2.31%), Pharmacology & Toxicology (13^{th}, 1.89%), Space Sciences (13^{th}, 1.55%), Mathematics (8^{th} and 3.56%), Molecular Biology & Genetics (19^{th} and 0.76%), and Immunology (20^{th} and 0.7%). It ranked 3^{rd} in Engineering (11^{th} and 2.39%) and Microbiology (17^{th} and 1.42%).

India's financial and human resources in S&T are far less compared to China's

India's annual increase in manpower and financial resources for R&D is not commensurate with the size and growth of its R&D infrastructure. As a result, its publications productivity lags behind other competing developing countries, such as China. In terms of relative citations impact, both India and China lag behind other developing countries, such as South Korea, Taiwan, Singapore, South Africa, Brazil, Mexico, Argentina and Chile.

Research in S&T in India is an institutional activity

Institutions participating in S&T research in the country have been categorized into five sectors: Institutes of National Importance (INI), Universities & Colleges, Mission-oriented R&D, Industry and Others.

India has a strong institutional base for S&T research, but majority of institutions are low and medium productive

India has invested heavily in terms of financial resources devoted to R&D, creation of infrastructure, institutional capacity and instrument & laboratory facilities over the years. The institutional participation in research has widened and has almost doubled from 1734 institutions in 1985-86 to 3443 in 2001-02. However, of the 3443 institutions (in 2001-02), only a small number (310) contributed the major (80%) share to the country's publications output. Also, there were only 24 institutions, which published 300 or more papers during 1985-86 or 1993-94 or 2001-02. It clearly reveals that a large section of S&T institutions in the country have not contributed enough papers.

Universities & Colleges sector leads others in publications productivity in S&T

The Universities & Colleges sector contributed the largest share (52.2%) to the country publications output in 1985-86, followed by mission-oriented R&D (28.3%), Institutes of National Importance (17.2%), and Industry (1.78%) sectors. Similar pattern of publications prevailed during all the three periods of study. The mission-oriented R&D sector witnessed the maximum increase (9.56%) in its national publications share during 1985-86 to 2001-02, followed by Institutes of National Importance, whereas Universities & Colleges sector witnessed decline by 5.56% in their national publication share during the corresponding period.

Mission-oriented R&D sector has shown the fastest publications growth in S&T research

This sector registered maximum growth rate (102.9%) in publications output, followed by Institutes of National Importance (79.8%), Industry (71.5%) and Universities & Colleges (35.6%) sectors in sixteen years during 1985-86 to 2001-02.

Industry sector has shown maximum growth in institutional participation

The industry sector witnessed the maximum growth (178.3%) in institutional participation during 1985-86 to 2001-02. Universities & Colleges (89.57%), mission-oriented R&D (49.52%), and Institutes of National Importance (8.33%) sectors, however, registered growth rate below the country's average growth rate of 98.56% in institutional participation.

India's publications in medium and high quality journals in science and technology have increased over the years

India's publications in quality journals have improved with time, although the major share (76% to 80%) of its publications continued to appear in zero and low impact journals during 1985-86 to 2001-02. In medium and high impact journals, its publications share has increased from 8.13% to 15% and 0.96% to 5.12%, respectively during the corresponding period, resulting in increase in its average impact per paper from 0.748 to 1.229 during 1985-86 to 2001-02. The rise in country's share in medium and high impact journals has been seen across all S&T sectors, the largest being in mission-oriented R&D sector, followed by Institutes of National Importance, Universities & Colleges, and Industry sectors.

Average citations received per paper have improved though marginally with time

India's publications quality as reflected in average citations received per paper (within 10-19 years of their publication) has improved marginally (from 4.92 to 5.25) during 1985-86 to 1993-94. The rise in citations performance is small, because bulk share (67.7-77.7%) of the country output received zero or low citations (1–4 citations per paper). India's share of medium and high-cited papers has increased from 24.14% to 26.8% and 4.8% to 5.4%, respectively during 1985-86 to 1993-94. The rise in country's share of medium and high cited papers has been seen across all S&T sectors though in different proportions, the largest being in mission-oriented R&D sector, followed by Institutes of National Importance, Universities & Colleges, and Industry sectors.

High productivity areas of Indian S&T research

Chemistry, Physics, and Engineering are the high productivity areas of S&T research in the country and have shown consistent rise in their publications share in country output during the three select periods (1985-86, 1993-94 and 2001-02).

Low and medium productivity areas of Indian S&T

Agriculture, Biology, Basic Life Sciences, Clinical Medicine, Biomedical Sciences and Earth & Environmental Sciences have been the medium productivity areas, whereas Mathematics and Computer Science have been the low productivity areas of Indian S&T.

Fast growing subject areas of Indian S&T

Compared to other broad subjects, India registered significantly high publication growth in Clinical Medicine (141.6%), Basic Life Sciences (81.6%) and Biomedical Sciences (76.4%), which was above the country average growth rate (51.7%) in sixteen years during 1985-86 to 2001-02.

Subject profile of Universities & Colleges sector

Under the Universities & Colleges sector, Chemistry, Physics, Engineering, and Clinical Medicine have shown high publications productivity, though in Engineering and Clinical Medicine, publications activity was less than the country's average. Although in Agricultural Sciences and Biology, it has shown decline in publications output, which may be due to the low coverage of their journals in *Web of Science* database, but their activity index was still above the country average. It means that these two subject areas are still actively pursued in the Universities & Colleges sector.

Subject profile of others S&T sectors

Compared to other sectors, the R&D sector has performed better in Physics, Basic Life Sciences, and Earth & Environmental Sciences. The Institutes of National Importance sector has performed comparatively better in Engineering, Physics, Chemistry and Clinical Medicine. Amongst these subjects, Physics & Clinical Medicine have shown rising publications output and Engineering & Chemistry declining publications output during 1985-86 and 2001-02. In the Industry sector, Engineering and Chemistry are more actively pursued for research.

India's has shown significant increase in its publications output in frontier and new emerging areas of S&T

The country has witnessed substantial rise (almost 3-fold) in its publications output in frontier and emerging areas, such as biotechnology, drugs & pharmaceuticals, material sciences, and medical sciences during 1985-86 to 2001-02. The publications output increased from 199 to 723 papers in biotechnology & applied microbiology, from 337 to 923 papers in pharmacy & pharmacology and from 128 to 361 papers in medicinal chemistry during 1985-86 to 2001-02. The materials science, which has several important applications to the industry also witnessed more than three-fold increase in publications output (from 715 to 2305 papers) during the corresponding period.

Substantial increase was also reported in chemical engineering (from 249 to 760 papers), telecommunications (from 47 to 211 papers), and artificial intelligence (from 16 to 80 papers).

In medical sciences, significant increase in publications output was witnessed in areas such as infectious diseases (from 43 to 183 papers), oncology (from 125 to 361 papers), ophthalmology (from 26 to 236 papers), urology & nephrology (from 30 to 186 papers), radiology & nuclear medicine (from 94 to 239 papers), surgery (from 151 to 590 papers), and hematology (from 33 to 105 papers) during 1985-86 to 2001-02.

In areas constituting earth & environmental sciences, increase in publications activity was reported in water resources (from 116 to 607 papers) and environmental engineering (from 25 to 139 papers) during 1985-86 to 2001-02.

India's collaborative research output has grown faster than its growth in total papers.

The country has shown significant rise in its collaborative publications (from 1700 to 14104 papers) with a growth rate of 729% during 1985-86 and 2001-02, which was significantly higher than the country's publications growth rate (51.8%). The collaborative share of papers in the total output of the country has increased nearly six fold, from 7% to 40% during 1985-86 and 2001-02. The share of national collaborative papers was relatively higher than the internationally collaborative papers. The national collaborative papers showed 714.15% growth (from 996 to 8109 papers), and international collaborative papers 751.27% growth (from 704 to 5993 papers), during 1985-86 to 2001-02. The share of national & international collaborative papers in country research output increased from 4.30% to 23.07% and 3.04% to 17.05%, respectively during 1985-86 to 2001-02. The number of countries having collaboration with India in S&T has also grown from 70 in 1985-86 to 113 countries in 2001-02, as reflected in its collaborative (co-authored) publications output.

Physics has been the most preferred subject area for collaborative research.

Among the broad subjects, the maximum collaborative activity, in terms of number of co-authored papers and its national share, was witnessed in physics (1922 papers, 28.28% share), followed by chemistry (1176 papers, 13.62% share), engineering (1115 papers, 15.85% share), basic life sciences (709 papers, 19.10% share), clinical medicine (550 papers, 13.30% share), earth & environmental sciences (409 papers, 18.0 share), and biomedical sciences (391 papers, 13.07% share) during 2001-02. The largest increase in the share of collaborative papers during 1985-86 to 2001-02 was witnessed in physics (from 4.16% to 28.28%), followed by basic life sciences (from 4.85% to 19.10%), earth & environmental sciences (2.87% to 18.0%), engineering (from 1.79% to 15.85%), chemistry (from 3.08% to 13.62%), and clinical medicine (from 4.27% to 13.20%).

United States continues to be the India's biggest collaborating partner, but publications share in collaborative research output has gradually declined

India's collaborative research output with Europe and Asia has significantly increased during 1985-86 to 2001-02. USA continues to be the India' s largest collaborating partner, followed by Germany, UK, Japan, France, Canada, Italy, Australia, etc. Amongst developing countries, India's leading collaborating partners are Taiwan, China, South Korea, Brazil, Singapore, Malaysia, etc. India's collaborative publications share has declined during 1985-86 to 2001-02 with USA, Canada, UK, Russia, and Italy and has increased with Germany, France, Netherlands, Switzerland, Spain, Sweden, Belgium, Denmark, Poland, Hungary, Norway, and Finland. Among Asian countries, collaboration share has also increased with Japan, Taiwan, China and South Korea.

Mission-oriented R&D sector leads in collaborative research activity in the country.

Comparing various S&T sectors in terms of growth in collaborative papers during 1985-86 to 2001-02, the largest publications growth (1017%) was registered by mission- oriented R&D sector, followed by Universities & Colleges (726%), Institutes of National Importance (620%), and Industry (609%) sectors. In terms of rise in share of collaborative papers during 1985-86 to 2001-02, the largest rise (from 14.8% to 61.6%) was registered during 1985-86 to 2001-02 by Industry sector, followed by mission-oriented R&D (from 8.5% to 46.8%), Universities & Colleges (from 7.4% to 45.1%), and Institutes of National Importance (from 7.3% to 40.1%) sectors. The maximum rise in the national share of collaborative papers was registered by Industry sector (from 57% to 75%), followed by Universities & Colleges (from 65% to 68%) sector. In contrast, the share of international collaborative papers by the country increased from 34% to 39% in mission-oriented R&D sector and from 39% to 43% in Institutes of National Importance sector during the corresponding period.

The country needs a balanced approach in regional distribution of its resources

Maharashtra, Delhi, Karnataka, Uttar Pradesh, Tamil Nadu, West Bengal and Andhra Pradesh are the leading states in publications productivity, accounting together for three - fourth of the publications output in S&T during 1985-86 to 2001-02. Kerala, Gujarat, Madhya Pradesh, Chandigarh, and Rajasthan (each with 2-3% publications share) together contributed only 15% share in country publications output during the corresponding period. Other states, such as Orissa, Haryana, Punjab, Bihar, Assam, Pondicherry, Himachal Pradesh, Goa, and J&K are considered as low productivity states and together contributed only 10.5% publications share in 2001-02. Except Assam, most of the low productivity states have witnessed decreasing publications share in their national research output during 1985-86 to 2001-02.

Regional disparities in publications productivity could be addressed through a more balanced distribution of financial and manpower resources approach.

India's research output has spread-out in too many international peer-reviewed journals

The number of peer-reviewed international journals reporting India's research output have increased consistently from 2113 journals in 1985-86, to 2558 in 1993-94, and to 3359 in 2001-02.

Implications & Recommendations

Catalyzing Research Capacity & Potential

India has the potential to deliver and sustain even much higher publications growth in S&T. However, there is a need to draw up a strategic plan for catalyzing S&T research, so that in the coming years, it catches up with other leading countries in the world. The key factors for catalyzing growth in S&T research are greater institutional participation, as well as national and international collaboration, encouraging creative scientific teams for innovation, and making available sophisticated laboratory and instrument facilities more widely with increased investment in R&D, increased deployment of qualified S&T manpower, greater interaction amongst S&T sectors, increased scientific cooperation with developed and developing countries, and stricter evaluation and monitoring system in promotions and in awarding degrees, research grants, and research projects. There is also a need to initiate new programs to attract bright talent at young age into science stream of education, and support in-service training of staff in creative and innovative ideas and in new and frontier fields.

Specific recommendations for catalyzing India's research capacity and potential are:

- The Universities & Colleges sector institutions should be strengthened and their infrastructure modernized
- Special grants should be made available for new disciplines and new universities to develop infrastructure and set up laboratory facilities.
- Strengthen low and medium productivity institutions.
- Direct the country R&D under clear-cut national plans and policy.
- Offer special packages to low and medium productivity states.
- Develop new institutes and strengthen existing ones, especially in the low and medium productivity states, on the models of INI or inter-university centres.
- Upgrade science laboratories, improve internet connectivity, improve information access, course contents and quality of teaching, with a view to improve the quality and quantity of research in Universities & Colleges.

- Provision of support to selected research centers, particularly in institutions, such as Universities & Colleges on long-term basis in selected areas to make them competitive.
- Improve research environment in R&D institutions by introducing better award system, encouragement of creative work, goal-oriented research, flexile organizational system and introducing sharing of benefits under consultancy on completion of national-funded research projects.
- Introduce reforms and improve work environment by enforcing transparency, uniformity of rules and consistency in their applications at all levels of career advancement in S&T.
- Increase accessibility to electronic resources in all types of institutions engaged in S&T.
- Provide better job opportunities for scientists in order to discourage the brain drain and to encourage scientists working abroad to return to India.

Gaining Competitive Edge in S&T

There is a strong need to strengthen the monitoring & evaluation system, particularly in the University & Colleges to ensure that the publications output from funded projects is reported mainly in medium and high impact journals. Strict evaluation measures need to be evolved for ensuring good quality output from Ph.D. research and from the projects funded through extra-mural research schemes of R&D agencies/departments. Provision of increased budget at the institutional level for hiring doctoral and post-doctoral students for 3 to 5 years may also help in increasing the research output of the institutions of this sector.

Specific recommendations in gaining competitive edge in S&T are:

- Strengthen monitoring & evaluation system.
- Encourage scientists to publish in select medium & high impact journals
- Review and strengthen current arrangements for international collaboration in S&T with developed and developing countries.
- Encourage institutes to set up open access archives to make their research work more widely accessible
- Introduce professional review of proposals submitted under extra-mural funding schemes of R&D agencies/departments

Achieving Leadership in Cutting Edge Areas of S&T

There is a need to strengthen high productivity institutions specializing in thrust areas and in high priority areas of national importance, such as biotechnology, electronics & communications, drugs & pharmaceuticals, computer science, materials science, nano-science & technology, alternate energy sources, etc. This is desirable to make them internationally competitive. Further, the existing low and medium productive research institutions also need to be strengthened in subject areas, such as agricultural sciences, biology, basic life sciences, clinical medicine, biomedical sciences and earth & environment sciences and mathematics. For this, there is a need to evolve new and effective national strategies for capacity building and improving research productivity. Given the special role played by agricultural sector in strengthening the GDP of the country and the consistent decline in agricultural science research publications, it is desirable that agricultural research be accorded higher priority.

Specific recommendations in this regard are:

- India needs to evolve time-bound programs, which capitalize on its existing strength as well as establish new institutions of excellence in cutting edge technologies for education, training, and research on the models of INI or inter-university centres.
- Pay focused attention on medium or low productivity areas of research, such as biomedical science, chemistry, clinical medicine, computer science, engineering, and mathematics, in order to improve research performance of the country in these areas.
- Integrate low and medium productivity institutions with high productivity institutions.
- Make quantum jump in the student's fellowship for doctoral and post-doctoral work in areas of national importance.
- Publishing in medium and high impact journals should be made mandatory for Ph.D. awards.
- Enhance opportunities for exchange of information and inter-personal contacts to develop joint international collaborative research projects
- Encourage younger and bright talent to go for post-doctoral research in advance countries by providing them financial support.
- Reward creative people at younger age by introducing more number of awards for younger scientists.

Bring Industry Participation in Research to the Center Stage

There is a strong need to encourage industry participation in research in different fields of S&T by involving enterprises in the national network and sectoral programs of the country. Research institutions and universities should be encouraged to undertake programs, which meet the needs of Indian industry, with the active participation from them.

Encourage inter-sectoral and intra-sectoral collaboration at national and international level

Encourage mobility and collaboration among various sectors through extra-mural funding schemes of the R&D agencies/departments at the national level. Structural linkages between research institutes and universities need to be further developed either by offering undergraduates teaching programs in existing campuses of the former or promoting interaction, wherein universities are able to access the laboratory facilities of research institutes and the faculty of research institutes could engage in teaching work at the university and also becomes joint or sole research supervisors for Ph.D work. We may also need to start locating research institutes on university campuses for better synergy. For enhancing international cooperation and collaboration, new models should be encouraged and the existing models, such as the one those with USA, France, Russia etc. be improved.

Monitoring India's S&T Output for Future S&T Policy Formulation

- Bring out a biennial S&T indicators report on India, based on publications output to monitor the status and progress in S&T.
- There is a need to develop a comprehensive database on Indian S&T publications output, balanced in the coverage of both local and international journals on long- term basis. Such a database could be useful in the national policy & planning process as well as to R&D funding agencies for judicious allocation of R&D funds to researchers and institutions and monitoring the impact of such allocation on the progress of S&T.
- Establish a laboratory to study, evaluate and monitor the status and progress of S&T in the country.

3

India & World S&T Scenario

3.1 Overview of Economic Regime

India and China are considered as the fastest growing economies of the world. India is already the 4th largest economy in the world after China and together they account for 18% of world GDP on a PPP basis in 2003, compared to 10% in 1990. They also account for 32% of global GDP growth in 2003, compared to 13% in 1990. India and China's share in the world GDP has increased from 4.3% and 5.7% in 1990 to 5.7% and 12.6%, respectively in 2003. However, India's economy has still not grown as large as China's. Since 1990, India's growth rate of GDP has been 7.3% compared to 20.1% of China. This is more because in terms of population growth, India is ahead of China. Its share in world population has increased from 15.5% in 1980 to 17.4% in 2003, in contrast to China's declining share from 22.1% to 19.6% during the corresponding period[1-2].

In Indian economy, the share of its services sector in the GDP has increased from 45.8% in 1997-78 to 50.8% in 2002-03. But its share in the GDP on account of both agriculture and manufacturing sectors declined from 26.5% and 17.7% in 1997-98 to 22% and 17.2%, respectively in 2002-03. On the other hand, the share of agriculture sector in Brazil and China remained limited to 6% and 15% of their GDP respectively in 2002. Thus, Indian economy comparatively is more agriculture-oriented and its manufacturing sector plays less prominent role; its share to GDP was only 17% in 2003 compared to more than 43% of GDP in China[1-2].

India is relatively a closed economy, as seen from its low ranking in the world on tariff and non-tariff barriers. Its trade as percentage of GDP in recent period was not high (31%), compared to China (55%), though was almost similar to Brazil (29%). Export of goods & services constituted 15% of GDP, compared to 15.5% of Brazil and 33% of China. India's share in global FDI also remains poor, less than 1% compared to China's share of 12%. China received a cumulative FDI inflow of US $480 billion since 1990, compared to US $33.1 billion in India[1-2].

India, not withstanding its rapid population growth has been able to improve its performance on Human Development Index (HDI) from 0.297 in 1990 to 0.595 in 2002, and ranked 127th position in world. In comparison, China had HDI index of 0.745 and ranked 94th, Brazil had HDI Index of 0.775 and ranked 72nd and South Africa had HDI Index of 0.666 and ranked 119th in 2002[3].

In 21st century, the challenge before the country is how to make use of knowledge more effectively to raise the productivity of agriculture, industry and services sectors in the country. The application of knowledge in areas, such as education & training skills, entrepreneurship and innovation, and R&D is one of the key elements of growth and competition in the global economy. India must evolve systems and procedures to facilitate such knowledge applications. Although knowledge has always been at the core of any country's developmental process, its rapid pace of generation and dissemination is the need of the hour. Hence knowledge management should form an important component in developmental strategy of the nation[1].

3.2 Education and Training Profile

India's population continues to grow at a faster pace, leading to greater stock of younger people. To convert them into a useful resource, the country needs to provide them not only primary education, but also vocational, secondary and tertiary education. India has improved its adult and youth literacy rates from 49.3% to 61% and 64.3% to 76.4%, respectively from 1990 to 2003. China too has substantially improved its adult and youth literacy rates from 78.3% to 90.9% and 95.3% to 98.99%, respectively during the corresponding period. India's average educational attainment level has been 5.06 years, compared to 4.66 years in Brazil and 6.35 years in China in 2000. In addition, China has already achieved higher share of its population (66.6%) with schooling than India (34%) in 1980, which increased to 82% and 56.1% in 2001[1,3].

In China, the share of its population with complete primary education rose from 4.7% in 1980 to 11.8% in 2000, and for India it rose from 11.8% to 12.8% during the corresponding period. In China, the share of its population with complete secondary education increased from 9.9% in 1980 to 14.8% in 2000, compared to India's increase from 5.4% to 6.5% during the same period. In comparison, Brazil has more than doubled its secondary enrollment during the same period.

However, India has made noteworthy strides in increasing its tertiary enrollment ratio until 1999[1] and had been leading compared to China in terms of gross enrollment ratio (GER) for tertiary education. In 2002-03, China surpassed India (tertiary GER of India 11.9% compared to 15.8% of China). But in spite of it, China had been no match to South Korea, Argentina, Chile and Brazil, which had impressive tertiary GER of 85.4%, 59.8% 45.4%, and 20.6%, respectively in 2002-03[1-2].

In 2000-01, developing countries accounted for 62% of the overall global tertiary enrollments and 52% in technical subjects (pure sciences, engineering, mathematics and computer sciences). During the same year, the highest number of tertiary students (13595.6 thousands) enrolled was in USA, followed by China (12143.7 thousands), India (9834 thousands), Russia Federation (12143.7 thousands), Japan (7224 thousands), Indonesia (3017.9 thousands), Korea (3003.5 thousands), Brazil (2781.3 thousands), Egypt (2447.1 thousands), etc. In terms of tertiary enrollment in technical subjects, China lead the world during 2000-01 with 2580 thousands enrollment, followed by Russia Federation (2388 thousands), India (1913 thousands), USA (1718.5 thousands), Korea (1000.4 thousands), Japan (817.1 thousands), Ukraine (643.8 thousands), etc. They were followed by Indonesia, Mexico and Brazil among developing countries. In terms of share of technical enrollment among total enrollments, the leading countries were Taiwan (36.58%), Korea (33.44%), Russia Federation (33.05%), Mexico (28.16%), Chile (28.08%), China (21.24%) and India (19.45%) during 2000-01[4].

In India, the student enrollment in higher education increased from 68.42 lakhs in 1996-97 to 99.53 lakhs in 2003-04. The corresponding increase in enrollment in science & engineering (S&E) was from 19.63 lakhs to 31.39 lakhs. The share of S&E enrollment in total enrollment also increased from 28.70% in 1996-97 to 31.53% in 2003-04. The science faculty increased its enrollment from 1,293,251 in 1996-97 to 1,834,493 during 2003-04, while the corresponding increase in engineering & technology faculty was from 416,029 to 692,087 (Table 3.1.). These figures, however, slightly differs from the data given in international sources.

Table 3.1: Enrollment in Higher Education in India, 1996-97 to 2002-03

Type of Faculty	Enrollment in Higher Education		
	1996-97	1999-2000	2002-03
Science	1293251	1582559	1834493
Engineering & Technology	416029	500088	692087
Medicine	199119	233477	300669
Agriculture	42424	46233	55367
Veterinary Science	13002	13870	14765
S&E Enrollment	19.63 lakhs	24.30 lakhs	31.39 lakhs
Total Enrollment	**68.42 Lakh**	**77.05 Lakh**	**92.27 Lakh**

Source. UGC. *University Development in India: Basic Facts & Figures, 1995-96 to 2001-01; Annual Report of UGC*

In terms of doctoral degrees earned by students in their own countries during 2000-01, the largest share was from USA, followed by Germany, Russia Republic, UK, China, India, Japan, France, Spain, South Korea, Brazil, etc. (Table 3.2). In terms percentage share of S&E doctoral degrees, the largest share was from France, followed by China, USA , Brazil, etc (Table 3.2–3.3). The growth in the doctoral degrees[4] awarded in S&T in select developed and developing countries is shown in Table 3.4

Table 3.2: Doctoral Degrees Earned in S&E in Selected Countries							
Country	All degrees	S&E degrees	% of S&E degrees	Country	All degrees	All S&E degrees	% of S&E degrees
USA (01)	40744	25,509	62.60	Spain (00)	6007	27303	45.45
Germany (01)	24796	11803	47.60	Korea (00)	6143	2865	46.64
Russia (00)	18274	10409	56.96	Brazil (99)	3604	2176	60.38
UK (01)	14210	8520	59.95	Canada (00)	3978	2249	56.53
China (01)	13,001	8153	62.71	Australia (00)	3687	2030	55.06
India (01)	11544	5393	46.72	Iran (00)	1609	305	18.95
Japan (01)	16078	7401	46.03	Mexico (00)	993	628	63.24
France (00)	9903	6577	66.41	Israel (00)	688	497	72.24

Source. NSF. Science & Engineering Indicators, 2004. Appendix Table 2-36

Table 3.3: S&E Doctoral Degrees Awarded in Select Countries					
		Year			
		1985	1995	2001	2003
China	All degrees	234	4364	12465	
	% of S&T degrees	53.42	78.30	65.41	
India	All degrees	7438	9070	11544	13733
	% of S&T degrees	53.87	44.10	46.72	46.00
South Korea	All degrees	1400	4462	6143*	6690**
	% of S&T degrees	39.14	43.03	46.64	48.20
Taiwan	All degrees	115	848	1463	1759
	% of S&T degrees	94.78	76.65	66.30	66.34
Japan	All degrees	7978	12645	16078	16314
	% of S&T degrees	38.70	41.16	46.03	46.47
USA	All degrees	312197	41743	40744	
	% of S&T degrees	60.50	63.57	62.61	
UK	All degrees	6210	7650	14210	
	% of S&T degrees	74.23	67.06	59.96	
Germany	All degrees	14951	22387	24796	
	% of S&T degrees	38.38	48.64	47.60	
France	All degrees		9801	24796***	
	% of S&T degrees		71.69	69.34	

*2000; *2002, ***1999

Source: NSF. Science & Engineering Indicators, 2006, Appendix Table 2-43; NSF. Science & Engineering Indicators, 2004, Appendix Table 2-38

Table 3.4. Number of Ph.D Degrees Awarded in S&T in Select Countries, 1983-2003									
Year	Number of Ph.Ds Produced in S&T								
	India	China	S. Korea	Taiwan	Japan	France	Germany	UK	USA
1983	3886	NA	281	8	2676	NA	4978	2430	19274
1985	4007	125	548	20	3088	NA	5738	2410	19663
1987	4123	218	759	35	3248	NA	6576	2580	20694
1989	4209	1024	984	42	3561	4888	7568	2940	22706
1991	4294	1198	1135	62	3874	5384	10465	3150	25061
1993	4320	1895	1421	97	4438	6820	10200	3030	26640
1995	4000	3417	1920	115	5205	7027	10889	2580	27864
1997	4764	5328	2189	163	6157	8962	11728	3420	28653
1999	5317	6778	2607	150	7082	7054	11984	3670	27339
2000	5395	7304	2865	147	7089	NA	11895	4370	27557
2001	5394	8153	NA	144	7401	NA	11803	4380	27160
2002	5527	NA	3225	NA	7461	NA	11017	4380	26226
2003	6318	NA	NA	202	7581	NA	10796	3780	26891

Source. NSF. *Science and Engineering Indicators 2006*. Appendix Tables 2.42 and 2.43; *NA=Not Available*

3.3 Financial Resources for Science & Technology

R&D expenditure and the R&D intensity are the two key indicators generally used to monitor resources devoted to S&T worldwide. The global gross expenditure on R&D (GERD) has more than doubled from US $410 billion in 1990 to US $830 billion in 2002, in terms of current purchasing power parity (PPPs). However, the R&D intensity measured by the ratio of GERD over GDP has slightly declined from 1.8% to 1.7% during the corresponding period. It implies that despite sustained growth in world GDP and sustained increase in funding to R&D by the countries, the overall world share to R&D activities in world economic wealth has declined, though marginally[5-6]. Developing countries, for example generally spend less than 1% of their GDP on R&D, whereas developed countries spend between 1-3 % of their GDP on R&D.

Among major geographical regions, North America leads in scientific investment, accounting for 37% of the world's GERD in 2002. Its R&D spending, however, remained almost stagnant (US$302 billion in 1990 and US$307 billion in 2002), but its R&D intensity has increased slightly from 2.6% to 2.7% during the corresponding period [5-8].

Asia has been the second largest investor in R&D with a share of 32% in 2002, overtaking Europe. This was due to the significant growth in share of China in world GERD (from 3.02% in 1990 to 8.07% in 2002) and of the "Newly Industrialized Countries of Asia" (from 4.9% in 1990 to 6.4% in 2002). These countries managed to withstood their financial crisis and massively increased their R&D investments (from US$ 8.2 billion in 1990 to US$ 53.3 billion in 2002), despite limited growth in their GDP[5-8].

Europe has been the third largest in R&D investments with US$ 226.2 billion spending in 2002. Its share in global R&D investments has, however, declined from 33.87% in 1990 to 27.30% in 2002. The decline has resulted from falling investment shares of "Central & Eastern Europe" and the "Community of Independent States of Europe". The European Union spends around 1.9% of GDP on R&D and has set the target of 3% by 2010.

R&D investments in Latin America have slightly declined in terms of world's share from 2.75% in 1990 to 2.6% in 2002, but in absolute terms it has doubled (from US$ 11.3 billions to US$ 21.7 billions). Its R&D intensity has, however, slightly increased (from 0.5% to 0.6%) during the corresponding period. The Africa and Arab states remained by far the least R&D intensive continents, contributing 0.3% and 0.2% of its R&D investments respectively in world total[5-8].

Amongst developed countries during 2001, the largest spending in R&D was made by USA, followed by Japan, Germany, France, United Kingdom, Canada, Italy, Russian Federation, Sweden, Spain, Australia and Switzerland. In most of them, R&D expenditure grew at varying rates (Table 3.5). Amongst developing countries, the largest expenditure on R&D was made by China during 2001, followed by India, South Korea, Brazil, Israel, South Africa, Mexico, Argentina, and other developing countries below US$ 1 billion (Table 3.6).

Table 3.5: Expenditure on R&D (GERD) of Top Developed Countries (in billion US$PPP)

Country	GERD in US$PPP		GERD as % of GDP		GERD per Capita	
	1996	2001	1996	2001	1996	2001
USA	200.25	274.64	2.55	2.80	743	963
Japan	81.91	98.60	2.77	3.09	651.2	776.2
Germany	40.99	51.54	2.26	2.50	500	633
France	27.05	31.26	2.30	2.20	464	528
United Kingdom	22.38	27.01	1.90	1.90	383	459
Canada	11.20	16.33	1.68	1.94	374	531
Italy	12.48	14.99*	1.01	1.07*	217	260*
Russian Federation	7.51	11.97	0.90	1.16	51	83
Netherlands	7.11	8.34*	2.01	1.95*	457	524*
Spain	5.35	7.93	0.83	0.96	135	193
Sweden	6.63**	9.61	3.67**	4.61	749**	1083
Australia	6.43	7.21*	1.65	1.53	300	289
Switzerland	5.02	5.27*	2.73	2.64*	698	734*

Note= *2000; **1997

Source. *Unesco Institute of Statistics. Gross Domestic Expenditure on Research and Development (GERD) by Source of Funds, 1996-2002.* March 2004; *Unesco Institute of Statistics. Selected Research and Development (R&D) Indicators, 1996-2002.* March 2004; *Unesco Science Report, 2005.*

Amongst developing countries, significant growth has taken place in the China's investment in R&D coupled with its strong economic growth and increase in its GDP, both in absolute terms and in its world share. India's R&D investment and its world's share although has increased from US$ 2.5 billion (0.61%) in 1990 to US$ 20.8 billion (0.7%) in 2000, but has failed to keep pace with its growth in GDP, particularly in late 1990's.

Table 3.6: Expenditure on R&D (GERD) of Top Developing Countries (in billion US$PPP)

Country	GERD in US$PPP		GERD as % of GDP		GERD per Capita	
	1996	2001	1996	2001	1996	2001
Israel	3.159	6.249	2.96	4.96	552.1	982.0
India	11.80	22.71	0.55	0.78	13.8	22.0
Brazil	8.25	13.00*	0.77	1.05*	51	76.0*
China	19.84	55.54	0.60	1.09	16.3	43.70
Korea, Rep of	14.42	21.11	2.60	2.96	318	446.0
Singapore	0.113	0.138	1.39	2.11	33.5	33.3
Mexico	2.038	3.271**	0.31	0.43**	22	34.0**
Argentina	1.619	1.802	0.42	0.42	46	48.0
South Africa	NA	3.754		0.77		86.8
Egypt	0.366	0.429*	0.21	0.19*	5.8	6.30*
Columbia	0.833	0.501	0.30	0.17	21	12.0
Chile	0.662	0.768	0.58	0.54	46	50.0
Cuba	NA	NA	0.38	0.65	NA	NA
Uruguay	0.069	0.069*	0.26	0.24	21	21
'Venezuela	0.366	0.617	0.29	0.44	16	25
Malaysia	0.354	1.034*	0.22	0.49*	16.8	44.5*
Tunisia	0.140	0.264*	0.30	0.45*	15.4	27.9*

* 2000; **1999

Source. Unesco *Institute of Statistics. Gross Domestic Expenditure on Research and Development (GERD) by Source of Funds, 1996-2002*. March 2004; *Unesco Institute of Statistics. Selected Research and Development (R&D) Indicators, 1996-2002*. March 2004; *Unesco Science Report, 2005*.

In terms of GERD as a percentage of GDP (R&D intensity), the largest ratio (4.96) was achieved by Israel during 2001, followed by South Korea (2.96), Singapore (2.11), China (1.09), Brazil (1.05), India (0.78), South Africa (0.77), Cuba (0.65), Chile (0.54), Malaysia (0.49), Tunisia (0.45), Argentina (0.42), etc. (Table 3.6).

Among these countries, China is well on the way of realizing its goal of 1.5% GERD/GDP ratio by 2006. The Government of India has also committed to increase its R&D spending by 2% of GDP in next five years. The Republic of/Korea, Singapore and Taiwan already spend 2% of GDP on R&D. Among Latin American countries, Brazil and Costa Rica reported the highest R&D intensity (1%)

during 2000, followed by Costa Rica (0.9%), Cuba (0.8%), Mexico (0.4%) and Argentina (0.4%). Moreover, Brazil, Mexico and Argentina together accounted for the 85% of the region's GERD.

Although Israel contributed 0.7% of the world R&D investments during 2002, but its R&D intensity has been the highest among developing countries. Amongst other countries, South Africa and Egypt contributed 0.4% and 0.1%, respectively of the world R&D investments, but their R&D intensity (0.7% and 0.4%) has been much higher, compared to R&D investments. South Africa is responsible for 90% of GERD in Sub-Saharan Africa. Egypt and to lesser extent Tunisia, Morocco and Algeria contribute practically all R&D activity among Arab states of Africa. Among Arab Asia region, Jordan, Kuwait and Saudi Arabia accounted for most of the sub-region's GERD and the first two had spent 0.4% of their GDP on R&D during 2001[5-8] (Table 3.5).

There is wide disparity among developing countries in terms of GERD per capita during 2001. Here again Israel leads the developing nations, followed by South Korea, South Africa, Brazil, Chile, Argentina, Malaysia, China, Mexico, Singapore, Venezuela), India, etc [5-8] (Table 3.6).

3.4 Manpower Resources in Science & Technology

R&D manpower in a country is more of a measure of the stock of total research staff employed in the R&D system. This includes 'researchers' who are the central element of the R&D system. They are mainly responsible for the conceptualization and creation of new knowledge, products, processes, methods and systems and are directly involved in the management of projects. The number of researchers is expressed in full-time equivalents (FTE) on R&D. FTE data on researchers give an indication of the research efforts of the member countries.

Researchers in developing countries accounted for almost one-third of the world total researchers during 2002. This was much higher than their share in R&D expenditure (19.74%) during 2002, and expenditure per researcher was much lower in less developed countries[6].

In 2002, the USA had the highest number of researchers (1.26 million) in the world, followed by China, Japan, Russia Federation, Germany, France, U.K, India, Brazil, Argentina, Mexico, Israel, and South Africa (Tables 3.7 to 3.8)[6].

The ratio of the researchers to the total number of the inhabitants gives an insight of the density of R&D resources in relation to the size of population. The number of researchers per million was very low in India (112.1), compared with Brazil (314.9) and China (633) during 2002, due to large size of their population and pattern of development. Sub-Saharan Africa, Arabs in Asia, and Latin American countries had relatively smaller (48.0, 93.5 and 261.2 respectively) number of researchers per million inhabitants during 2002, implying that they have relatively small workforce. Compared to this, East European countries had higher number of researchers, in relation to their population. However, high supply lead to low average expenditure per researcher (103.4 during 2002) than the Latin America (156.5 during 2002) [5-8] (Table 3.8)

Table 3.7: Researcher per Million Inhabitants in Developed Countries						
Country	**Researchers (Thousands)**		**Researchers per million inhabitants**		**GERD per researcher**	
	1996	**2002**	**1996**	**2002**	**1996**	**2002**
USA	1040.9	1261.2***	3863	4373.7		230.0
Japan	617.36	646.5	4909	5084.9		164.5
Germany	230.19	264.5	2810	3208.5		211.4
France	154.74	177.4	2658	2981.8		198.4
United Kingdom	144.73	157.7****	2477	2661.9		184.2
Canada	91.6	90.81***	3059			
Italy	76.44	64.88***	1333			
Russian Federation	562.07	491.9	3801	3414.6		30.0
Netherlands	34.48	40.62***	2219			
Spain	51.63	80.08*	1304	1948*		
Sweden	36.87*****	45.99*	4167*****	5186*		
Australia	61.04	65.80**				
Switzerland	21.63	25.75**	3006	3592**		

* 2001 ; **2000 ; ***1999 ; ****1998 ; *****1997

Source. *Unesco Institute of Statistics. Gross Domestic Expenditure on Research and Development (GERD) by Source of Funds, 1996-2002*. March 2004; *Unesco Institute of Statistics. Selected Research and Development (R&D) Indicators, 1996-2002*. March 2004; *Unesco Science Report, 2005.*

Table 3.8: Researchers per Million Inhabitants in Developing Countries					
Country	**Researchers (Thousands)**		**Researchers per million inhabitants**		**GERD per researcher** (US$thousands)
	1996	2002	1996	2002	2002
China	787.0	810.5	459	633.0	88.8
India	149.32	117.5****	157	112.1****	176.8****
Brazil	NA	54.9**	NA	314.9**	238**
Israel	7.62	9.2***	1391	1395.2***	661.1*****
Mexico	19.85	21.9***	215	274***	159.7***
Argentina	22.93	26.08	651	715.0	61.5
South Korea	99.4	136.34*	2184	2979	
South Africa	NA	8.71	NA	192.0	357.6
Chile	5.16	6.44*	358	419*	
Columbia	3.28	2.24**	83	101*	
Singapore	9.11	16.74*	2482	4352	
Tunisia	1.08	3.15	NA	1013	
Venezuela	4.43***	4.75*	NA	193*	
Malaysia	1.89	7.15	90	276*	
Cuba	5.15	5.49*	468	489*	
Iran	NA	13.74*	NA	484*	

*2001 ; **2000 ; *** 1999 ; ****1988 ; *****1997

Source. *Unesco Institute of Statistics. Gross Domestic Expenditure on Research and Development (GERD) by Source of Funds, 1996-2002*. March 2004; *Unesco Institute of Statistics. Selected Research and Development (R&D) Indicators, 1996-2002*. March 2004; *Unesco Science Report, 2005.*

For the countries with large population, the annual average R&D expenditure per researcher gives an accurate indication of the size of the workforce, as seen from their values (Table 3.8) measured in US $ thousands during 2002: India (176.8), Brazil (238) and China (88.8). These values were obtained in spite of higher GERD during 2002 of China (US$72 billion), India (US$20.8 billion), and Brazil (US$13.1). The R&D expenditure as the annual average per researcher is an indicator of the working environment of the researchers, in terms of access to financial resources, instrumentation, other capital equipment and research facilities. The lower value of R&D expenditure indicates that it is distributed across large number of scientists employed in these countries. For some countries such as Israel, the average expenditure per researcher (661.1) is higher than India (176.8). This is, however, not due to the availability of higher financial resources, but rather because of the low number of researchers (0.12% of world) than India (2.1% of the world) during 2002 (Table 3.8).

3.5 Publications Share of Different Regions/Countries in World Output

For comparison of Indian research output with other countries, the present study analyzed the 11 years combined publication and citation data of 146 countries during 1993 to 2003. The publications data were derived from the *Web of Science* database (downloaded in February 2004) and drawn from ISI-Thomson Database Report on *Essential Science Indicators.* In addition, we have looked at the publications data as presented by King in his article published in *Nature (2004)*.

For a decade, the North America had been the largest contributor to the scientific publications output in the world. But more recently, the Europe has overtaken it. It contributed the largest publications share (43.6% papers) to the world publications output (40.8% citations share), of which 36.8% papers and 37.9% citations were from Western Europe and 7.3% papers and 2.88% citations from Eastern Europe. Compared to Europe, the America contributed 35.4% publications (45.8% citations share), of which 33.6% papers and 44.7% citations were from North America and only 1.84% papers and 0.97% citations were from Central/South America.

The Asian share of publications in the world output was 16.9% (10.4% citations share), of which the largest share (10.5% papers and 7.55% citations) was from Far East Asia, followed by South Asia (2.06% papers and 0.71% citations), Middle East (1.48% papers and 1.15 citations), and South East Asia (2.96% papers and 0.99% citations). The Oceania region contributed only 2.77% share in world publications and 2.52% citations share. In contrast, the smallest share (1.2% papers and 0.58% citations) to world output was from Africa.

Fig 3.1: World Publications Output by Broad Regions

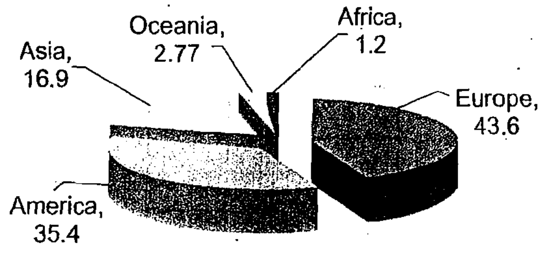
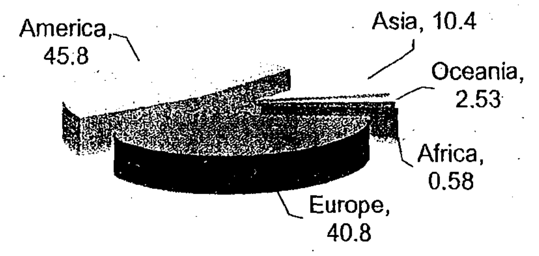


Fig 3.2: Share of Citations Received by Broad Regions



3.5.1 Top 38 World Countries

India is one of the top 19 countries, each contributing 1% share or more to the world output

The 19 countries contributed more than 1% publications share to the world research output and together accounted for 86.2% of the total world publications output and 91.4% of the total world citations. The publications output was the largest from USA (29.18%), accounting for 40.13% citations share of the world. U.K., Japan Germany and France contributed 5% to 9% of world's publications share, whereas Canada, Italy and Russia contributed 3% to 4%.

The China, Australia, Spain and the Netherlands contributed 2% to 3% of world's publications share, while India, Sweden, Switzerland, South Korea, Belgium, Israel, and Poland contributed 1% to 2% world's publications share (Table 3.9). The next 19 countries contributed 0.25% to 0.99% share to world output. Their combined publications share was 10.15% and citations share 6.8%. Of these, 11 countries (Denmark, Finland, Austria, Turkey, Norway, Greece, Czech Republic, Hungary, Ukraine, Portugal and Ireland) were from Europe, two (South Africa and Egypt) from Africa, two (Brazil and Argentina) from South America, two (Taiwan and Singapore) from Asia and one each from North America (Mexico) and Oceania (New Zealand) (Table 3.9).

3.5.2. Developed vs. Developing Countries

Out of 146 countries covered in *Essential Science Indicators* database, 48 are developed and 98 are developing countries. The combined publications output of developed countries during 1993 to 2003 was 87.27% accounting for 94.74% citations of the world, whereas developing countries contributed only 12.73% publications share and 5.36% citations share.

Amongst the developed countries (Table 3.9), the top seven countries contributed 64.38% papers and 75.17% citations during 1993 to 2003, the next seven countries 13.9% papers and 12.72% citations, and the next seven contributed 5.45% papers and 4.8% citations. The combined output of these 21 developed countries was 83.8% papers and 92.74% citations of the world total output (Table 3.9).

Table 3.9: Contribution of Top 38 Countries, 1993-2003								
Country	Papers			Citations			Average citations per Paper	
	No.	%	Rank	No.	%	Rank	Ratio	Rank
USA	2799593	28.56	1	35368637	39.08	1	12.63	13
UK	862475	8.92	2	8959964	9.90	2	10.57	20
Japan	739208	7.65	3	5463285	6.04	4	7.39	49
Germany	679702	7.03	4	6284605	6.94	3	9.25	29
France	501380	5.19	5	4510910	4.98	5	9.0	32
Canada	370928	3.84	6	3801884	4.20	6	10.25	22
Italy	323452	3.34	7	2762461	3.05	7	8.54	35
Russia	294362	3.04	8	904404	1.00	14	3.07	116
China	253566	2.62	9	2409488	2.66	18	2.90	121
Australia	219768	2.27	10	1870756	2.07	10	8.51	36
Spain	218895	2.26	11	1532623	1.69	12	7.00	53
Netherlands	202184	2.09	12	2291060	2.53	8	11.33	17
India	184892	1.91	13	583260	0.64	19	3.15	114
Sweden	158136	1.63	14	1715691	1.89	11	10.85	19
Switzerland	142982	1.48	15	1893545	2.09	9	13.24	12
South Korea	118492	1.22	16	464136	0.51	21	3.92	103
Belgium	103181	1.07	17	1004630	1.11	13	9.74	25
Israel	99551	1.03	18	897607	0.99	15	9.02	31
Poland	98155	1.02	19	452762	0.51	22	4.61	84
Taiwan	96394	1.00	20	420234	0.46	25	4.36	95
Brazil	96120	0.99	21	423083	0.47	24	4.40	94
Denmark	79929	0.83	22	890018	1.01	16	11.14	18
Finland	74106	0.77	23	753810	0.86	17	10.17	23
Austria	71515	0.75	24	583035	0.66	20	8.15	39
Turkey	53559	0.56	25	151167	0.17	36	2.82	124
Norway	51253	0.53	26	452162	0.51	23	8.82	33
Greece	48342	0.50	27	247515	0.28	27	5.12	75
Mexico	45155	0.47	28	208622	0.24	30	4.62	83
New Zealand	43942	0.46	29	338238	0.38	26	7.70	47
Czech Republic	41876	0.44	30	191002	0.22	33	4.56	90
Hungary	40946	0.43	31	243651	0.28	28	9.95	65
Argentina	40306	0.42	32	206570	0.23	31	5.13	74
South Africa	39881	0.42	33	209395	0.24	29	5.25	72
Ukraine	38030	0.40	34	101010	0.11	39	2.66	129
Singapore	32369	0.34	35	138338	0.16	37	4.27	97
Portugal	28882	0.30	36	160395	0.18	35	5.55	70
Ireland	26267	0.27	37	203229	0.23	32	7.74	46
Egypt	25013	0.26	38	68213	0.08	41	2.73	127

Amongst the developing countries (Table 3.10), the top seven countries contributed 8.84% papers and 3.39% citations of the world output, the next seven countries 2.01% papers and 1.07% citations, and the next seven 0.8% papers and 0.33% citations. The combined output of these 21 countries was 11.65% papers and 4.78% citations to the world output (Table 3.10).

Table 3.10: Contribution of Top 23 Developing Countries, 1993-2003

Name of the Country	Papers			Citations			Average citations per paper	
	No.	%	Rank	No.	%	Rank	Ratio	Rank
China	253566	2.62	9	734488	0.83	18	2.90	121
India	**184892**	**1.91**	**13**	**583260**	**0.66**	**19**	**3.15**	**114**
South Korea	118492	1.22	16	464136	0.53	21	3.92	103
Taiwan	96394	1.00	19	420234	0.48	25	4.36	95
Brazil	96120	0.99	20	423083	0.48	24	4.40	94
Mexico	45155	0.47	28	208622	0.24	30	4.62	83
Argentina	40306	0.42	32	206570	0.23	31	5.13	74
South Africa	39881	0.41	33	209395	0.24	29	5.25	72
Singapore	29117	0.30	35	138338	0.16	37	4.27	97
Egypt	25013	0.26	37	68213	0.08	41	2.73	127
Chile	19271	0.20	40	112672	0.13	38	5.85	67
Saudi Arabia	15419	0.16	43	46315	0.05	47	3.00	119
Thailand	11817	0.12	47	58053	0.07	44	4.91	78
Iran	11617	0.12	48	29264	0.03	55	2.52	131
Venezuela	8702	0.09	50	43515	0.05	48	4.57	89
Morocco	8702	0.09	51	24879	0.03	58	2.86	122
Malaysia	8423	0.09	52	26592	0.03	57	3.16	113
Nigeria	8344	0.09	53	20009	0.02	62	2.40	132
Pakistan	6416	0.07	54	18314	0.02	65	2.85	123
Kenya	5784	0.06	55	38279	0.04	49	6.62	57
Tunisia	5269	0.05	58	14424	0.02	67	2.74	126
Columbia	5268	0.05	59	29637	0.03	54	5.63	69
Cuba	5127	0.05	60	18796	0.02	64	3.67	109

Considering the rank order based on publications share (1993-97 & 1997-2001) and citations share of top 1% of highly cited publications during 1997-2001 (King, 2004), the ranking of G-8 has not changed much, but the ranking of most of the developing countries has improved. Amongst G-8 countries, the publications and citations share of UK, Germany, Japan, France and Italy had increased, while that of the USA, Canada and Russia decreased. Significant fall had been observed in the case of USA in publications output (37.46% to 34.86%) and in citations (52.3% to 49.43%), Canada (publications output decreased from 5.05% to 4.58% and citations from 5.59% to 5.30%), and Russia (publications output from 3.65% to 3.40% and citations from 1.23% to 1.43%). However, Japan had increased its publications share from 8.69% to 9.28% and in citations from 7.54% to 8.44%, during the corresponding period.

Amongst developing countries, maximum increase was seen in the case of China. Its publication share had increased from 2.06% to 3.18% and citations share from 0.95% to 1.56% during 1993-97 to 1997-2001, followed by South Korea (0.81% to 1.53% in publications and 0.44% to 0.88% in citations), Singapore (0.27% to 0.42% in publications and 0.15% to 0.25% in citations), Iran (0.06% to 0.13% in publications and 0.03% to 0.06% in citations), and Taiwan (0.98% to 1.25% in publications and 0.52% to 0.69% in citations). In case of India and South Africa, although there was increase in their publications output, but their publications share in world output had slightly declined (from 2.19% to 2.13% in case of India and from 0.52% to 0.50% in the case of South Africa). However, their share of citations output had improved (from 0.76% to 0.86% in the case of India and from 0.29% to 0.31% in the case of South Africa) during 1993-97 to 1997-2001 (Table 3.10).

3.6 Developing Countries Share in World Output by Subject

The combined publication output of developing countries during 1993-2002 was classified into 19 broad subjects, and their publications share in world output and in world citations were analyzed. Among the broad subjects, materials science ranked at the top with 21.60% share of the total papers by developing countries, followed by agriculture (19.56%), chemistry (17.75%), engineering (17.39%), physics (15.91%), plant & animal sciences (15.76%), mathematics (14.49%), computer science (13.34%), and pharmacology & toxicology (12.76%) (Table 3.11).

The developing countries have acquired significant ranks amongst the first top 20 in world output in 19 broad subject fields. The world publications rank and percentage share in world output are given in parenthesis against each subject. For example, India ranked 1st amongst developing countries in publications output in four subjects: agriculture (4th rank, 5.63%), plant & animal sciences (8th rank, 3.13%), energy & environment (11th rank, 1.97%) and biology & biochemistry (14th rank, 1.51%). India ranked 2nd in publications productivity amongst developing countries in materials science (8th rank, 3.56%), chemistry (8th rank, 3.62%), physics (9th rank, 2.26%), geosciences (11th rank and 2.31%), pharmacology & toxicology (13th rank, 1.89%), space sciences (13th rank, 1.55%), mathematics (8th rank and 3.56%), molecular biology & genetics (19th rank and 0.76%), and immunology (20th rank and 0.7%) and 3rd in engineering (11th rank and 2.39%) and microbiology (17th rank and 1.42%).

China ranked 1st among developing countries in terms of publications output in subjects, such as material science (4th rank, 7.62%), mathematics (5th rank, 4.77%), chemistry (7th rank, 5.54%), physics (7th rank, 4.71%), engineering (7th rank, 3.86%), computer science (8th rank, 2.62%), pharmacology & toxicology (10th rank, 2.01%), space sciences (12th rank, 1.78%), geosciences (10th rank, 2.76%), biology & biochemistry (15th rank, 1.50%), and psychiatry/psychology (20th rank, 0.45%). It ranked 2nd in energy & environment, and 3rd in plant & animal sciences, as well as in molecular biology & genetics (Table 3.12).

Brazil acquired 1st rank among developing countries in neuroscience & behavior (13th rank, 1.17% contribution), molecular biology & genetics (16th rank, 0.93%) and immunology (17th rank, 0.92%). It ranked 2nd in agriculture, plant & animal sciences and microbiology. South Korea acquired first rank among developing countries in publications output in only microbiology (12th world rank, 1.75% contribution), and 3rd rank onwards in all other subjects (Table 3.12).

The subjects (listed in order of ranking) that attracted more citations than the average citations for developing countries are: materials science (13.13%), engineering (11.15%), agriculture (9.63%), chemistry (9.55%), physics (9.1%), mathematics (9.04%), computer science (7.87%), plant & animal science (7.58%), space sciences (5.94%), geosciences (5.72%) and pharmacology & toxicology (5.46%) (Table 3.11).

Table 3.11: Relative Share of Developed and Developing Countries by Subject,1993-2003

Subject	#. Of Countries	World Total		Developed Countries		Developing countries		# of countries	
		Papers	Citations	Papers	Citations	Papers	Citations	Developed	Developing
Chemistry	83	929294	8106317	82.25	58.63	17.75	9.55	42	41
Physics	80	1087058	8293558	84.01	91.90	15.91	9.10	36	44
Clinical Medicine	105	1985872	21934156	92.25	96.10	7.75	3.90	40	65
Mathematics	75	244376	659166	85.51	90.96	14.49	9.04	41	34
Materials Science	69	363116	1467958	78.40	86.87	21.60	13.13	31	38
Computer Science	70	184190	467380	86.66	92.13	13.34	7.87	31	39
Space Science	59	169321	2037659	90.72	94.06	9.28	5.94	38	21
Geosciences	90	276855	2247815	88.72	94.28	11.28	5.72	37	53

Subject	#. Of Countries	World Total		Developed Countries		Developing countries		# of countries	
		Papers	Citations	Papers	Citations	Papers	Citations	Developed	Developing
Engineering	91	709698	2300714	82.61	88.85	17.39	11.15	47	44
Plant & Animal Sci.	99	561159	3435784	84.24	92.42	15.76	7.58	35	64
Pharmacology & Toxicology	74	175622	1646157	87.24	94.60	12.76	5.46	38	36
Neuroscience & Behavior	69	316885	5246600	94.51	97.65	5.49	2.35	34	32
Multidisci. Sci.	67	30293	142334	79.91	93.41	20.09	6.59	35	3
Mol. Biology & Genetics	80	304372	7793795	94.47	98.04	5.53	1.96	40	40
Microbiology	83	172326	2440718	89.59	94.95	10.41	5.05	37	46
Immunology	84	149974	2946898	93.03	96.45	6.97	3.55	32	52
Agriculture	93	167002	771336	80.44	90.37	19.56	9.63	36	57
Psychiatry/ Psychology	75	223844	1817341	96.67	98.37	3.33	1.63	36	39

Developing countries that faired better in terms of relative citation index in different subjects are shown in Table 3.13. In fact, the developing countries (particularly India and China) that have shown higher productivity generally have not done well in terms of relative citation index. However, the Latin American countries, though contributing medium level research output, have done better in terms of relative citation impact compared to Asian and African countries. Amongst Asian countries, South Korea, Taiwan, and Singapore made greater relative citation impact than China, India, Thailand and Malaysia in different subject fields. Amongst Africa, only South Africa made high impact in few subject fields (Table 3.13).

Table 3.12: Developing Countries in the Top 20 World Countries List by Different Subjects, 1993-2003	
Subject Fields	**World Publications Rank and Percentage Share of Publications in World Output**
Agriculture	**India (4th rank, 5.63% papers)**, Brazil (12th rank, 2.36% papers)
Biology & Biochemistry	**India (14th rank**, 1.51% papers), China (15th rank, 1.5% papers), South Korea (16th rank, 1.16% papers)

Subject Fields	World Publications Rank and Percentage Share of Publications in World Output
Chemistry	China (7th rank, 5.54% papers), **India (8th rank, 3.62% papers)**, South Korea (13th rank, 1.90% papers), Brazil (20th rank, 0.97% papers)
Clinical Medicine	China (20th rank, 0.86% papers)
Computer Science	China (98th rank, 2.62% papers), Taiwan (9th rank, 2.53% papers), South Korea (10th rank, 2.48% papers), **India (16th rank**, 1.36% papers), Singapore (19th rank, 1.12% papers)
Engineering	China (7th rank, 3.86% papers), Taiwan (10th rank, 2.57% papers), **India (11th rank, 2.39% papers)**, South Korea (12th rank, 2.3% papers), Singapore (19th rank, 1.095 papers)
Geosciences	China (10th rank, 2.76% papers), **India (11th rank, 2.34% papers)**, South Africa (18th rank, 0.89% papers), Brazil (20th rank, 0.8% papers)
Immunology	Brazil (17th rank, 0.92% papers), **India (20th rank, 0.7% papers)**
Materials Science	China (4th rank, 7.62%), **India (8th rank, 3.56%)**, South Korea (9th rank, 3.15%)
Mathematics	China (4th rank, 7.62% papers), **India (8th rank, 3.56% papers)**, South Korea (9th rank, 3.09% papers), Taiwan (13th rank, 1.84% papers), Singapore (20th rank, 0.9% papers)
Microbiology	South Korea (12th rank, 1.75% papers), Brazil (15th rank, 1.53% papers), and **India (17th rank, 1.42% papers)**
Molecular Biology & Genetics	Brazil (16th rank, 0.93% papers), **India (19th rank, 0.76% papers)**, China (20th rank, 0.72% papers)
Neurobiology & Behavior	Brazil (13th rank, 1.17% papers)
Pharmacology & Toxicology	China (10th rank, 2.01% papers), **India (13th rank, 1.89% papers)**, South Korea (14th rank, 1.7% papers), Taiwan (17th rank, 1.23% papers), Brazil (18th rank, 1.22% papers)
Physics	China (7th rank, 4.71% papers), **India (9th rank, 2.26% papers)**, South Korea (13th rank, 1.98% papers), Brazil (16th rank, 1.44% papers)
Plant & Animal Sciences	**India (8th rank, 3.13% papers)**, Brazil (12th rank, 1.7% papers), China (14th rank, 1.47% papers), South Africa (15th rank, 1.36% papers)
Psychiatry/ Psychology	China (20th rank, 0.45% papers)
Space Sciences	China (12th rank, 1.78% papers), **India (13th rank, 1.55% papers)**, Chile (14th rank, 1.23% papers), Brazil (16th rank, 1.14% papers), Mexico (18th rank, 1.10 papers)

Table 3.13: Relative Citations-Impact (RCI) of Various Countries, 1993-2003	
Subject Fields	**Name of the Countries along with RCI**
Materials Science	South Africa (-14.3), Taiwan (-22.2), South Korea (-26.1), Morocco (-26.6), Argentina (-27.2), Singapore (-29.30), Mexico (-34.13), Brazil (-35.35), Columbia (-35.91), **India (-36.68)**, Chile (-40.43), China (-50.13), Malaysia (-54.78), Venezuela (-54.99), Thailand (-55.98), Saudi Arabia (-57.55), Egypt (-57.6), Nigeria (-63.06), and Iran (-66.51)
Engineering	Venezuela (-4.0), Argentina (-10.5), Brazil (-16.6), Taiwan (-22.58), South Africa (-24.59), Chile (-25.88), Singapore (-31.68), South Korea (-39.45), Iran (-42.32), **India (-42.56)**, Morocco (-42.57), Mexico (-44.1), Saudi Arabia (-44.78), China (-45.13), Egypt (-45.79), Thailand (-50.03), Nigeria (-65.02), and Malaysia (-66.48)
Agriculture	South Africa (-0.9), Indonesia (-4.53), Columbia (-8.9), Taiwan (-11.5), Argentina (-21.3), Mexico 9-24.87), Chile (-30.73), Kenya (-31.89), South Korea (-32.81), Malaysia (-34.39), Thailand (-39.91), China (-40.5), Morocco 9-42.16), Egypt (-52.05), Venezuela (-56.96), Nigeria (-64.6), Brazil 9-66.93), Iran (-68.84), Saudi Arabia (-69.03), and **India (-74.08)**
Chemistry	Singapore (-24.6), Venezuela (-32.7), Taiwan (-34.78), South Africa (-35.6), Mexico (-42.1), South Korea (-45.0), Brazil (-45.51), Argentina (-45.9), **India (-51.58)**, Chile (-52.01), Morocco (-55.08), Columbia (-56.14), Malaysia (-57.53), Iran (-58.15), China (-62.08), Saudi Arabia(-62.93), Thailand (-64.65), Egypt (-67.37), and Nigeria (-72.19)
Physics	Chile (-18.3), Argentina (-24.1), Columbia (-25.9), South Africa (-32.0), Brazil (-32.2), **India(-40.08)**, Taiwan (-41.85), South Korea (-41.85), Venezuela (-45.64), Mexico (-46.07), Iran(-55.43), Morocco (-58.91), China (-59.02), Singapore (-60.21), Egypt (-64.40), Malaysia(-66.93), Saudi Arabia (-69.44), and Thailand (-76.43)
Mathematics	Chile (-7.6), South Korea (-7.7), Venezuela (-17.6), Taiwan (-23.4), Brazil (-25.0), Argentina(-28.17), South Africa (-33.40), Columbia (-40.91), China (-41.52), Saudi Arabia (-42.81), South Korea (-43.37), Mexico (-44.18), Egypt (-47.85), **India (-53.83)**, Morocco (-64.57), Iran (-66.65), and Malaysia (-68.19)
Computer Science	Argentina (-23.8), Singapore (-30.5), Chile (-30.9), Taiwan (-32.74), **India (-34.8)**, South Africa (-36.01), Columbia (-41.73), Brazil (-41.99), Tunisia (-42.8), Mexico (-47.76), Egypt (-49.48), Venezuela (-49.69), Saudi Arabia (-49.98), Thailand (-52.05), South Korea (-54.12), China (-55.19), Iran (-65.83), Malaysia (-67.48), and Morocco (-74.83)

Subject Fields	Name of the Countries along with RCI
Plant & Animal Sciences	Singapore (-24.75), Taiwan (-33.74), Kenya (-33.99), Columbia (-34.50), Thailand (-34.98), South Africa (-37.09), South Korea (-39.86), Chile (-43.04), Argentina (-43.48), Malaysia(-45.58), Mexico (-46.68), Morocco (-55.07), China (-56.40), Brazil (-59.79), Egypt (-64.36), Saudi Arabia (-64.87), Nigeria (-66.02), Venezuela (-70.08), **India (-73.50),** and Iran (-79.16)
Space Sciences	Chile (-14.7), South Africa (-17.4), Venezuela (-23.7), Mexico (-25.5), Brazil (-29.7), South Korea (-33.13), Taiwan (-34.04), Argentina (-39.04), **India (-56.69),** Morocco (-61.66), China(-64.15), Nigeria (-68.11), Egypt (-78.26)
Pharmacology & Toxicology	Chile (-38.0), Mexico (-40.3), Croatia (-41.6), Taiwan (-43.1), Brazil (-44.8), South Africa (-44.84), Singapore (-44.84), Argentina (-50.32), Saudi Arabia (-56.90), South Korea (-60.52), Thailand (-60.55), Venezuela (-62.13), **India (-66.97),** Malaysia (-67.67), China (-68.39), Egypt (-70.96), Iran (-72.49), Morocco (-75.15), Nigeria (-79.45)

Findings

- The developing countries contributed only 12.73% publications output to the global research output and attracted only 5.36% world citations share. In addition, a few developing countries have made comparatively larger contributions in few subject fields, both in terms of research papers and citations.

- Amongst developing countries, India ranks at the top in terms of research output in agriculture (4th world rank, 5.63% contribution), plant & animal sciences (8th rank, 3.13%), energy & environment (11th rank, 1.97%) and biology & biochemistry (14th rank, 1.51%). It ranks 2nd following China closely, in materials science, chemistry, physics, geosciences, pharmacology & toxicology, space sciences, mathematics, molecular biology and immunology. In terms of relative citations impact, both India and China lag behind other developing countries, particularly Latin American countries, South Korea, Taiwan, Singapore and South Africa.

- To conclude, concentrated efforts are required for improving the quality and quantity of research output in the country. India needs to build up more effectively its scientific capacity, competence, and knowledge base to bridge scientific and technological gap with developed countries. **Achieving this will depend in part on the increased investment in R&D and higher education for strengthening the educational and R&D infrastructure, and in part on increased deployment of qualified S&T manpower, better interaction amongst the various S&T sectors, and increased scientific cooperation between developed and developing countries.**

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Institution	Total Papers			CQI		
	85-86	93-94	01-02	85-86	93-94	01-02
COCHUC	44	134	203	0.71	0.58	0.96
ANDHUW	195	138	205	1.28	1.02	0.94
GURUUA	109	67	214	0.61	0.94	0.94
MC-KGM-MAN	31	93	103	0.96	0.86	0.84
BOMBUB	191	221	423	0.94	1.02	0.82
ALIGUA	270	235	251	0.92	0.84	0.81
MYSOUM	128	95	243	2.41	1.36	0.81
OSMAUH	222	203	159	0.87	1.11	0.71
CHCHUH	309	280	193	0.63	0.48	0.70
PANJUL	321	296	153	0.51	0.49	0.68
GORAUG	184	96	81	0.61	0.46	0.62
MC-GMC-CHAN	0	0	103	0.00	0.00	0.62
				1.00	1.00	1.00

For abbreviations, kindly refer to Appendix 5.3

The 10 leading institutions ranked according to their CQI during 2000-01 were: Hyderabad University (1.99), Pune University (1.48), Madras University (1.47), Panjab University, Chandigarh (1.39), Christian Medical College, Vellore (1.37), Delhi University (1.35), Jadavpur University, Kolkata (1.32), Jawaharlal Nehru University, New Delhi (1.32), Anna University, Chennai (1.29) and Banaras Hindu University, Varanasi(1.23) (Table 5.16). A complete profile of select major institutions of Universities & Colleges sector in terms of total papers, number of collaborative and international papers, average IF per paper and average citation per paper is given in Appendix – 5.1 and 5.2.

Findings & Recommendations

Findings

- **The national publications share of the Universities & Colleges sector has declined during 1985-86 to 2001-02.** The Universities & Colleges sector is largest of all the S&T sectors in the country in terms of publications productivity and institutional participation. However, its share in the total papers published in the country has declined from 52% in 1985-86 to 46% in 2001-02, which may be attributed to its slow publications growth rate (35.6%), compared to other sectors of S&T.

- **Highly skewed publications activity.** The publications activity of the Universities & Colleges sector is highly skewed. Nearly 73% of its publications output was from 80 institutions alone and the remaining 27% was from the 1592 institutions in 2001-02. It implies that majority of the institutions in this sector are the low publications productivity institutions.

- **Universities dominate all other constituents in the Universities & Colleges sector in terms of publications output.** Although the universities comprise the largest constituent of the Universities & Colleges sector, their publications share in the sector has declined from 71% in 1985-86 to 68.5% in 2001-02. Colleges contributed the second largest publications share (22.4% in 1985-86, 18.6% in 1993-94, and 26.9% in 2001-02), followed by the medical colleges (6.34% in 1985-86, 8.16% in 1993-94, and 10.4% in 2001-02). The contribution of the other constituents of this sector had rather been small (0.2% to 2.2%).

- **Research activity in the general colleges has grown faster than in the universities.** General colleges have shown higher growth rate (62.7%), compared to universities (31%) segment in publications output during 1985-86 and 2001-02.

- **Universities & Colleges sector is still not publishing enough research papers in the high impact journals.** Nearly 80-83% research output of this sector is published in low impact journals (IF between 0.001 and 1.999), 6-10% in medium impact journals (IF between 2 and 3.999), 3.6-12.5% in zero impact journals, and only upto 0.6 - 3% in high impact journals (IF 4 and above) during 1985-86 to 2001-02.

- **Universities & Colleges sector papers largely receive low citations.** About 96% papers by this sector are low to medium cited papers (received 1 to 19 citations per paper within 10-19 years of their publication) or zero cited papers. Only a small proportion of papers (3.7%) are cited frequently (received 20 or more citations per paper within 10-19 years of their publication). The low citation frequency of the sector might be due the fact that bulk of its research output appears in low impact journals.

- **Chemistry, physics, engineering, and clinical medicine have been the high productivity areas of research in the Universities & Colleges sector.** The publications share of these subjects had been above the sector's average in 2001-02.

- **Engineering and clinical medicine** are the high productivity areas of the Universities & Colleges sector, but publications activity of this sector in these areas is still less than the country's average.

- **The publications share of the Universities & Colleges sector in agricultural sciences and biology is on the decline.** The activity index of this sector in agricultural sciences and biology had been above the country's average, despite its declining research output. The decline in agricultural sciences publications output is a matter of serious concern, more so because country has large number of well-established agricultural universities and colleges engaged in the research However, it may be mentioned here that decline observed in the present study in publications output in agricultural sciences may not be necessarily due to lower research output, but may also be due to the low coverage of agricultural sciences journals in the *Web of Science* database, which has been considered for the present study.

- **Universities lag behind other sector constituents in collaborative research activity.** Universities share of collaborative research output has been the lowest, compared to other constituents of this sector. Besides, collaborative research at international level is also on the decline in the Universities & Colleges sector.

Recommendation

- Inter-University Centres under the Universities & Colleges sector are a good model to emulate for planning and organizing research activity in the country, in terms of quantity and quality of research output.

9

Findings and Recommendations

This report provides a quantitative and qualitative analysis of the progress of Indian S&T, as reflected in the publications output reported in mainstream national and international journals. The main objective of the report is to examine the status of S&T in the country in relation to its stronger and weaker areas of research, quantity & quality of research, and dynamics of research across institutions, sectors, geographical areas and subjects. Such a study is significant and useful for science planners & policy-makers for gaining macro insights into the country S&T system.

Chapter 1 reviews the progress and status of Indian S&T as seen from Indian and global studies/ reports on the measurement of S&T research output, and it identifies the factors underlying the growth, stagnation and decline in Indian S&T. It also places in context the reasons for undertaking the present study. Chapter 2 describes the database that has been searched for capturing Indian research output, and the methodology followed in studying and analyzing the data. It also defines indicators and classification that have been used for comparing different sets of data and drawing inferences. Chapter 3 describes the position of India vis-à-vis other developed and developing countries in terms of economic status, education & training strength, financial & manpower resources devoted to S&T, publication strength and citation visibility in overall S&T as well as across broad subject fields. Chapter 4 describes the broad characteristics of publications output of Indian S&T in terms of size and growth characteristics, the type of institutions participating, their pattern of research communication, concentration and scattering in institutional productivity, quantifying publications output by type of institutions, sectors, subjects and geographical areas, nature of collaboration, and measurement of quality in terms of average impact factor and citations per paper. Chapter 5 to 8 discuss about the different sectors of S&T *i.e.* Universities & Colleges, mission-oriented R&D, Institutes of National Importance (INI), and Industry, in terms of size and growth characteristics, role of their constituents, contributions across broad subjects, impact and quality of research efforts, patterns of collaborative research, and quantitative & qualitative assessment of major participating institutions. Chapter 9 gives the findings and recommendations emerging from the report.

It may be pointed out here that there are limitations in analyzing research trends by using publications output. This is because bibliometrics, informetric and scientometric techniques/methods employed do not take into account the other outputs of research efforts, such as technology know-how, patents, new or improved products, devices, processes, etc. However, publications in journals have remained the most favored data source for mapping, despite limitations in quantitative techniques, generally used.

Salient Results on Indian S&T as Reflected in Publications covered by International Multidisciplinary & Subject Databases

(1) Publications Output and Growth

The S&T activity in the country is picking up, both in terms of growth rate and quantity of publications output, as reflected in the following observations:

India achieved publications growth rate of 2.51% annually during 1985-2005 as reflected in *Web of Science* database. The growth rate has more than doubled (5.4%) in 10 years 1995-2005, and quadrupled (10.1%) in recent five years 2000-2005.

Its decennial publications growth as derived from international multidisciplinary databases such as *SCI* and the *Web of Science* was nearly 73% during 1996-2005. Its publication output had increased from 11177 to 19448 papers in *SCI* and from 16486 papers to 28603 papers in *Web of Science* during the corresponding period.

India showed 6-8% growth rate on its five-yearly cumulative output in *Web of Science* during 1986-90 to 2001-05, but its growth rate swung to 32% in the recent five-yearly output during 1996-2000 to 2001-2005.

India's publications output is expected to touch 38000 papers per year by 2010, based on the forecast made on 15 years annual publications data reported in *Web of Science*, 1990- 2005.

India's publications share in world research output, as reflected in international multidisciplinary S&T databases has improved in recent years and has grown from 1.68% to 1.77% (*SCI*) and from 2.03% to 2.08% (*Web of Science*) from 1993 to 2003.

Compared to international multidisciplinary S&T databases (wherein India's contribution is around 2%), India's publications share in international subject databases has also shown improvement. In engineering sciences (COMPENDEX), its publications output has increased from 2421 papers to 8248 papers (3.5 times increase) and world share from 2.03% to 2.55% during 1993-2003. In medical sciences (PubMed), its publications output has increased from 2533 to 6768 (2.6 times increase) and world share from 0.58% to 1.20% during 1995-2004, and in agricultural sciences, its publications output has increased from 10763 to 13631 and world share from 7.32% to 7.48% during 1994-2003.

India's annual publications growth in international subject databases during recent 10 years, 1993-2003 was 15.8% in engineering sciences, 13.2% in medical sciences, 3.1% in chemical and physical sciences, and 2% in agricultural sciences. In last five years (1999-2003), it was comparatively faster, 17.38% in engineering sciences, 15.7% in medical sciences, 6.4% in physical sciences, and 5.6% in chemical sciences.

Evidently, the scientific activity in the country has been growing and its pace has been relatively faster in recent years than in earlier periods. The study shows that there is a positive growth trend in the publications output in S&T in India, which is contrary to the earlier studies reporting decline and stagnation in Indian S&T during 1985-2000.

(2) India's Strengths and Weakness in Publications Productivity & Quality in S&T in Comparison with Other Developing Countries

India along with China leads the developing countries in S&T in majority of subject fields. India tops in publications productivity among developing countries in four broad subject fields. Based on cumulative publications output during 1993-2003 (*Web of Science* data), these subjects were: agriculture (4th world rank, 5.63% contribution), plant & animal sciences (8th world rank, 3.13% contribution), energy & environmental sciences (11th world rank, 1.97% contribution) and biology & biochemistry (14th world rank, 1.51% contribution).

India ranked 2nd in publications productivity amongst developing countries, following China, in materials science (8th world rank, 3.56% contribution), chemistry (8th world rank, 3.62% contribution), physics (9th world rank, 2.26% contribution), geosciences (11th world rank and 2.31% contribution), pharmacology & toxicology (13th world rank, 1.89% contribution), space sciences (13th world rank, 1.55% contribution), mathematics (8th world rank and 3.56% contribution), molecular biology & genetics (19th world rank and 0.76% contribution), and immunology (20th world rank and 0.7% contribution) and 3rd in engineering (11th world rank and 2.39% contribution) and microbiology (17th world rank and 1.42% contribution).

India is devoting comparatively fewer resources to S&T: India is devoting fewer financial and human resources to S&T compared to China. In addition, its annual increase in manpower and financial resources for R&D is not commensurate with the size and growth of its R&D infrastructure. As a result, its publications productivity lags behind that of China's.

India and China lag behind major developing countries in publications quality: In terms of relative citations impact, both India and China lag behind other major developing countries, particularly South Korea, Taiwan, Singapore, South Africa, Brazil, Mexico, Argentina and Chile. To increase the quality of its publications, India has to upgrade the skills of the existing R&D manpower through in-house training and higher education, create opportunities for brilliant scientists and post-doctoral students from developed countries and other developing countries to work in Indian institutions, invite diasporas scientists to work on short-term assignments in India, and increase its international collaborative programs and linkages with developed and developing countries and international organizations.

India lags behind major developing countries in the rise in its publications share in world output: India still lags behind countries like China, Brazil and South Korea as their world share in publications output has been increasing constantly over the years, both in international multidisciplinary and subject databases (covering agricultural, chemical, physical, medical and engineering sciences). To catch up with the leading developing countries, the country needs to evolve strong and effective research strategies to achieve a higher annual publications growth and also significantly improve its publications quality.

Salient Results on S&T as seen from the analysis presented in the Study

(3) India has strong infrastructure, wide institutional participation and large R&D manpower deployment across various geographical regions in the country

India has a widely spread-out research base with a large number of participating institutions. It has invested heavily in building its S&T infrastructure, institutional capacity, and instrument and laboratory facilities. Its institutional participation in research has increased from 1734 in 1985-86 to 3443 institutions in 2001-02, at a growth rate of 98.5%. However, its large R&D manpower is fast depleting, due to lack of fresh recruitment, and retirement of scientists upon superannuation. Besides, the institutional management has failed to evolve policies to help scientists upgrade their knowledge, and to catch up with modern developments in various fields. It has not been able to create attractive system of incentives & rewards that could motivate the scientists to contribute effectively.

The country has only few institutions of excellence, in spite of wide institutional base. As much as 80% of the country's publications output was contributed by less than 10% (310 institutions), out of 3443 institutions that participated in research activity during 2001-02. It clearly reveals that a large section of S&T institutions do not contribute enough. There is need to create and enlarge the base of institutions, capable of giving higher publications output as well as catalyze research activity in the small & medium productivity institutions, for ensuring higher publications output.

Only 24 high productivity institutions rule the rankings. There are only 24 institutions, which published 300 or more papers during 1985-86 or 1993-94 or 2001-02. On analyzing the publication quality of these institutions, in terms of average IF and citations per paper, share of collaborative and international collaborative papers, ten best performing Indian institutions in S&T are: Jawaharlal Nehru Centre for Advanced Scientific Research (Bangalore), Tata Institute of Fundamental Research (Mumbai), University of Hyderabad (Hyderabad), Indian Institute of Science (Bangalore), Saha Institute for Nuclear

Physics (Kolkata), University of Madras (Chennai), Indian Institute of Technology (Bombay), Indian Association for the Cultivation of Sciences (Kolkata), Indian Institute of Technology (Kanpur), and Indian Statistical Institute (Kolkata).

Institutions engaged in S&T research are not evenly spread-out geographically in the country. The states such as Maharashtra, Delhi, Karnataka, Uttar Pradesh, Tamil Nadu, West Bengal and Andhra Pradesh together accounted for three-fourth of the total country's research output during 1985-86 to 2001-02. Of these, only Tamil Nadu and West Bengal witnessed rise in their national publications share during the corresponding period. Except Uttar Pradesh and West Bengal, these states have shown publications growth above the country average. The states, namely Kerala, Gujarat, Madhya Pradesh, Chandigarh, and Rajasthan (each with 2-3% share) together contributed only 15% publications share (less than the Maharashtra publications share alone). Some states, such as Orissa, Haryana, Punjab, Bihar, Assam, Pondicherry, Himachal Pradesh, Goa, and Jammu & Kashmir were the low productivity states with their combined share was 10.5% (almost equal to that of West Bengal) in 2001-02. Except Assam, these low productivity states witnessed decrease in their national publications share during 1985-86 to 2001-02.

Regional disparities in publications productivity could be addressed through a more balanced allocation of financial and manpower resources and by further strengthening the S&T infrastructure, especially in low & medium productivity states.

India's research output is spread-out in too many peer-reviewed journals and their numerical strength has been consistently increasing with time. Its publications output was reported in 2113 international peer-reviewed journals in 1985-86, which rose to 2558 in 1993-94, and to 3359 in 2001-02. **Of these, foreign journals reporting Indian output far exceeded journals of Indian origin.** India's publications output had appeared only in 26 journals of Indian origin in 1985-86 (out of a total of 2113 journals), 44 in 1993-94 (out of a total of 2558 journals), and 49 in 2001-02 (out of a total of 3359 journals). The numerical strength of Indian journals reporting India's publications output increased by 88% in sixteen years (1985-86 to 2001-02). On the other hand, India's research output appearing in journals of Indian origin declined from 28.4% (of total 6586 papers) in 1985-86 to 21.5% (of total 7582 papers) in 2001-02.

There is a need to strengthen Indian journals, in terms of better management, strong and effective peer-reviewed system, introduction of specialization in coverage, timely publication, timely review of papers, and international participation of scientists in editorial boards and introduction of open access system.

(4) Strengths & Weakness of S&T Sectors in India

Research in S&T in India is an institutional activity. In India, like in many other developed & developing countries, research is an institutional activity having participation from various institutional bodies, such as Institutes of National Importance (INI), Universities & Colleges, mission-oriented R&D, Industry and Others.

Publications strength of the various S&T sectors: The Universities & Colleges sector contributed the largest share to the country publications output (52.2%), followed by mission-oriented R&D (28.3%), Institutes of National Importance (17.2%), and Industry (1.78%) sectors in 1985-86. This pattern of publications output in the country persisted during all the three periods of study 1985-86, 193-94, and 2001-02.

Growth & decline in the publications share of S&T sectors in the country output: Among the S&T sectors, the mission-oriented R&D sector witnessed the largest increase (9.56%) in its share to the country's output, followed by Institutes of National Importance (3.19%), and Industry (0.23%) sectors during the period from 1985-86 to 2001-02. Universities & Colleges sector, on the other hand, witnessed decline in their national publications share by 5.56% in the corresponding period.

Growth in publications output and institutional participation of various S&T sectors: Among S&T sectors, the mission–oriented R&D sector had shown the fastest publications growth rate of 102.9%, followed by Institutes of National Importance (79.8%), Industry (71.5%) and Universities & Colleges (35.6%) sectors in sixteen years during 1985-86 to 2001-02. Though the Universities & Colleges sector contributed the largest share to the country research output, yet its growth rate of 35.6% was less than the country average growth rate (51.7%). In contrast, in institutional participation from industry sector witnessed comparatively higher publications growth rate (121.15%) during 1985-86 to 2001-02, followed by Universities & Colleges (89.57%), mission-oriented R&D (49.52%), and Institutes of National Importance (8.33%) sectors, against the country's average growth rate of 98.56%.

Universities & Colleges Sector

National share of the Universities & Colleges sector has been declining for the last 16 years. The Universities & Colleges sector is largest of all the S&T sectors in the country in publications productivity and institutional participation. However, its publications share to the country output declined from 52% in 1985-86 to 46% in 2001-02. Its publications growth rate had also been the slowest (35.6%) during sixteen years period from 1985-86 to 2001-02, and was also below the country average growth rate (51.7%) during the corresponding period.

Universities dominate all other constituents in the Universities & Colleges sector in terms of publications output. The universities segment contributed the largest publications share in the Universities & Colleges sector. Its publications share, however, is on the decline, from 71% in 1985-86 to 68.5% in 2001-02. Colleges contributed the second largest publications share, 22.4% in 1985-86, 18.6% in 1993-94, and 26.9% in 2001-02, followed by medical colleges (6.34% in 1985-86, 8.16% in 1993-94, and 10.4% in 2001-02). The publications share of remaining constituents of the sector, *viz*, inter-university centers, deemed universities and special institutions, had been rather small, ranging between 0.2% and 2.2%

Publications output is growing faster in general colleges than in universities. General colleges have shown higher publications growth (62.7%), compared to universities segment (31%) in sixteen years during 1985-86 and 2001-02.

Mission-Oriented R&D Sector

Of all the S&T sectors in the country, the mission-oriented R&D sector is the second largest in terms of publications output in S&T.

The R&D sector comprises two constituents. (i) R&D agencies/departments and their institutions, and (ii) research institutions/departments supported by socio-economic ministries/state governments and both differ in their research priorities.

The R&D agencies/departments comprise Council of Scientific and Industrial Research (CSIR), Department of Atomic Energy (DAE), Indian Council of Agricultural Research (ICAR), Department of Science and Technology (DST), Indian Council of Medical Research (ICMR), Department of Space (DOS), Defence Research and Development Organization (DRDO), Department of Biotechnology (DBT), Department of Electronics (DOE), and Department of Ocean Development (DOD).

The socio-economic ministries under central/state governments comprise Ministry of Health & Family Welfare (MHFW), Ministry of Mines (MOM), Ministry of Human Resource Development (MHRD), Ministry of Information & Communication Technology (MOIT), Ministry of Environment, Forests & Wildlife (MOEN), Ministry of Textiles (MOTX), Ministry of Water Resources (MWR), Ministry of Non-Conventional Energy Sources (MNES), Ministry of Power (MOP), Ministry of Petroleum & Natural Gas (MPNG), and Department of Culture (DOCU).

R&D sector has shown the fastest publications growth rate (102.9%) in sixteen years during 1985-86 to 2001-02, compared to other competing S&T sectors. Its publications growth was twice the average publications growth rate of the country (51.7%).

Of all the socio-economic ministries/departments in the R&D sector, the Ministry of Health & Family Welfare made the largest contribution. It contributed 38.3% publications share in 1985-86, 31.6% in 1993-94 and 46.7% in 2001-02 to the sector output.

Of all the R&D agencies/departments in the R&D sector, the Council of Scientific & Industrial Research (CSIR) had been the largest contributor, followed by DAE, DST, ICAR, DRDO, DOS, ICMR, and DBT.

The R&D sector in the country has very few high productivity institutions, publishing, say, 100 or more papers. Among the high productivity research institutes, the top 10 ranked on composite quality index are: Jawaharlal Nehru Centre for Advanced Scientific Research (Bangalore), Institute of Physics (Bhubaneswar), Tata Institute of Fundamental Research (Mumbai), Physical Research Laboratory (Ahmedabad), Indian Institute of Astronomy (Bangalore), Saha Institute of Nuclear Physics (Kolkata), Centre for Chemical & Molecular Biology (Hyderabad), S N Bose National Centre for Basic Sciences (Kolkata), Indian Association for the Cultivation of Sciences (Kolkata) and National Physical Laboratory (New Delhi).

Institute of National Importance (INI) Sector

The 13 INI sector institutes participated in research in S&T during 1985-86 to 2001-02. The INI institutes are divided in three broad subject groups: (i) Seven devoted to engineering & technology, (ii) four to medical sciences and (ii) two to overall S&T. The engineering & technology institutes are: Indian Institutes of Technology at Bombay, Delhi, Gauhawti, Kanpur, Kharagpur, Madras, and Roorkee. The medical sciences institutes are: All India Institute of Medical Sciences (New Delhi), Post Graduate Institute of Medical Education and Research (Chandigarh), Sree Chitra Tirunal Institute for Medical Sciences and Technology (Thiruvananthapuram), National Institute of Pharmaceutical Education and Research (Mohali, Punjab). The institutes devoted to overall S&T are: Indian Institute of Science (Bangalore) and Indian Statistical Institute (Kolkata).

Of all the S&T sectors of the country, the INI sector is the third largest in S&T in terms of publications output.

The INI sector has registered the second fastest publications growth rate (79.8%) in the country during 1985-86 to 20001-02.

Amongst various categories of INIs, the largest publications output had come from institutes devoted to engineering & technology. However, their combined publications share declined from 57.6% in 1985-86 to 51.1% in 2001-02. In contrast, the publications share of institutes devoted to overall S&T and medical sciences increased from 26.3% to 28.7% and 16.1% to 21.7%, respectively during 1985-86 to 2001-02.

Growth & stagnancy in publications share of INIs: Among the seven institutes devoted to engineering & technology, only Indian Institute of Technology (Bombay) and Indian Institute of Technology (Roorkee) had shown rise in their publications share, while others showed decline or stagnancy in their share during the three periods of study. Among medical sciences institutes, except Post Graduate Institute of Medical Education and Research (Chandigarh), all others have improved their publications share during 1985-96 to 2001-02. Amongst institutes devoted to overall S&T, Indian Institute of Science

(Bangalore) has shown marginal decrease and Indian Statistical Institute (Kolkata) marginal increase in their publications share.

Industry Sector

The Industry sector contributed a very small publications share (2%) to country output in S&T. However, it is the fourth largest contributor to the publications output in S&T in the country.

The private sector enterprises are more active in research compared to public sector. The private sector enterprises contributed larger publications share to the industry sector, compared to the public sector. Their publications share rose from 63.9% in 1985-86 to 76.2% in 2001-02, whereas the public sector enterprises had shown decline in publications share from 36% to 23.7% during the corresponding period.

(5) Quality of Research Output –Impact Factor per Paper

Although India's publications quality, as reflected in its average impact per paper, has shown improvement with time, its major publications output continues to appear in zero and low impact journals. But its share in such journals had declined from 90.8% to 79.8% during 1985-86 to 2001-02. In contrast, India's publications share in medium and high impact journals has increased from 8.13% to 15% and 0.96% to 5.12% during the corresponding period. The rise in India's share in medium and high impact journals corresponds well with the rise in average impact per paper of the country from 0.748 to 1.229 during 1985-86 to 2001-02.

The mission-oriented R&D sector has substantially reduced its share of papers (from 88.1% to 73.3%) published in zero and low impact factors journals, followed by Institutes of National Importance (from 87.6% to 76%), Industry (from 90.8% to 79.8%), and Universities & Colleges (from 93.4% to 86.8%) sectors during 1985-86 to 2001-02.

Of India's papers published in medium and high cited journals, the maximum increase in their publications share (10.6% to 19.3% and 1.25% to 7.32%) was registered by mission-oriented R&D sector, followed by Institutes of National Importance (from 11% to 18.88% and 1.33% to 5.13%), Universities & Colleges (5.88% to 10.1% and 0.65% to 3%), and Industry (6.57% to 8.94% and 0.73% to 2.7%) sectors during 1985-86 to 2001-02. This trend also corresponds to rise in the average impact factor per paper of the mission–oriented R&D sector (from 0.869 to 1.454), followed by the Institutes of National Importance (from 0.91 to 1.37), Universities & Colleges (from 0.631 to 0.975), and Industry (from 0.644 to 0.945) sectors during 1985-86 to 2001-02. It indicates that the quality of publications output has improved all over the country.

Amongst the constituents of mission-oriented sector, the average impact factor per paper of the R&D agencies/departments is higher than that by socio-economic ministries/departments. The average impact factor per paper for R&D agencies/departments was 0.901 in 1985-86, 0.971 in 1993-94, and 1.479 in 2001-02. Among the R&D agencies/department, the largest increase (from 1.39 to 2.74) was reported by institutions affiliated to Department of Biotechnology, followed by departments of Science & Technology (from 1.33 to 1.92), Indian Council of Medical Research (from 0.86 to 1.84), and Department of Atomic Energy (from 1.31 to 1.79) during 1985-86 to 2001-02. On the other hand, the average impact factor per paper for publications by socio-economic ministries/departments was 0.706, 0.768, and 1.357, respectively during the corresponding period. The leading socio-economic ministries were Department of Culture, Ministry of Health & Family Welfare and Ministry of Information & Communications Technology, as they showed average impact factor per paper above the country's average in 2001-02.

Amongst the broad subject categories of institutions under Institutes of National Importance, the institutes devoted to medical sciences registered the maximum increase in their average impact factor per paper (from 1.04 to 1.61), followed by institutes devoted to overall S&T (from 1.14 to 1.72), and engineering & technology (from 0.77 to 1.08) during 1985-86 to 2001-02

Among the various constituents of the Universities & Colleges sector, inter-university centers registered the maximum increase (0.0 to 1.91) in impact factor per paper, followed by medical colleges (from 1.13 to 1.46), universities (from 0.64 to 0.97), deemed universities (from 0.56 to 0.71), and general colleges (0.45 to 0.80) during 1985-86 to 2001-02.

(6) Quality of Research Output –Average Citations per Paper

India's publications quality, measured in terms of average citations received per paper within (10-19 years of their publication) has improved though marginally from 4.92 to 5.25 during 1985-86 to 1993-94. A very high percentage of country publications (67.7% to 77.7%) received zero or low (1-4) citations per paper. However, the share of papers which received citations in medium range (5 – 19 citations per paper) has increased from 24.14% to 26.8%, and its share of papers in high-cited papers range (20 or more per paper) increased only marginally from 4.8% to 5.4% during the corresponding period.

Sector-wise, publications share of mission–oriented R&D sector substantially declined in zero and low citations range (from 67.5% to 62.9%), followed by Institutes of National Importance (from 64.7% to 60.6%), Industry (from 75.1% to 71.3%), and Universities & Colleges (from 71.7% to 67.7%) sectors during 1985-86 to 1993-94. In the medium and high-cited papers range, the rise in publications share was the largest (from 26.2% to 29.9% and from 5.4% to 6.23%) in the mission-oriented R&D sector, followed by Institutes of National Importance (28.3% to 31.6% and from 6.89% to 7.2%), Universities & Colleges (22.4% to 23.3% and from 3.35% to 3.7%), and Industry (19.7% to 24.8% and from 3.83% to 5.09) sectors during the period from 1985-86 to 1993-94.

The publications quality was also measured in terms of average citations per paper. The mission-oriented R&D sector showed the largest rise (from 5.63 to 6.25) in average citations per paper, followed by Institutes of National Importance (5.97 to 6.5), Universities & Colleges (4.16 to 4.24), and Industry (4.05 to 4.29) sectors during 1985-86 to 1993-94. This, in overall, indicates that the quality of Indian publications output has increased only marginally.

In the mission-oriented R&D sector, the R&D agencies/departments showed better citations performance, compared to the socio-economic ministries/departments. The share of R&D agencies/departments, which received 20 or more citations per paper was between 6.8% and 7.4% during 1985-86 and 1993-94, compared to 2.7% and 3.7% by socio-economic ministries/departments during the corresponding period.

Amongst various R&D agencies/departments, DST supported institutions ranked at the top in terms of highest citations received per paper (3.698), followed by DBT (3.464), DAE (3.438), ICMR (3.038), CSIR (2.767), DOS (2.511), DRDO (1.424), ICAR (0.966), and DOE (0.333) in 2001-02. The citations window for computing citations performance of various R&D agencies/departments was 2-3 years.

Amongst various socio-economic ministries, the Department of Culture supported institutions ranked at the top in the highest citations received per paper (23.5) in 2001-02, followed by DCP (3.31), DOC (3.17), MPNG (3.11), MOIT (3.09), MHFW (2.16), MOP (1.35), MOM (1.32), MOEN (1.29), MHRD (1.27), MWR (0.83), MOTX (0.44), MOT (0.43), and DCA (0.29). The citations window for computing citations performance of various socio-economic ministries was 2-3 years.

Among INIs, the largest increase (from 8.08 to 8.72) in average citations per paper was achieved by institutes devoted to overall S&T, followed by medical sciences institutes (from 5.69 to 6.97) and engineering & technology institutes (from 5.08 to 5.11) during 1985-86 to 1993-94

Among the various constituents of the Universities & Colleges sector, the largest increase (from 0.0 to 8.2) in average citations per paper was registered by inter-university centers, followed by medical colleges (from 5.11 to 5.72), and universities (from 4.41 to 4.37) during 1985-86 to 1993-94.

(7) Subject Areas of Strengths & Weaknesses in Indian S&T System

Chemistry, physics, and engineering were the high productivity areas of research in S&T and had shown consistent rise in their national publications share during 1985-86 to 2001-02. Agriculture, biology, basic life sciences, clinical medicine, biomedical sciences and earth & environmental sciences were the medium productivity areas. Mathematics and computer science were the low productivity areas of research in S&T.

Among the broad subject areas, clinical medicine, basic life sciences and biomedical sciences registered faster growth in publications output, compared to other areas of S&T. Clinical medicine registered the highest publications growth rate of 141.6%, followed by basic life sciences (81.6%), and biomedical sciences (76.4%), compared to country's average publications growth rate of 51.7% in sixteen years during 1985-86 to 2001-02.

In the Universities & Colleges sector, chemistry, physics, engineering, and clinical medicine had been the high productivity areas of research. Their publications share in these subjects had been above the sector's average in 2001-02. In **engineering and clinical medicine,** the publications activity was less than the country's average. **The publications share and activity index of the Universities & Colleges sector in agricultural sciences and biology had although declined,** but their activity index had been above the country's average. It implies that despite their declining publications share, these subjects are still being pursued actively in this sector. The decline in the publications output of agricultural sciences observed may not represent the actual decline and also be due to decreasing trend in coverage of agricultural sciences journals in the *Web of Science* database (used in the present study) over the years.

The R&D sector has outperformed other sectors in subjects such as physics, basic life sciences, and earth & environmental sciences. In these areas, it has gained competitive edge over other sectors, in terms of their overall publications activity. However, in other subject areas, the R&D sector lags behind other sectors.

Engineering, physics, chemistry and clinical medicine are the leading areas of research of the INI sector. In physics and clinical medicine, the publications output of this sector had shown rising trend. But, in engineering (from 34.5% to 33.5%) and chemistry (from 21.9% to 19.4%), publications output had witnessed declining trend during 1985-86 to 2001-02.

The INI sector has gained competitive edge in a few subject areas only. In comparison to other competing S&T sectors, the INI sector has shown competitive edge in physics, mathematics, engineering, clinical medicine, and computer science. But, **agricultural sciences, basic life sciences, biology, biomedical sciences and chemistry have been its weaker areas.**

Engineering and chemistry have been the high productivity areas of research of the Industry sector during 2001-02. Its publications share in these subjects had been above the country's average (8.3%). But in other subjects, such as computer science, biomedical science, basic life sciences, and earth & environmental sciences, its publications activity had been below the country's average.

Substantial increase has been reported in the country's publications output in new and frontier areas such as biotechnology, drugs & pharmaceuticals, material sciences, and medical sciences. These fields have significant applications for strategic and industrial development, and in research aimed at improving the quality of human life. In biotechnology and applied microbiology, the country registered more than three-fold increase from 199 to 723 papers during 1985-86 to 2001-02. In pharmacy & pharmacology, substantial increase was registered from 337 to 923 papers, and in medicinal chemistry from 128 to 361 papers. In materials science, three-fold increase in publications output was witnessed from 715 to 2305 papers during 1985-86 to 2001-02. In addition, chemical engineering witnessed increase from 249 to 760 papers, telecommunications from 47 to 211 papers, and artificial intelligence from 16 to 80 papers during the corresponding periods. In infectious diseases, the country registered increase from 43 to 183 papers, oncology from 125 to 361 papers, ophthalmology from 26 to 236 papers, urology & nephrology from 30 to 186 papers, radiology & nuclear medicine from 94 to 239 papers, surgery from 151 to 590 papers, and hematology from 33 to 105 papers during 1985-86 to 2001-02. In water resources, the country witnessed increase from 116 to 607 papers, and in environmental engineering from 25 to 139 papers during the corresponding period.

(8) Collaborative Research Profile

The country has witnessed significant growth in its collaborative research output (from 1700 papers to 14104 papers) as compared to growth rate of its total papers in 16 years during 1985-86 and 2001-02, and nearly 84% of this increase occurred in the recent eight years, 1993-94 to 2001-02. The collaborative papers showed growth rate at 729%, which was 14 times higher than the growth rate of total papers in the country (51.8%) in 16 years, during 1985-86 and 2001-02. The collaborative papers share in the total country's output has increased nearly 6 times, from 7% to 40%, during the corresponding period.

The country share of papers through national collaboration is greater than its share through international collaboration. The share of papers through national collaboration increased from 996 to 8109, witnessing 714.15% growth rate during 1985-86 to 2001-02. The increase in its papers through international collaboration was from 704 to 5993 (751.27% growth) during the corresponding period. The publications share of country's papers through national collaboration increased from 4.3% to 23.07% during 1985-86 to 2001-02, whereas its share of internationally collaborative papers increased from 3.04% to 17.05% during the corresponding period.

The number of countries with which India had collaboration in S&T has increased from 70 in 1985-86 to 113 in 2001-02, as reflected in its co-authored papers.

Among the broad subject areas, the largest collaborative activity, measured in terms of the number of collaborative papers and share in the country's output was witnessed in physics (1922 papers, 28.28% share), followed by chemistry (1176 papers, 13.62% share), engineering (1115 papers, 15.85%

share), basic life sciences (709 papers, 19.10% share), clinical medicine (550 papers, 13.30% share), earth & environmental sciences (409 papers, 18.00 share), and biomedical sciences (391 papers, 13.07% share) during 2001-02. The largest increase in share of collaborative papers during 1985-86 to 2001-02 was in physics (from 4.16% to 28.28%), followed by basic life sciences (from 4.85% to 19.10%), earth & environmental sciences (2.87% to 18.0%), engineering (from 1.79% to 15.85%), chemistry (from 3.08% to 13.62%), and clinical medicine (from 4.27% to 13.20%.

India's collaborative research in S&T with Europe and Asia has increased during 1985-86 to 2001-02. USA continues to be the India' s largest collaborating partner, followed by Germany, UK, Japan, France, Canada, Italy, and Australia. Among developing countries, India's leading collaborating partners are Taiwan, China, South Korea, Brazil, Singapore, and Malaysia. India's collaborative publications share has registered decline with USA, Canada, UK, Russia, and Italy. On the other hand, its share with Germany, France, Netherlands, Switzerland, Spain, Sweden, Belgium, Denmark, Poland, Hungary, Norway, and Finland has increased. The country's publication share with Japan, Taiwan, China and South Korea has also increased.

Comparing various S&T sectors for their performance in collaborative research during 1985-86 to 2001-02, the highest growth rate (1017%) in collaborative papers was registered by mission-oriented R&D sector, followed by Universities & Colleges (726%), Institutes of National Importance (620%), and Industry (609%) sectors. In terms of rise in share of collaborative papers in total papers during 1985-86 to 2001-02, the largest (from 14.8% to 61.6%) rise was from Industry sector, followed by mission-oriented R&D (from 8.5% to 46.8%), Universities & Colleges (from 7.4% to 45.1%), and Institutes of National Importance (from 7.3% to 40.1%) sectors.

The maximum increase in the country's share of collaborative papers during 1985-86 to 2001-02 was registered by Industry (from 57% to 75%) sector, followed by Universities & Colleges (from 65% to 68%) sector. In contrast, the share of international collaborative papers has increased from 34% to 39% in mission- oriented R&D sector and from 39% to 43% in Institutes of National Importance sector during the corresponding period.

Collaborative research output by R&D sector is growing much faster than the rate at which the total national publications output is growing. The R&D sector had shown faster growth rate in collaborative research output (1017%), compared to growth at which the total output by the sector had grown (103%) during sixteen years from 1985-86 and 2001-02. The R&D agencies/departments and socio-economic ministries had also shown similar trends. However, the growth rate in collaborative research output by R&D agencies/departments (1126%) was faster than the growth rate in socio-economic ministries (544%).

Collaborative research profile of the socio-economic ministries is better compared to that of R&D agencies/departments. The socio-economic ministries collaboration papers share was 15.9% in 1985-

86, 26.3% in 1993-94, and 59.2% in 2001-02. The R&D agencies/departments contributed 7.96%, 15.45% and 46.2% collaborative papers share during the corresponding period.

Among the R&D agencies/departments, CSIR, DAE, and DST reported greater share of collaborative papers during 1985-86, 1993-94, and 2001-02. However, the collaborative publications share of CSIR and DAE remained constant (around 31-32%) during the three periods of study, but DST showed a significant rise in share from 10% in 1985-86 to 19% in 2001-02. The other R&D agencies/departments had contributed only smaller share in the total collaborative output.

Universities lag behind other sector constituents in collaborative research activity. Universities share in the total collaborative papers of the Universities & Colleges sector has been the smallest compared to other constituents of the sector. Also, its share of internationally collaborative papers is also on the decline.

Implications & Recommendations

The key factors for catalyzing growth in S&T have been identified as greater institutional participation in research, greater national and international collaboration, creative scientific teams for innovative research, sophisticated laboratories and instrument facilities. There has been 100% rise in institutional participation in S&T research within a span of 16 years (from 1733 institutions in 1985-86 to 3443 in 2001-02). In research output, the country witnessed 51% rise (from 23153 to 35142 papers) during the same time interval. Collaborative research activity in the country has shown significant rise (729.6%) during the same period. Hence, for catalyzing growth and quality in research, efforts should be made to improve and nurture creativity of individuals and teams, may be by catching talent at young age, organizing training programs for the in-service staff, and rewarding team efforts. Sophisticated instrument facilities may also be made available to individuals and teams working in low and medium productivity institutions to improve their productivity.

Catalyzing Research Capacity & Potential

India has great potential in giving and sustaining still higher growth in S&T in the next 10 years. Given the scale and size of R&D infrastructure and its skilled and sizable manpower, India's current growth in S&T as measured in terms of publications output is indeed very low. The country must, therefore, plan for catalyzing its S&T activity, so that in the coming 10 years, it catches up with other leading countries in the world.

The country, therefore, needs to build up its scientific capacity, competence, and knowledge base to help bridging the scientific and technological gap with leading countries. Achieving this will depend, in part on the increased investment in R&D and in higher education, strengthening the educational and R&D infrastructure, increased deployment of qualified S&T manpower, better interaction amongst

S&T sectors, increased scientific cooperation with developed and developing countries, and stricter evaluation and monitoring system in promotions, in awarding degrees, research grants, and research projects.

Improve research capacity of universities and colleges: This is possible by further improving this sector, in terms of technical and computing infrastructure, course-content, teaching methods, faculty development in the emerging fields, allocation of funds in highly specialized areas, creating better linkages with R&D and other sectors, and by attracting bright talent at masters and doctoral level. This must be accompanied by strict criteria for the selection of students for Ph.D. programmes and their evaluation for the degree and in faculty evaluation for time-scale promotion. At least one or two papers in peer-reviewed journals should be made mandatory for every doctoral thesis, as that will result in enhancing the quality & quantity of Indian research output to some extent.

Strengthen low and medium productivity institutions. There is an urgent need to initiate a national plan to strengthen linkages between low and medium productivity institutions and bigger institutions, within their own geographical regions. This would also enable them to benefit from the rich experiences of bigger institutions, and use their equipment and facilities available in specific fields.

Plan for systematic R&D development in the country. There is a need to draw out long-term and short-term plans for R&D development in the country. The country needs to organize goal-oriented and need-based programs at the national and institutional level, as well as change its methods of deciding priorities for allocation of funds, particularly the extra-mural funding, and also the priorities for awarding research contracts. An element of competition should be brought into the bidding of funds for large-scale projects.

Effective models of S&T performance. Given their qualitative and quantitative performance in the publications output, the Institutes of National Importance and inter-university centers seem to be the effective models for influencing research activity in the country. They imbibe special features such as best in-take of students, faculty, ensuring best physical and technical infrastructure, sophisticated instrument and research facilities, combing teaching and research, stricter evaluation system, and selective areas of specialization.

Ensure better regional distribution of resources. The country needs a much better regional distribution of resources, in terms of funding support for creating new infrastructure, so that low and medium productivity states like Kerala, Gujarat, Madhya Pradesh, Chandigarh, and Rajasthan are also able to contribute.

Offer special packages to low and medium productivity states. The low and medium productivity states should be offered special packages to create and improve their research potential and capacity.

Develop new institutes and strengthen the existing ones especially in the low and medium productivity states on the model of Institutes of National Importance. To enhance the country S&T output, there is a need to strengthen the existing institutes in the low and medium productivity states as well as opening up new institutes in such states, on the pattern of inter-university centers or INI.

Upgrade science laboratories, improve internet connectivity, information access, course contents and quality of teaching, as this would improve the quality and quantity of research in universities and colleges.

Become internationally competitive. For this, selected research centers needs to be supported/ strengthened on long-term basis in selected areas.

Set up more centres of excellence. To attract talent and ensure quality in research, there is a need to establish centres of excellence on the pattern of inter-university centres or INI.

Improve research environment in research institutions. This may be achieved by introducing better award system, encouragement for creative work, goal-oriented research and flexile organizational system.

Introduce reforms and improve work environment. This may be achieved by enforcing transparency, uniformity of rules and consistency in their applications at all levels of career advancement in S&T, and by ensuring a world-class environment and R&D facilities, etc.

Better job opportunities. This is crucial for sustenance of science, preventing brilliant scientists leaving the country, and encouraging scientists working abroad to return to India

Agricultural research should receive higher priority. Given the special role that agricultural sector plays in strengthening the country's GDP and considering consistent decline in agricultural research, it is desirable that agricultural science be accorded higher priority in allocation of funds.

Increase accessibility to electronic resources in research organizations.

Gaining Competitive Edge in Science & Technology

Strengthen monitoring and evaluation system. There is a strong need to strengthen the monitoring and evaluation system, particularly in the universities & colleges to ensure that the output from funded projects is reported mainly in medium and high impact journals. Strict evaluation measures need to be evolved for ensuring good quality output from Ph.D. work and from the projects funded by national agencies. Provision of adequate budget to institutions for hiring doctoral and post-doctoral students may help in increasing their research output.

Encourage scientists to publish in select medium and high impact journals. Scientists publishing in high impact journals or receiving high citations must be rewarded. Further, introduction of high specialty journals should be encouraged in the country as this would help in arresting India's outflow of papers to foreign journals.

Review and strengthen current arrangements for international collaboration in S&T with developed and developing countries. Collaborative research, especially at international level must be encouraged for accelerating the pace of growth and for ensuring quality and quantity in research output. India's collaborative research with countries like the USA, UK, Russia, and Canada is on the decline, though it is on the rise with Germany, France, the Netherlands and Spain. New initiatives are needed to strengthen India's collaboration with select developed and developing countries.

Encourage institutes to set up open access archives to make their research results more widely accessible.

Introduce a system of professional review of proposals submitted for financial support under extra-mural funding schemes of R&D agencies/departments.

At the national level inter-institutional collaborative participation should be made compulsory, particularly for the large-scale funded projects under extra-mural programs of R&D agencies/departments.

Encourage mobility and collaboration among various sectors through extra-mural funding schemes of the R&D agencies/departments at the national level. Structural linkages between research institutes and universities need to be developed further for promoting two-way interaction. This may be achieved by allowing universities to have access to laboratory facilities of research institutes and scientists from research institutes to engage in teaching students in universities and also become joint or independent research supervisors for Ph.D work.

Augment international collaboration in a significant way. For enhancing international cooperation and collaboration, introduce new models and improve the existing models of international collaboration, such as those exist between India and USA, France, or Russia

Achieving Leadership in Cutting Edge Areas of S&T

India needs to achieve leadership in cutting-edge technologies in areas such as biotechnology, drugs & pharmaceuticals, material sciences, and medical sciences to remain competitive in the world. To develop cutting-edge technologies for strategic, industrial and societal applications, there is a need to evolve time-bound programs, capitalize on its existing strength in S&T, and create fresh potential by establishing new institutions of excellence in these specific areas on the pattern of INI or inter-university centres.

Pay focused attention on low and medium productivity areas of research. Agriculture science, biology, basic life sciences, clinical medicine, biomedical sciences and earth & environment science are the medium productivity areas of Indian science. Mathematics and computer science are its low productivity areas. There is a strong and urgent need to evolve new and effective strategies to improve research productivity in these areas.

Integrating smaller and medium productivity institutions with high productivity institutions. This report underlines the need to initiate a national plan to strengthen institutional linkages, wherein smaller productivity institutions could be integrated with bigger institutions within their own geographical regions, with a view to give smaller institutions new opportunities, to learn from the expertise in bigger institutions, besides using their experiences, equipments and facilities. For further improving the quantity and quality of research output, the country needs to organize goal-oriented and need-based programs at the national and institutional level.

Some other suggestions for achieving leadership in cutting edge technologies are:

- Infusion of young blood with good academic track record in the universities as teaching faculty.
- Make quantum jump in the student's fellowship for doctoral and post-doctoral studies in areas of national importance.
- Publishing in peer-reviewed, medium and high impact journals should be mandatory for Ph.D. awards.
- Enhance opportunities for exchange of information and inter-personal contacts to facilitate joint international collaboration in research.
- Encourage younger talent to go for post-doctoral research studies in advanced countries by providing adequate financial support.
- Increasing in number awards for younger scientists.

Bring Industry Participation in Research to the Center-Stage

There is a strong need to encourage industry's participation in research in different fields of S&T, by involving industries in the national network and sectoral programmes of the country. Research institutions and universities should be encouraged to undertake programmes of relevance to Indian industry preferably with their active participation.

Monitoring India's S&T Output for Inputs in Future S&T Policy Formulation

It is suggested that a comprehensive database on Indian S&T publications, balanced in the coverage of both local and international journals, be developed to present a total picture of India in S&T. Such a database could benefit national policy & planning process and also R&D funding agencies in judicious allocation of resources to researchers and institutions, and in linking of research output to funding sources. It could also be utilized to create research profiles of scientists by age, gender, social and educational background.

A centralized system of pooling publications data by individual research organizations, similar to that already existing for patents world-wide can be considered as one of the approaches to create a national database in S&T. Countries like China and South Africa have already taken such initiatives and as a result have been able to monitor their research output more effectively than those dependent on international databases. To evolve such a system, contributions from Indian institutions or individuals may be registered through voluntary efforts or it may be made mandatory through legislation.

Another option in creating a national database in S&T could be to harness data as reported and indexed in international multidisciplinary databases, such as *Science Citation Index* and *Web of Science*. This effort may be supplemented by bringing in new inputs from such national journals as are covered in international subject databases, and putting in place a new classification system.

It is also suggested that the country should bring out a biennial S&T indicator report on India based on publications output to monitor its status and progress in S&T. Besides, a laboratory should be established to study, evaluate and monitor the status and progress of Indian S&T on regular basis.

General Recommendation

Special working teams/task force might be required for examining in-depth the issues identified in the report and evolving the modalities for their implementation in academic and research institutions in the country.

Annexure V

MAJOR POLICY ISSUES AND RECOMMENDATIONS

SCIENTIFIC ADVISORY COUNCIL TO THE PRIME MINISTER (SAC-PM)

ANNUAL REPORT 2005-06

The Scientific Advisory Council to the Prime Minister (SAC-PM) was constituted on 27th January, 2005 and has successfully completed one year. So far, Council has met 12 times and discussed several important issues related to promotion of Science & Technology and made recommendations for the consideration of the Government.

In addition, two meetings with the Hon'ble Prime Minister were organized to apprise him of the deliberations and recommendations of the Council. Meetings with Hon'ble Health Minister as well as with Hon'ble Finance Minister were also organized along with the Hon'ble Minister of Science & Technology.

In order to sensitize the role of Science & Technology for the development of the States, a meeting of all the Heads of State S&T Councils and State S&T Ministers was organized at Bangalore. A National Symposium on **"Competitiveness and Preparedness of India in S&T in the coming decades: Challenges, opportunities and Strategies"** was also organized at National Institute of Advanced Studies (NIAS), Bangalore. During the meeting, eminent scientists, technologists, social scientists and policy makers participated. During the meeting, the identified/invited speakers focused on the existing scenario in science and technology in the country and the future strategies that needs to be taken up to meet the challenge.

Some of the items discussed during the SAC-PM meetings are as under:

- **National Science & Engineering Research Foundation (NSERF)**
- **Indian Institutes of Science Education & Research (IISER)**
- **Earth Commission**
- **Centres for Nanotechnology, Molecular Materials and Computational Materials Science**
- **Task Force on Women in Science**
- **Autonomy to ICMR**
- **Ramanujan & JC Bose Fellowships**
- **Rejuvenating R&D in Universities**
- **DBT-ICMR-Industry Institute for Animal based Research**
- **Administrative reforms for Autonomous S&T Institutions**

- **Service conditions & career opportunities for Scientific personnel**
- **Networking of S&T programmes of State S&T Councils**
- **Instituting National Science & Technology Medals**
- **S&T for Rural Development**
- **Restructuring Non-Conventional Energy R&D programmes**
- **Forensic Science in India**
- **Bird Flu**
- **National Council of Science Museums**
- **Proposals for Diamond Jubilee of India's independence**

1. NATIONAL SCIENCE & ENGINEERING RESEARCH FOUNDATION (NSERF)

The pace of advances in science and technology over past 50 years has been remarkable and has touched almost every aspect of human activity. Investments in science and technology are critically important for national development. Over the past 30 years, the Government has consciously supported the growth of science in this country and several S&T departments and agencies fund research projects in all areas of science and engineering. In most agencies, the emphasis has shifted towards specific applications. However, science funding in academic institutions has not kept pace with the growing cost of basic research. It is also felt that the mechanisms for funding and administering individual investigator initiated projects have also become mired in bureaucracy, with complex financial procedures inhibiting efficient operation.

The need for new funding mechanism and de-bureaucratization has been stated in the S&T Policy – 2003 and reiterated in the Hon'ble Prime Minister's speech to the Indian Science Congress at Ahmedabad.

The proposal recommended by SAC-PM, seeks to outline a strategy for providing a fresh thrust to science in India by creating an autonomous agency i.e. **National Science & Engineering Research Foundation (NSERF)** which will strongly promote and fund research in all fields of science and engineering. Such a platform is essential both for the absorption and creation of new technologies. There is an urgent need to recognize that basic research output is stagnating or on the decline and that a concerted effort by a new body will be necessary to revive this process.

It is with the above background, the Council discussed and recommended to set up a National Science & Engineering Research Foundation (NSERF). The key element in the proposed foundation would be its status as an autonomous body charged with the mandate of raising the level of science activity in India to International competitive levels.

Action:

Council recommended setting up of a new mechanism namely National Science & Engineering Research Foundation (NSERF) for funding research in the country. A presentation was made to the Hon'ble Prime Minister emphasizing the need to have a new funding mechanism for research in the area of science and engineering which was endorsed by the Hon'ble Prime Minister. A draft Note for the Cabinet has been circulated to all concerned ministries and S&T agencies.

Detailed Report appended at Annexure I

2. INDIAN INSTITUTES OF SCIENCE EDUCATION AND RESEARCH (IISER)

While the scientific scenario today looks bright in many respects, it also has future which is becoming increasingly worrisome. This has to do with the quality and quantity of basic research being carried out in the university sector. Infrastructure as well as the specialized fields for research in the universities has gradually come to such a low level that the very absorptive capacity of institutions is directly affected. In the meantime, the gap between us and that of advanced countries with respect to scientific research has increased enormously. The problem of the basic research in the universities has assumed serious proportions, particularly in the last 2 to 3 years, because of the many other diversions available for young talents/students. In this situation, providing major research grants to selected individuals or group alone will not serve the purpose, since very few in the university system are able to take up competitive research. In fact, the number of good research proposals from the universities has become very small and the number of high impact publications coming out of this sector in major journals in science and engineering has decreased enormously. This is specially the case with experimental research in Physical Science and Engineering Sciences. Unless the facilities and overall environment in research in the education system are considerably improved, there is no way of increasing the absorptive capacity of these institutions. In the absence of good research, teachers in the universities also are becoming sterile. This will ultimately lead to an acute shortage of high quality research in educational institutions. Such a situation would have a direct impact on national development.

It is not only that the universities are able to provide the right kind of opportunities supported by educational guidance but also the environment for young researchers to get attracted to take up basic scientific research. It is, therefore, a matter of utmost importance that everything possible is done to promote, support and enhance high quality scientific research in the universities. Unless, this is done on a war-footing, there is every possibility that we may, in the near future, lose even the little assets we have at present.

Planning, development and appropriate action is the remedy for this alarming situation in the universities. It is necessary to base it on a long term strategy of 15-20 years, since the absorptive capacity of these institutes can not be increased overnight. Various steps need to be taken systematically on a continuous basis.

Based on the recommendations of the SAC-PM, the MHRD had set up a Task Force to examine the need of setting up of Indian Institutes for Science Education and Research (IISER).

Action:

Based on the recommendations, the Government has approved setting up of three Indian Institutes for Science Education and Research (IISER) at Kolkata, Pune and in Punjab.

Detailed Report and Charter of IISER appended at Annexure II

3. EARTH COMMISSION

Given that land and water are primary resources for the common man in India, and that advanced science and technology are needed for providing adequate services in all areas involving the earth system, it is proposed that the nation adopt for itself the following vision.

To provide the Indian citizen with integrated services on all matters connected with meteorology, the oceans, geosciences and the environment interpreted in the broadest sense, recognizing that such services are essential for economic development and that land and water are the primary resources for the common man, and using all the support that the most advanced science and technology can offer; and

To ensure that, just as India has joined the top half-a-dozen countries in nuclear and space technologies, it is necessary to attain a similar position in Earth System Science, and strive for *the* top position in tropical meteorology and oceanography, realizing that we are the biggest nation economically and the most advanced scientifically in the global tropics.

Earth system science is one strong candidate for a visionary science and technology initiative for the 21st century – just like atomic energy in the 50s and 60s, space in the 70s and 80s and life sciences more recently. India keeps facing major natural disasters such as Tsunami, earthquakes, cyclones and monsoon failure.

Based on discussion, it was **recommended that an Earth Commission may be set up** to address all such issues such as Tsunami, Earthquakes, Cyclone, Monsoon failure etc.

The Earth Commission's **mission statement** should include the following:
To provide the nation with the best possible services in :

- **forecasting the monsoons and other weather/climate parameters, ocean state, earthquakes, tsunamis and other phenomena relating to the earth system, through well integrated programmes utilizing the best that science and technology can offer today at the highest international standards,**

- **offering extensive data resources and setting up appropriate decision support systems to serve the interests of the common man whose primary resources are land and water,**

- **supporting all other industrial and scientific activity (including aviation, engineering industry, water resources, aquaculture etc.) through authentic, adequately processed earth system data of various kinds,**

- **working closely with other agencies, both public and private, to provide them with S&T support and assist in ensuring adequate preparedness for handling natural disasters and managing their consequences, and**

- **supporting research and development in ESS and enlarging the human resource base through special funding programmes.**

Action:

Based on the recommendations of the Council, a Cabinet Note was prepared and sent to the Government for setting up of an Earth Commission.

Detailed Report appended at Annexure III

4. CENTRES FOR NANOTECHNOLOGY, MOLECULAR MATERIALS AND COMPUTATIONAL MATERIALS SCIENCE

Council discussed that there is an urgent need to set up a few Centres for Nanotechnology and Molecular Materials including computational materials science to boost the research activities in these frontier areas.

Expert panels have been set up to examine such centre and locations based on the expertise available.

Action:

A National Centre for Molecular Materials is being set up in Thiruvananthapuram and a Centre for Computational and Material Science has already been established in JN Centre for Advanced Scientific Research, Bangalore. Six Nanotechnology Centres have been setup in different institutions.

5. TASK FORCE ON WOMEN IN SCIENCE

Council discussed the ways and means to use the expertise of the qualified and trained Women Scientists and Engineers. Keeping in view the social obligations, it also recommended that there should be a provision for the women scientists to have flexible working hours. A Task Force was recommended to be set up to examine all such issues pertaining to women scientists and technologists.

Action:

Based on the recommendations of the Council, a Task Force has been set up to examine the various aspects on how Women Scientists can be involved in the socio-economic development of the Country. The Task Force would also prepare a report on "Women in Science" for consideration of the Government.

Task Force Composition Order is appended as Annexure IV.

6. AUTONOMY TO INDIAN COUNCIL OF MEDICAL RESEARCH (ICMR)

Indian Council of Medical Research is an apex body in India for the formulation, coordination and promotion of biomedical research, and is one of the oldest medical research institutions in the world. The Council's research priorities coincide with the national health priorities such as control and management of communicable diseases, fertility control, maternal and child health, control of nutritional disorders, developing vaccines etc.

In order to give special thrust to medical research programmes, it was felt necessary that Indian Council of Medical Research (ICMR) should have more autonomy and flexibility including the status of a Department under the Union Government, headed by a Medical Professional at the level of Secretary to Government of India. This would enhance the status as well as the visibility of medical research of the country at national and international level.

Action:

The recommendations of the Council was conveyed to the Hon'ble Minister of Science & Technology and subsequently a meeting of few selected members along with Hon'ble Minister of Science & Technology and Chairman, SAC-PM was organized with Hon'ble Health Minister. The concern of the medical research was conveyed and a recommendation of the Council was presented.

Based on the proposal, the Hon'ble Minister agreed with the recommendations and the status of Director General, ICMR has been raised to the level of Secretary to the Government of India.

Other recommendations are under consideration.

7. RAMANUJAN & J.C. BOSE FELLOWSHIPS

In order to give a boost to the outstanding scientists and engineers, the Council discussed new attractive fellowship programmes for outstanding research workers. After detailed discussion, it was decided to institute the following Fellowships:

Ramanujan Fellowships:

This fellowship is to attract brilliant scientists and engineers from all over the world to take up scientific research positions in India. There will be a pool of such Fellows which will be operated by the Department of Science & Technology. The fellowships are scientist specific, very selective and will have close academic monitoring. The **Ramanujan Fellows** could work in any of the scientific institutions and universities in the country and they would be eligible for regular Research Grants through the extramural and other research schemes of various S&T agencies of the Government of India.

The value of the fellowship will be Rs.50,000/- per month for the first three years of the fellowship and will be increased to Rs.60,000/- per month during the last two years. Each fellow will, in addition, receive a contingency of Rs.5.00 lakh per annnum.

J.C. Bose National Fellowships:
This Fellowship is meant to recognize active scientists and engineers for their outstanding performance and contributions. The Department of Science & Technology will administer this scheme. The fellowships are scientist specific, very selective and is open to Indian Nationals residing in India who are below the age of 60 years. The value of the fellowship will be of Rs.20,000/- per month in addition to regular income. In addition, each fellow will receive a contingency of Rs.5.00 lakh per annum for conferences and other expenses. The duration of the fellowship will be initially for five years.

Action:

Both these Fellowships have been announced and Expert Committees constituted to consider the applications.

8. REJUVENATING R&D IN UNIVERSITIES

The Council noted the problem of basic research in universities is becoming acute, in spite of major initiatives for infrastructure funding have been initiated by the University Grants Commission and the Department of Science & Technology. In view of other diversions being easily available to the young talented people, it was also felt that there is a need to rejuvenate basic scientific research in the universities by creating more research opportunities. In fact, the Council expressed its concern at the reducing number of good research proposals emanating from the university sector and the reducing number of publications coming out from the universities in major journals of science and engineering.

The Council, therefore, recognizing the urgent need of boosting support to high quality scientific research in the universities had recommended that a Task Force be set up jointly under the Ministry of Human Resource Development (MHRD), Department of Science & Technology umbrella to examine the problems and challenges associated with boosting scientific research in universities and to come up with their recommendations, at the earliest.

MHRD was conveyed about this recommendation and a Task Force for basic Scientific Research in Universities was constituted in March 2005 with Professor M.M. Sharma as its Chairman. Two other members of the SAC-PM; Professor G. Mehta and Dr. P. Rama Rao were members of the Task Force. The terms of reference of the Task Force included assessing the present status of scientific research and training in universities and determining the areas of concern, suggesting solutions, strategies to enhance excellence in scientific research and to make assessment of the physical and financial resources required to improve the strategies.

Action:

The task force submitted its report to MHRD identifying the areas of concerns and recommending several strategies to meet the challenges. The main recommendations included the following:

i) **Creation of 1000 positions of research scientists at various levels, e.g. that of Lecturers, Readers and Professors for a period of five years. The Universities would be asked to draw from these experts for their faculty positions.**
ii) **Up-gradation of existing labs and research infrastructure**
iii) **Enhancing the number of "quality" Ph.D's from Indian universities by almost five fold in a span of 10 years.**
iv) **Formal linkages between universities and national labs for joint research projects and training to be encouraged**
v) **An empowered autonomous body headed by an eminent scientist to oversee the implementation of the recommendations with earmark grant of Rs.600 Crores per annum for implementation of the programme**

MHRD has since set up a Standing Committee to give effect to the recommendations.

Report submitted to MHRD is appended as Annexure V

9. RESTRUCTURING NON-CONVENTIONAL ENERGY R&D PROGRAMMES

The Council had recommended a meeting exclusively focusing on energy, especially on non-conventional energy sources.

During this meeting, experts from the field of non-conventional energy sources where specifically invited. The Experts presented to the Council the status of research in non-conventional energy sources that included Solar, Wind, Biomass, Bio-diesel, Solar-Thermal and Small Hydro Technology, Liquid fuels and solid residues. The Experts also pointed out the lacunae in the current structure of research programmes in non-conventional energy sources.

The Council, after detailed deliberations had prepared a comprehensive report on "Renewal Energy" identifying four major national missions to be created on a high priority basis to achieve a multi-fold increase in utilization of renewable energy over the next 10-15 years. These missions focus on the use of wasteland for growing plantations for producing oil, mission for utilization of urban solid waste for energy generation, photovoltaic technology mission and use of solar energy for water heating.

Action:

A detailed report on **"Renewable Energy"** has been submitted to the Hon'ble Prime Minister and the same is appended as **Annexure VI**.

10. DBT-ICMR-INDUSTRY INSTITUTE FOR ANIMAL BASED RESEARCH

According to the guidelines issued by the Committee for the Purpose of Control & Supervision of Experiments on Animals (CPCSEA), it is mandatory for testing of any drugs or vaccines developed in the country or anywhere, only the colony bred animals of different species with defined genology can be used for experimental purposes. Since the country does not have any large animal facility with international accreditation for such animals, the Council discussed and recommended to set up a national Animal Resources Facility at the earliest with participation from concerned departments such as Indian Council of Medical Research (ICMR), Department of Biotechnology (DBT), Department of Science & Technology (DST) and Ministry of Health & Family Welfare.

Action:

Based on the recommendations of the SAC-PM, a proposal has been formulated and is under discussion to finalize the details and structure.

Hyderabad has been identified as the location for setting up this Institute.

11. ADMINISTRATIVE REFORMS FOR AUTONOMOUS S&T INSTITUTIONS

The Council deliberated on the difficulties being faced in the S&T Departments and autonomous S&T institutions due to administrative procedures. It was felt that S&T departments have a different mandate that would require special procedures in order to keep up with the international competition in research and development. Therefore, it is being felt by the scientific community, that since the progress in scientific activities is contingent upon the availability of talent, R&D infrastructure and ease of operation, it is a matter of considerable urgency to liberalize administrative procedures in S&T departments and autonomous research institutions.

Action:

SAC-PM had constituted a group consisting of Dr. Vijay Kelkar, Dr. R.A. Mashelkar and Dr. P. Rama Rao to come up with a set of recommendations for the consideration of the Government. Based on the inputs from the Committee, a note on "Administrative Reforms" in relation to S&T departments and other institutions was drafted and sent to Cabinet Secretariat for setting up a group consisting of Member Secretary (Planning Commission); Secretary (Expenditure); Secretary (Personnel); Dr. P. Rama Rao and Secretary, DST as its Convenor. The group has met once and the recommendations of the SAC-PM are under consideration.

12. SERVICE CONDITIONS & CAREER OPPORTUNITIES FOR SCIENTIFIC PERSONNEL

India is positioning itself as a global power in Science & Technology. It is, thus, important to reinforce its Science & Technology Policy so as to attract the best minds in S&T. Unfortunately, today, the best minds are not coming to science but are in science by virtue of the "default paradigm". The vast majority of students passing out of Indian institutions/national laboratories/ universities have chosen science as a career by default and not by choice or by design. This is a serious problem which calls for introspection on the existing opportunities in science and technology so that the best minds come to science by choice and not by default.

The SAC-PM has had detailed discussions on the **retirement age of scientists, engineers and other related technical professionals** working in the scientific agencies, research laboratories, higher educational institutions and autonomous bodies supported by the Government. In view of the shortage of talented manpower in the various sectors and the desirability of uniform service benefits to these personnel, the SAC-PM makes the following recommendations:

> "Considering the retirement age in Institutions such as the Central Universities, ICAR, IITs and the Indian Institute of Science is 62 years and that there is a provision for continuing the services of exceptional individuals up to the age of 64 years, it is recommended that the retirement age of scientists in all the governmental agencies, national laboratories, higher educational institutions and autonomous bodies be uniformly made 62 years. The term of service of individuals among these professionals with a proven track record may be extended to 65 years after a suitable external peer review process, by the concerned departments/ agencies/ governing bodies. This procedure is recommended in lieu of a centralized mechanism which is likely to make the review process difficult."

Action:

The Task Force set up for **"Administrative Reforms"** was also requested to examine the concerns regarding service conditions and career opportunities in order to attract young talents towards research and development as a career.

13. NETWORKING OF S&T PROGRAMMES OF STATE S&T COUNCILS

In order to have more involvement of States in S&T programmes, the Council discussed the issue and decided to organize an interaction meeting involving all Heads of the State S&T Councils and State S&T Ministers. A meeting was organized on 10th December, 2005 at Indian Institute of Science, Bangalore in which Heads of all State S&T Councils participated and presented activities being pursued by the States in science and technology. After detailed deliberations, the SAC-PM recommended the following:

- i) **Chairman SAC-PM to send a communication to the Chief Ministers of States to ensure enhanced allocation for S&T in the State Budget.**
- ii) **DST to ensure separate allocations for S&T in the State Budget allocations by Planning Commission.**
- iii) **The possibility of including S&T as an agenda item in the National Development Council meeting to be explored.**
- iv) **An interactive meeting of the State S&T Councils to be convened annually by the State S&T Councils for continuous information dissemination. The invitation extended by the Punjab State S&T Council for organizing the next year meeting was accepted.**
- v) **Publishing an annual/bi-annual news letter on the activities of various State S&T Council to be initiated.**
- vi) **Each State S&T Council should have its own informative website, with regular up-gradation, for which support from DST may be provided separately if required.**
- vii) **Keeping in view the requirement of States based on their S&T related programmes, DST may enhance the support being provided to State S&T Councils, particularly to take care of their needs including scientific and technical manpower.**
- viii) **To evolve a suitable policy for ensuring mobility of scientists from Central Departments/ Agencies & Academic Institutions to State S&T Council for short term/ long term tenures.**

Report of the meeting is appended as Annexure VII.

It was also decided by the Council that Chairman SAC-PM may write to the Hon'ble Prime Minister in this connection and request him to transfer Indian Council of Science Museums to Ministry of Science & Technology from Ministry of Culture. The Hon'ble Prime Minister has kindly agreed in principal for transfer of NCSM.

The communication from Chairman, SAC-PM to the Hon'ble Prime Minister and Hon'ble Minster for Science & Technology and Ocean Development is appended as **Annexure X**.

19. PROPOSAL FOR DIAMOND JUBILEE OF INDIA'S INDEPENDENCE

There were some preliminary discussions on proposals for celebrating the diamond jubilee of India's independence.

During the 12th meeting of the SAC-PM, the Council discussed various proposals and it was felt that a Centre depicting the cultural, technological heritage of India combined with the modern scientific and technological advances in the country should be set up wherein the masses at large would get a feel of our traditional strengths in S&T along with the present advances in indigenous science and technology.

Action:

It was recommended to establish India Heritage Exposition combined with a world class modern digital library as a mega project to commemorate the Diamond Jubilee of India's independence.