

Measurement of Indian science and technology using publications output data during 1996-2010

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Abstract

The study analyses India's performance in science and technology (S&T), using publications data and different quantitative and qualitative measures. Its focuses on India's global publication share, rank and growth rate, citation quality, international collaborative publications share, its publication share and distribution in various broad and narrow subjects using 15 years data from the Scopus international multidisciplinary database. The study suggests the need to increase the pace of Indian scientific research and also improve its quality compared with other developed and developing countries. It also suggest the need for India to build up its scientific capacity, competence and knowledge base to help bridging the scientific and technological gap with leading countries

Keywords: Scientometrics, Indian Science and Technology, Publications, Research.

Introduction

Recognizing the importance of science and technology in economic and industrial development, the Government of India reemphasized the need to view them together in its "Science and Technology Policy-2003" following the "Science Policy Resolution of 1958" and the "Technology Policy Resolution of 1983". The policy has recognized the central role of S&T system in the economic and industrial development of the country, in raising the quality of life of its people, in creating national wealth, in utilizing the natural resources, in protecting environment and in ensuring national security. Over the years, the country has invested heavily in developing infrastructure for R&D in different fields of S&T, including frontier areas, such as atomic energy, space sciences, electronics & telecommunication and more recently in biotechnology and information technology (Gupta & Gupta, 2011).

India has achieved a threshold level in its R&D spending, which increased from US\$1.38 billion in 1985 to US\$3.68 billion in 2000 and to US\$9.45 billion in 2007 (Kharbanda, 2012). The share of India in global GERD (gross domestic expenditure on research and development) in PPP\$ amounts to 2.2% in 2007. In terms of break-up of GERD by source, around 20% of the funding came from the private sector. Through spending has increased in recent years, the proportion of GDP that India dedicates to R&D has remained below 1 per cent - it has risen from 0.65% in 1996 to 0.9% in 2010. To improve India's international standing, the Indian Prime Minister Manmohan Singh wants the R&D spending to double over the next five years to 2% of GDP (Parishwad, 2012).

At the time of independence, the S&T base of the country was very small. But, today it consists of a wide spectrum of infrastructure in terms of higher education institutions, research laboratories and institutions, in-house R&D establishments of industry, etc. covering several disciplines. Indian universities and its constituent

colleges are the main institutes of higher education in India. As of 2009, India has 20 central universities, 215 state universities, 100 deemed universities, 5 institutions under the state act and 39 institutes of national importance, besides 16000 colleges functioning under the above institutions imparting higher education in the country. The number of R&D units involved in research was 1293 in private sector, 112 in public/joint sector, besides 350 scientific and industrial research organizations in 2005-06. There has been tremendous increase in the number of foreign R&D centers in India, which has grown from fewer than 100 in 2003 to about 750 by the end of 2009. Other organizations include hospitals, clinics, medical colleges, private and non-profit organizations, international funded institutions and other organizations.

Several bibliometric studies have so far attempted to look at indicators as required for understanding the status of science and technology in India (Arunachalam *et al.*, 1998; Garg & Dutt, 1992; Garg *et al.*, 2006; Glanzel & Gupta, 2008; Gupta & Dhawan, 2007; Gupta & Dhawan, 2008a Gupta & Dhawan, 2008b; Gupta & Dhawan, 2009a; Gupta & Dhawan, 2009b). They had focused on developing indicators of institutional productivity, national productivity, scattering of research across Indian & foreign journals, quality of research, and nature of collaboration, etc. Another important study (Gupta & Dhawan, 2006) had reported several important indicators to understand the progress in Indian science and technology, covering the period 1985-1986, 1995-96 and 2001-2002. A more recent study (Gupta, 2010) compared overall S&T publications output of India, China and South Korea across twenty broad subjects as defined by Scopus bibliographical database. The present study seeks to build Indian S&T indicators by examining and analyzing 15-years continuous S&T publications data from India for the purpose.



Objectives

The main objective of this study is: (i) to analyze India's publications growth rate and research impact and global share in comparison with select leading countries; (ii) to identify its share of its international collaborative papers and (ii) to analyze its research priorities as reflected in its subject areas distribution of publications output by broad and narrow subject areas.

Methodology and data source

The present study uses Scopus international multidisciplinary bibliographical database for analyzing publication data of India and other countries in S&T. Scopus covers more than 17,000 peer-reviewed journals, 600 trade publications, 350 book series and 3.7 million conference papers from proceedings. The Scopus database classifies each item covered under 20 subject categories of S & T and four broad subject categories, as physical science, engineering science, life science and health science. Physical science includes such as physics & astronomy, chemistry, mathematics, earth & planetary science and environmental science. Similarly, engineering science includes subjects such as engineering, materials science, computer science, chemical engineering and energy. Life science includes subjects such as agricultural & biological sciences, biochemistry, genetics & molecular biology, pharmacology, toxicology & pharmaceuticals, immunology & microbiology and neurosciences. Health science includes subjects such as medicine, veterinary sciences, health profession, dentistry and nursing. The 20 broad subject fields are further sub-divided into 231 sub-fields. The data covered in this study has been derived from SCImago Journal and Country Rank website (<http://www.scimagojr.com>). In this website, the data is

available country-wise as well as by main broad subject-field wise and sub-field wise. The data is available year-wise and well in block periods from 1996-10. The main available data used from this website is number of papers, citations received, citations per paper, h-index, share of international collaborative papers and share of global publications output. There is overlapping of coverage of journals under 20 broad subject fields. Similarly, there is overlapping of the coverage of journals under sub-fields under each of the 20 broad subject fields.

Analysis

India's publication share and rank in world

India ranks 10th among the top 20 productive countries in science and technology, with its global publications share of 2.29% as computed from cumulative world publications data for 1996-2010 (Table 1). The other countries in the top 20 list that contributed world share similar to that of India are Spain (with 2.50%), Australia (2.23%) and Russia Federation (2.06%). In overall, the global publication shares of the top 20 productive countries in S&T from 1996-2010 ranged from 1.02% to 22.83%. The United States tops the list with its global publication share of 22.77% during 1996-2010, followed far behind are China (7.93%), United Kingdom (6.58%), Japan (6.28%) and Germany (5.99%). The countries than rank between 6th and 12th positions are France, Canada, Italy, Spain, India, Australia and Russia Federation (with their publications share from 2.06% to 4.38%). The countries than rank between 13th and 20th position are Netherlands, South Korea, Brazil, Switzerland, Taiwan, Sweden, Poland and Belgium (with their publications share from 1.02% to 1.87%). The publications share of most developed countries (except Spain, Australia,

Table 1. Publication productivity, share, rank and citation impact of top 20 most productivity countries, 1996-2010

Country	Publications Output			Publications Share			Publications Rank			ACPP
	1996-10	1996-98	2008-10	1996-10	1996-98	2008-10	1996-10	1996-98	2008-10	
USA	5322590	960747	1328564	22.83	27.78	21.21	1	1	1	18.88
China	1848727	94875	843949	7.93	2.74	13.48	2	8	2	4.00
UK	1533434	249366	393576	6.58	7.21	6.28	3	3	3	16.00
Japan	1464273	256624	330106	6.28	7.42	5.27	4	2	5	11.24
Germany	1396126	224877	355992	5.99	6.50	5.68	5	4	4	14.64
France	1021041	166997	267031	4.38	4.83	4.26	6	5	6	13.86
Canada	790397	140124	221833	3.39	4.05	3.54	7	6	7	15.42
Italy	762290	112521	211549	3.27	3.25	3.38	8	7	8	12.94
Spain	583554	74244	179875	2.50	2.15	2.87	9	10	10	11.26
India	533006	63153	185676	2.29	1.83	2.96	10	13	9	6.03
Australia	520045	68672	160286	2.23	1.99	2.56	11	11	11	13.62
Russia Fed	480665	92800	103677	2.06	2.68	1.66	12	9	16	5.11
Netherlands	435083	66747	120024	1.87	1.93	1.92	13	12	14	17.94
South Korea	430438	34961	152444	1.85	1.01	2.43	14	16	12	7.77
Brazil	328361	30163	122383	1.41	0.87	1.95	15	20	13	7.34
Switzerland	309549	46209	85268	1.33	1.34	1.36	16	15	17	19.41
Taiwan	308498	33210	104939	1.32	0.96	1.68	17	19	15	7.75
Sweden	304831	51144	75541	1.31	1.48	1.21	18	14	18	17.75
Poland	265139	34592	74501	1.14	1.00	1.19	19	17	19	6.99
Belgium	237081	34473	66832	1.02	1.00	1.07	20	18	20	15.28
World	23313577	3458215	6262939							

Poland, Italy, Belgium and Switzerland) has declined from 1996-08 to 2008-10, with maximum decline (6.57%) in United States, followed by Japan (2.15%), Russia Federation (1.02%), United Kingdom (0.93%), Germany (0.82%), France (0.57%), Canada (0.51%), Sweden (0.27%) and Netherlands (0.01%). In contrast, all developing countries included in top 20 productive countries have shown rise in their publications share, with maximum increase (10.74%) in China, followed by South Korea (1.42%), India (1.13%), Brazil (1.08%) and Taiwan (0.72%) from 1996-98 to 2008-10.

In terms of global ranking from 1996-98 to 2008-10, the countries showing decrease are Japan (from 2nd to 5th), France (from 5th to 6th), Canada (from 6th to 7th), Italy (from 7th to 8th), Russia Federation (9th to 16th), Netherlands (12th to 14th), Switzerland (from 15th to 17th), Sweden (14th to 18th), Poland (17th to 19th) and Belgium (from 18th to 20th), as against increase in all developing countries such as China (from 8th to 2nd), followed by India (13th to 9th), South Korea (from 16th to 12th), Brazil (from 20th to 13th) and Taiwan (from 19th to 15th). For other countries, namely United States, United Kingdom, Germany, Spain and Australia, the global rank has remained the same from 1996-98 to 2008-10.

In terms of research impact as reflected in average citations per paper, Switzerland tops the list with citation impact of 19.41 (with global publication rank of 16th) during 1996-2010, followed by United States (18.88) at second position and 1st global publication rank, Netherlands (17.94) at 3rd position and 13th global publication rank, Sweden (17.75) at 4th position and 18th global publication rank, United Kingdom (16.00) at 5th position and 3rd global publication rank, Canada (15.42) at 6th position and also 6th global publications rank, Belgium (15.28) at 7th position and 20th global publication rank, Germany (14.64) at 8th position and 5th global publication rank, etc. The smaller developed countries (compared to larger developed countries with few exceptions) have improved their global citation impact ranking compared to their global publication ranking. As against this, the developing countries have shown different picture: China has registered the global citation

impact rank of 20th with 2nd global publication rank, India (with global citation impact rank of 18th with 10th global publication rank, Brazil (with global citation impact rank of 16th with 15th global publication rank, with the exception of Taiwan (with global citation impact rank of 15th with 17th global publication rank and South Korea (with global citation impact rank of 14th with 14th global publication rank).

India's annual publication growth rate in world context

The developed and developing countries differ significantly in their annual average publication growth rate as seen from their annual publications output data during 1996-2010 in S&T. It was 1.31% to 7.77% for developed countries and 9.52% to 22.50% for developing world. In general the developed countries maintained slow pace of growth in their publications output, the developing countries on the other hand have shown significantly faster growth rate. Among developing countries, the fastest annual average growth rate (22.50%) was achieved by China during 1996-2010, followed by South Korea (13.37%), Brazil (12.75%), Taiwan (9.83%) and India (9.52%)(Table 2).

Table 2. Annual average growth rate of publications in S&T of top 20 countries, 1996-2010

Country	Growth rate	Country	Growth rate
United States	3.38	Australia	7.39
United Kingdom	4.04	Russia Federation	1.31
China	22.50	Netherlands	5.08
Japan	2.30	South Korea	13.37
Germany	4.53	Brazil	12.75
France	4.28	Switzerland	5.52
Canada	5.13	Taiwan	9.83
Italy	4.88	Sweden	3.84
Spain	7.77	Poland	6.53
India	9.52	Belgium	5.81

India's international collaboration

India's average share of international collaborative papers in its total cumulative publications output during 1996-2010 has been 18.64%, compared with 15.68% for China, 19.87% for Taiwan, 26.11% for South Korea and 31.235% for Brazil. India, Taiwan and South Korea

Table 3. International collaborative papers share of India, China, South Korea, Taiwan and Brazil during 1996-2010

Country/Period	TP	TICP	%TICP	Country/period	TP	TICP	%TICP
India				China			
1996-00	109172	18181	16.65	1996-00	177841	32421	18.23
2006-10	275103	54180	19.69	2006-10	1229298	185230	15.07
1996-10	533006	99331	18.64	1996-10	1848727	289921	15.68
South Korea				Brazil			
1996-00	66777	16170	24.22	1996-00	55843	19624	35.14
2006-10	235599	63067	26.77	2006-10	181893	53379	29.35
1996-10	430438	112377	26.11	1996-10	328361	102543	31.23
Taiwan							
1996-00	57791	10303	17.83				
2006-10	161776	34305	21.21				
1996-10	308498	61302	19.87				



Table 4. Distribution of Indian Medicine Output by Sub-Fields, 1996-2010

Sub-field	TP	ACPP	Sub-Field	TP	ACPP
Medicine (Miscell.)	21016	4.82	Pulmonary & respiratory medicine	1412	9.18
Paediatrics, perinatology & Child Health	9274	3.82	Orthopedics & sports medicine	1067	9.02
Neurology (Clinical)	5223	7.02	Endocrinology, diabetics & metabolism	1054	16.74
Surgery	4738	6.43	Immunology & allergy	967	9.92
Dermatology	4252	5.02	Genetics (Clinical)	934	16.40
Radiology, nuclear medicine & imaging	4165	4.71	Complementary & alternative medicine	845	9.54
Ophthalmology	4023	8.47	Histology	818	4.57
Cardiology & cardiovascular medicine	3923	6.01	Nephrology	718	8.57
Public Health, Environmental & Occupational Health	3666	7.92	Transplantation	705	5.44
Oncology	3587	10.26	Emergency medicine	469	8.29
Microbiology (Medical)	3516	7.25	Critical Care & Intensive Care medicine	451	5.18
Pathology & forensic medicine	3087	5.40	Health policy	415	7.97
Anesthesiology & pain medicine	2962	3.67	Rheumatology	403	8.01
Infectious diseases	2928	8.21	Geriatrics & gerontology	348	9.67
Pharmacology (Medicine)	2815	6.65	Biochemistry (Medical)	328	7.85
Otorhinolaryngology	2800	1.90	Epidemiology	306	19.21
Obstetrics & Gynecology	2481	6.74	Health informatics	270	11.44
Gastroenterology	2293	9.73	Reproductive medicine	224	10.40
Hematology	1945	7.85	Heptology	195	15.82
Urology	1815	6.78	Physiology (Medical)	176	6.41
Psychiatry & Mental Health	1609	11.50	Rehabilitation	146	6.06
Internal Medicine	1515	2.49	Drug guides	4	1.33
Anatomy	1505	6.39	Family practice	1	0.00

TP=Total papers; ACPP=Average citations per paper

Note. There is overlapping in the coverage of journals under various sub-fields. As a result, the combined output of all sub-fields may be more than total output of the main subject field

witnessed increase in its share of international collaborative papers from 16.65%, 17.83% and 24.22% during 1996-00 to 19.69%, 21.21% and 26.77% during 2006-10, as against decrease in China and Brazil from 18.23% and 35.14% during 1996-00 to 15.07% and 29.35% during 2006-10 (Table 3).

publication share of India in medicine, was 11.15% during 2006-10, which has increased from 10.32% during 1996-00 to 11.15% during 2006-10. The world publication share of India in medicine was 1.39% during 1996-2010, which has increased from 0.95% during 1996-00 to 1.87% during 2006-10. The average citation per paper

Table 5. Distribution of Indian chemistry output by sub-fields, 1996-2010

Sub-field	TP	ACPP	Sub-field	TP	ACPP
Chemistry (Miscell.)	25592	7.45	Analytical chemistry	6094	11.12
Organic chemistry	20044	11.14	Spectroscopy	4116	11.32
Physical & theoretical chemistry	15658	12.84	Electrochemistry	3678	11.14
Inorganic chemistry	7749	11.04			

TP=Total Papers; ACPP=Average citations per paper

Note. There is overlapping in the coverage of journals under various sub-fields. As a result, the combined output of all sub-fields may be more than total output of the main subject field

Subject profile of India in science & technology

High productive subject areas of research in India

Medicine, chemistry, agricultural & biological sciences, biochemistry, genetics & molecular biology, physics & astronomy, materials science and engineering are considered as the seven high productivity areas of India in S&T, each contributing publishing share from 9.38% to 17.61% in the cumulative national publications output of India during 1996-2010.

Medicine

The national publication share of India in medicine was 17.61% (93864 publications) during 1996-2010, which has increased from 15.37% during 1996-00 to 17.90% during 2006-10. The international collaborative

registered by all Indian publications in medicine was 4.92 during 1996-2010, which has decreased from 8.31 in 1996-00 to 2.72 in 2006-10. The publication output in Indian medicine during 1996-2010 has been classified under 46 sub-fields (Table 4).

Chemistry

The national publication share of India in chemistry was 13.92% (74204 publications) during 1996-2010, which has decreased from 14.44% during 1996-00 to 13.25% during 2006-10. The international collaborative publication share of India in chemistry was 14.76% during 1996-2010, which has increased from 10.09% during 1996-00 to 16.06% during 2006-10. The world publication share of India in chemistry was 4.62% during 1996-2010,



Table 6. Distribution of Indian agricultural & biological sciences output by sub-fields, 1996-2010

Sub-Field	TP	ACPP	Sub-Field	TP	ACPP
Agricultural & Biological Sciences (Miscell.)	15214	4.17	Soil Science	2991	10.05
Plant Science	13137	7.91	Aquatic Science	2945	9.76
Food Science	11268	8.73	Ecology, Evolution Behavior & Systematic	2759	9.77
Animal Science & Zoology	10078	2.31	Forestry	1851	8.51
Agronomy & Crop Science	9819	7.27	Insect Science	1377	5.41
Horticulture	3024	7.62			

TP=Total Papers; ACPP=Average citations per paper

Note. There is overlapping in the coverage of journals under various sub-fields. As a result, the combined output of all sub-fields may be more than total output of the main subject field

Table 7. Distribution of Indian biochemistry, genetics & molecular biology output by sub-Fields, 1996-2010

Sub-Field	TP	ACPP	Sub-field	TP	ACPP
Biochemistry	20565	13.67	Cell biology	4699	11.62
Biotechnology	9929	11.37	Clinical biochemistry	4026	9.66
Biochemistry, Genetics & Molecular Biology (Miscell.)	7438	7.81	Cancer research	3089	11.06
Genetics	6432	13.40	Physiology	2432	7.77
Molecular Biology	6153	14.20	Endocrinology	2269	11.47
Biophysics	5117	10.99	Developmental biology	1066	13.67
Structural Biology	4878	6.59	Aging	296	13.72
Molecular Medicine	4870	6.67			

TP=Total papers; ACPP=Average citations per paper

Note. There is overlapping in the coverage of journals under various sub-fields. As a result, the combined output of all sub-fields may be more than total output of the main subject field

which has increased from 3.81% during 1996-00 to 5.67% during 2006-10. The average citation per paper registered by all Indian publications in chemistry was 8.84 during 1996-2010, which has decreased from 12.03 during 1996-00 to 5.28 during 2006-10. The publication output in Indian chemistry during 1996-2010 has been classified under 7 sub-fields (Table 5).

Agricultural & biological sciences

The national publication share of India in agricultural & biological sciences was 11.52% (61407 publications) during 1996-2010, which has decreased from 14.20% during 1996-00 to 10.08% during 2006-10. The international collaborative publication share of India in agricultural & biological sciences was 17.05% during 1996-2010, which has increased from 14.76% during 1996-00 to 20.44% during 2006-10. The world publication share of India in agricultural & biological sciences was 3.71% during 1996-2010, which has increased from 3.55% during 1996-00 to 3.91% during 2006-10. The average citation per paper registered by all Indian publications in agricultural & biological sciences was 5.26 during 1996-2010, which has decreased from 7.04 during 1996-00 to 3.08 during 2006-10. The publication output in Indian agricultural & biological sciences during 1996-2010 has been classified under 11 sub-fields (Table 6).

Biochemistry, genetics & molecular biology

The national publication share of India in biochemistry, genetics & molecular biology was 11.26% (60041 publications) during 1996-2010, which has increased from 10.37% during 1996-00 to 11.76% during 2006-10. The international collaborative publication share of India

in biochemistry, genetics & molecular biology was 20.03% during 1996-2010, which has increased from 19.12% during 1996-00 to 21.97% during 2006-10. The world publication share of India in biochemistry, genetics & molecular biology was 2.22% during 1996-2010, which has increased from 1.52% during 1996-00 to 3.14% during 2006-10. The average citation per paper registered by all Indian publications in biochemistry, genetics & molecular biology was 8.95 during 1996-2010, which has decreased from 13.71 during 1996-00 to 4.97 during 2006-10. The publication output in India in biochemistry, genetics & molecular biology during 1996-2010 has been classified under 15 sub-fields (Table 7).

Physics & astronomy

The national publication share of India in physics & astronomy was 10.52% (56077 publications) during 1996-2010, which has decreased from 11.32% during 1996-00 to 10.39% during 2006-10. The international collaborative publication share of India in physics & astronomy was 30.74% during 1996-2010, which has increased from 29.50% during 1996-00 to 31.51% during 2006-10. The world publication share of India in physics & astronomy was 3.15% during 1996-2010, which has increased from 2.79% during 1996-00 to 3.86% during 2006-10. The average citation per paper registered by all Indian publications in physics & astronomy was 7.62 during 1996-2010, which has decreased from 11.60 during 1996-00 to 3.73 during 2006-10. The publication output in Indian physics & astronomy during 1996-2010 has been classified under 10 sub-fields (Table 8).

Materials science

The national publication share of India in materials science was 9.69% (51654 publications) during 1996-2010, which has



Table 8. Distribution of Indian physics & astronomy Output by Sub-Fields, 1996-2010

Sub-Field	TP	ACPP	Sub-Field	TP	ACPP
Physics & Astronomy (Miscell)	21376	8.23	Statistical & Nonlinear Physics	2352	8.51
Condensed Matter Physics	20572	8.78	Instrumentation	1922	7.93
Nuclear & High Energy Physics	6812	13.80	Radiation	1303	7.06
Atomic & Molecular Physics and Optics	5364	10.04	Astronomy & Astrophysics	644	4.91
Surfaces & Interfaces	2986	13.73	Acoustics & Ultrasonics	527	4.01

TP=Total Papers; ACPP=Average Citations per Paper

Note. There is overlapping in the coverage of journals under various sub-fields. As a result, the combined output of all sub-fields may be more than total output of the main subject field

Table 9. Distribution of Indian materials science output by sub-fields, 1996-2010

Sub-Field	TP	ACPP	Sub-Field	TP	ACPP
Materials Science (Miscell)	21067	7.96	Metals & Alloys	5786	6.18
Electrical, Optical & Magnetic Materials	10434	7.30	Ceramics & Composites	4087	9.17
Polymers & Plastics	9672	7.22	Surfaces, Coatings & Films	3557	11.25
Materials Chemistry	8240	10.87	Biomaterials	934	15.45

TP=Total Papers; ACPP=Average citations per paper

Note. There is overlapping in the coverage of journals under various sub-fields. As a result, the combined output of all sub-fields may be more than total output of the main subject field

Table 10. Distribution of Indian engineering output by sub-fields, 1996-2010

Sub-Field	TP	ACPP	Sub-Field	TP	ACPP
Electric & Electronic Engineering	16757	6.34	Computational Mechanics	2042	6.40
Engineering (Miscell)	10942	4.89	Building & Construction	1345	2.32
Mechanical Engineering	7386	6.92	Biomedical Engineering	1339	13.76
Industrial & Manufacturing Engineering	5027	4.99	Aerospace Engineering	1147	3.06
Control & System Engineering	3037	8.50	Ocean Engineering	834	3.19
Civil & Structural Engineering	2716	6.95	Architecture	758	0.63
Safety, Risk Reliability & Quality	2316	11.14	Media Technology	298	22.73
Mechanics of Materials	2240	6.94	Automotive Engineering	159	3.79

TP=Total Papers; ACPP=Average citations per paper

Note. There is overlapping in the coverage of journals under various sub-fields. As a result, the combined output of all sub-fields may be more than total output of the main subject field

decreased from 9.95% during 1996-00 to 9.52% during 2006-10. The international collaborative publication share of India in materials science was 19.14% during 1996-2010, which has increased from 15.81% during 1996-00 to 21.62% during 2006-10. The

world publication share of India in materials science was 3.90% during 1996-2010, which has increased from 3.24% during 1996-00 to 4.51% during 2006-10. The average citation per paper registered by all Indian publications in materials science was 6.99 during 1996-2010, which has decreased from 10.13 during 1996-00 to 4.11 during 2006-10. The publication output in Indian materials science during 1996-2010 has been classified under 8 sub-fields (Table 9).

Engineering

The national publication share of India in engineering was 9.38% (49990 publications) during 1996-2010, which has decreased from 10.20% during 1996-00 to 9.11% during 2006-10. The international collaborative publication share of India in engineering was 20.02% during 1996-2010, which has increased from 19.54% during 1996-00 to 20.02% during 2006-10. The world publication share of India in engineering was 1.75%

during 1996-2010, which has increased from 1.66% during 1996-00 to 2.20% during 2006-10. The average citation per paper registered by all Indian publications in engineering was 5.04 during 1996-2010, which has decreased from 7.75 during 1996-00 to 3.07 during 2006-10. The publication output in Indian engineering during 1996-2010 has been classified under 16 sub-fields (Table 10).

Medium productive subject areas of research in India

Chemical engineering, environmental science, pharmacology, toxicology & pharmaceuticals, mathematics, earth & planetary sciences, computer science, immunology & microbiology and veterinary science are considered as the eight medium productivity areas of India in S&T, each contributing publishing share from 2.30% to 5.64% in the cumulative national publications output of the country during 1996-2010.

Chemical engineering

The national publication share of India in chemical engineering was 5.64% (30053 publications) during 1996-2010, which has decreased from 5.65% during 1996-00 to 5.58% during 2006-10. The international collaborative publication share of India in chemical engineering was 13.34% during 1996-2010, which has decreased from



Table 11. Distribution of Indian chemical engineering output by sub-fields, 1996-2010

Sub-field	TP	ACPP	Sub-field	TP	ACPP
Chemical engineering (Miscell.)	12565	7.27	Fluid flow & transfer processes	3213	6.80
Bioengineering	5827	8.14	Colloid & surface chemistry	2432	18.35
Process chemistry & technology	4789	18.96	Filtration & separation	1315	12.70
Catalysis	3821	14.04	Chemical health & safety	1173	16.17

TP=Total papers; ACPP=Average citations per paper

Note. There is overlapping in the coverage of journals under various sub-fields. As a result, the combined output of all sub-fields may be more than total output of the main subject field

Table 12. Distribution of Indian environmental science output by sub-fields, 1996-2010

Sub-Field	TP	ACPP	Sub-Field	TP	ACPP
Environmental Science (Miscell)	11238	7.23	Health, Toxicology & Mutagenesis	2126	9.75
Environmental Chemistry	6953	8.99	Waste Management & Disposal	971	12.60
Ecology	5928	4.75	Management, Monitoring, Policy & Law	866	10.47
Water Science & Technology	3999	10.82	Nature & Landscape Conservation	385	12.29
Pollution	2833	8.21	Global & Planetary Change	223	15.83
Environmental Engineering	2544	12.98	Ecological Modeling	187	32.08

TP=Total Papers; ACPP=Average citations per paper

Note. There is overlapping in the coverage of journals under various sub-fields. As a result, the combined output of all sub-fields may be more than total output of the main subject field

Table 13. Distribution of Indian pharmacology, toxicology & pharmaceuticals output by Sub-Fields, 1996-2010

Sub-Field	TP	ACPP	Sub-Field	TP	ACPP
Pharmacology	9107	11.27	Toxicology	3628	11.87
Pharmaceutical Science	8334	10.16	Pharmacology, toxicology & pharmaceuticals (Miscell..)	2391	4.54
Drug Discovery	5112	11.86			

TP=Total Papers; ACPP=Average citations per paper

Note. There is overlapping in the coverage of journals under various sub-fields. As a result, the combined output of all sub-fields may be more than total output of the main subject field

Table 14. Distribution of Indian mathematics output by sub-fields, 1996-2010

Sub-Field	TP	ACPP	Sub-Field	TP	ACPP
Applied Mathematics	5819	6.30	Analysis	1249	5.70
Mathematical Physics	5019	9.93	Numerical Analysis	913	5.48
Mathematics (Miscell)	4588	3.52	Algebra & Number Theory	849	3.07
Theoretical Computer Science	3676	14.78	Discrete Mathematics & Combinatorics	607	5.04
Statistics & Probability	1835	5.44	Control & Optimization	412	8.09
Computational Mathematics	1759	6.10	Geometry & Topology	302	6.71
Modeling & Simulation	1757	6.91	Logic	15	7.61

TP=Total Papers; ACPP=Average Citations per Paper

Note. There is overlapping in the coverage of journals under various sub-fields. As a result, the combined output of all sub-fields may be more than total output of the main subject field



Table 15. Distribution of Indian earth & planetary science output by sub-fields, 1996-2010

Sub-Field	TP	ACPP	Sub-Field	TP	ACPP
Earth & Planetary Sciences (Miscell)	6066	5.64	Geophysics	1498	11.99
Space & Planetary Science	4050	10.33	Geology	1124	5.91
Atmospheric Science	2941	9.49	Paleontology	879	12.81
Geochemistry & Petrology	2783	10.84	Computers in Earth Sciences	612	8.82
Geotechnical Engineering & Engineering Geology	2194	5.45	Economic Geology	85	7.00
Oceanography	2174	7.20	Stratigraphy	76	16.05
Earth Surface Processes	1782	11.74			

TP=Total Papers; ACPP=Average citations per paper

Note. There is overlapping in the coverage of journals under various sub-fields. As a result, the combined output of all sub-fields may be more than total output of the main subject field

Table 16. Distribution of Indian computer science output by sub-fields, 1996-2010

Sub-Field	TP	ACPP	Sub-Field	TP	ACPP
Hardware & Architecture	4583	4.59	Artificial Intelligence	2173	16.85
Computer Science (Miscell)	4316	2.43	Information Systems	1503	10.47
Computer Science Applications	2871	9.01	Signal Processing	1494	9.09
Computer Networks & Communications	2669	7.92	Computer Vision & Pattern Recognition	985	13.13
Software	2572	4.83	Computer Graphics & Computer-Aided Design	832	15.54
Computational Theory & Mathematics	2496	13.56	Human-Computer Interaction	253	11.11

TP=Total papers; ACPP=Average Citations per paper

Note. There is overlapping in the coverage of journals under various sub-fields. As a result, the combined output of all sub-fields may be more than total output of the main subject field

Table 17. Distribution of Indian immunology & microbiology output by sub-fields, 1996-2010

Sub-field	TP	ACPP	Sub-field	TP	ACPP
Applied Microbiology & Biotechnology	6268	10.75	Parasitology	2775	8.53
Microbiology	5445	10.69	Virology	1360	16.97
Immunology	4819	12.68	Immunology & Microbiology (Miscell)	143	5.97

TP=Total Papers; ACPP=Average citations per paper

Note. There is overlapping in the coverage of journals under various sub-fields. As a result, the combined output of all sub-fields may be more than total output of the main subject field

Table 18. Distribution of Indian veterinary science output by sub-fields, 1996-2010

Sub-Field	TP	ACPP	Sub-Field	TP	ACPP
Veterinary Science (Miscell...)	11471	1.37	Equine	101	10.08
Food Animals	756	6.25	Small Animals	91	11.62

TP=Total papers; ACPP=Average citations per paper

Note. There is overlapping in the coverage of journals under various sub-fields. As a result, the combined output of all sub-fields may be more than total output of the main subject field

13.88% during 1996-00 to 11.16% during 2006-10. The world publication share of India in chemical engineering was 2.95% during 1996-2010, which has increased from 2.97% during 1996-00 to 3.33% during 2006-10. The average citation per paper registered by all Indian publications in chemical engineering was 8.80 during 1996-2010, which has decreased from 11.34 during 1996-00 to 5.77 during 2006-10. The publication output in Indian chemical engineering during 1996-2010 has been classified under 8 sub-fields (Table 11).

Environmental science

The national publication share of India in environmental science was 5.19% (27668 publications) during 1996-2010, which has increased from 4.50% during 1996-00 to 5.36% during 2006-10. The

international collaborative publication share of India in environmental science was 14.50% during 1996-2010, which has increased from 13.79% during 1996-00 to 16.72% during 2006-10. The world publication share of India in environmental science was 3.20% during 1996-2010, which has increased from 2.48% during 1996-00 to 3.99% during 2006-10. The average citation per paper registered by all Indian publications in environmental science was 5.98 during 1996-2010, which has decreased from 8.98 during 1996-00 to 3.66 during 2006-10. The publication output in Indian environmental science during 1996-2010 has been classified under 12 sub-fields (Table 12).



Table 19. Distribution of Indian energy output by sub-fields, 1996-2010

Sub-Field	TP	ACPP	Sub-Field	TP	ACPP
Nuclear Energy & Engineering	2809	5.21	Energy (Miscell)	1668	7.71
Renewable Energy, Sustainability & Environment	2481	11.80	Fuel Technology	1390	6.33
Energy Engineering & Power Technology	2357	7.91			

TP=Total papers; ACPP=Average citations per paper

Note. There is overlapping in the coverage of journals under various sub-fields. As a result, the combined output of all sub-fields may be more than total output of the main subject field

Table 20. Distribution of neurosciences output by sub-fields, 1996-2010

Sub-Field	TP	ACPP	Sub-Field	TP	ACPP
Neuroscience (Miscell)	2232	13.61	Development Neuroscience	224	13.19
Cellular & Molecular Neuroscience	414	17.04	Biological Psychiatry	100	17.28
Neurology	323	14.33	Cognitive Neuroscience	38	11.78
Behaviour Science	251	15.31	Sensory Systems	8	3.94

TP=Total papers; ACPP=Average citations per paper

Note. There is overlapping in the coverage of journals under various sub-fields. As a result, the combined output of all sub-fields may be more than total output of the main subject field

Pharmacology, toxicology & pharmaceuticals

The national publication share of India in pharmacology, toxicology & pharmaceuticals was 4.41% (23505 publications) during 1996-2010, which has increased from 2.91% during 1996-00 to 5.44% during 2006-10

The international collaborative publication share of India in pharmacology, toxicology & pharmaceuticals was 9.37% during 1996-2010, which has increased from 7.38% during 1996-00 to 10.50% during 2006-10. The world publication share of India in pharmacology, toxicology & pharmaceuticals was 3.41% during 1996-2010, which has increased from 1.90% during 1996-00 to 5.65% during 2006-10. The average citation per paper registered by all Indian publications in pharmacology, toxicology & pharmaceuticals was 7.00 during 1996-2010, which has decreased from 11.90 during 1996-00 to 3.73 during 2006-10. The publication output in Indian pharmacology, toxicology & pharmaceuticals during 1996-2010 has been classified under 5 sub-fields (Table 13).

Mathematics

The national publication share of India in mathematics was 3.92% (20888 publications) during 1996-2010, which has increased from 3.91% during 1996-00 to 3.97% during 2006-10. The international collaborative publication share of India in mathematics was 30.76% during 1996-2010, which has increased from 29.26% during 1996-00 to 31.14% during 2006-10. The world publication share of India in mathematics was 2.31% during 1996-2010, which has increased from 2.31% during 1996-00 to 2.54% during 2006-10. The average citation per paper registered by all Indian publications in mathematics was 5.40 during 1996-2010, which has decreased from 9.24 during 1996-00 to 2.18 during 2006-10. The publication output in Indian mathematics during 1996-2010 has been classified under 14 sub-fields (Table 14).

Earth & planetary sciences

The national publication share of India in earth & planetary sciences was 3.84% (20450 publications) during 1996-2010, which has decreased from 4.90% during 1996-00 to 3.34% during 2006-10. The international collaborative publication share of India in earth & planetary sciences was 25.40% during 1996-2010, which has increased from 21.32% during 1996-00 to 29.20% during 2006-10. The world publication share of India in earth & planetary sciences was 2.35% during 1996-2010, which has increased from 2.30% during 1996-00 to 2.56% during 2006-10. The average citation per paper registered by all Indian publications in earth & planetary sciences was 6.57 during 1996-2010, which has decreased from 8.76 during 1996-00 to 3.61 during 2006-10. The publication output in Indian earth & planetary sciences during 1996-2010 has been classified under 13 sub-fields (Table 15).

Computer science

The national publication share of India in computer science was 3.34% (17814 publications) during 1996-2010, which has increased from 2.88% during 1996-00 to 3.77% during 2006-10. The international collaborative publication share of India in computer science was 30.17% during 1996-2010, which has decreased from 34.79% during 1996-00 to 26.64% during 2006-10. The world publication share of India in computer science was 1.60% during 1996-2010, which has increased from 1.55% during 1996-00 to 2.02% during 2006-10. The average citation per paper registered by all Indian publications in computer science was 5.71 during 1996-2010, which has decreased from 12.76 during 1996-00 to 2.42 during 2006-10. The publication output in Indian computer science during 1996-2010 has been classified under 12 sub-fields (Table 16).



Table 21. Distribution of dentistry output by sub-fields, 1996-2010

Sub-Field	TP	ACPP	Sub-Field	TP	ACPP
Dentistry (Miscell)	1550	8.68	Orthodontics	5	2.13
Oral Surgery	77	1.60	Periodontics	3	3.00

TP=Total Papers; ACPP=Average citations per paper

Note. There is overlapping in the coverage of journals under various sub-fields. As a result, the combined output of all sub-fields may be more than total output of the main subject field

Immunology & microbiology

The national publication share of India in immunology & microbiology was 3.24% (17272 publications) during 1996-2010, which has increased from 2.87% during

1996-00 to 3.31% during 2006-10. The international collaborative publication share of India in immunology & microbiology was 20.12% during 1996-2010, which has decreased from 21.65% during 1996-00 to 20.79% during 2006-10. The world publication share of India in immunology & microbiology was 2.30% during 1996-2010, which has increased from 1.51% during 1996-00 to 3.21% during 2006-10. The average citation per paper registered by all Indian publications in immunology & microbiology was 8.93 during 1996-2010, which has decreased from 15.46 during 1996-00 to 5.35 during 2006-10. The publication output in Indian immunology & microbiology during 1996-2010 has been classified under 6 sub-fields (Table 17).

Veterinary science

The national publication share of India in veterinary science was 2.30% (12247 publications) during 1996-2010, which has decreased from 2.82% during 1996-00 to 1.97% during 2006-10. The international collaborative publication share of India in veterinary science was 22.54% during 1996-2010, which has increased from 15.71% during 1996-00 to 31.11% during 2006-10. The world publication share of India in veterinary science was 6.38% during 1996-2010, which has increased from 6.40% during 1996-00 to 6.57% during 2006-10. The average citation per paper registered by all Indian publications in veterinary science was 1.44 during 1996-2010, which has decreased from 2.16 during 1996-00 to 0.83 during 2006-10. The publication output in Indian veterinary science during 1996-2010 has been classified under 4 sub-fields (Table 18).

Low productive subject areas of research in India

Energy, neurosciences, dentistry, health profession and nursing are considered as the five low productivity areas of India in S&T, each contributing publishing share

from 0.18% to 1.52% in the cumulative national publications output of the country during 1996-2010.

Energy:

The national publication share of India in energy was 1.52% (8080 publications) during 1996-2010, which has decreased from 1.65% during 1996-00 to 1.57% during 2006-10. The international collaborative publication share of India in energy was 17.18% during 1996-2010, which has decreased from 18.08% during 1996-00 to 15.87% during 2006-10. The world publication share of India in energy was 2.44% during 1996-2010, which has increased from 2.53% during 1996-00 to 3.05% during 2006-10. The average citation per paper registered by all Indian publications in energy was 6.31 during 1996-2010, which has decreased from 7.02 during 1996-00 to 4.48 during 2006-10. The publication output in Indian energy during 1996-2010 has been classified under 5 sub-fields (Table 19).

Neurosciences

The national publication share of India in neurosciences was 0.60% (3177 publications) during 1996-2010, which has increased from 0.52% during 1996-00 to 0.68% during 2006-10. The international collaborative publication share of India in neurosciences was 24.43% during 1996-2010, which has decreased from 23.86% during 1996-00 to 21.23% during 2006-10. The world publication share of India in neurosciences was 0.56% during 1996-2010, which has increased from 0.47% during 1996-00 to 1.12% during 2006-10. The average citation per paper registered by all Indian publications in neurosciences was 10.71 during 1996-2010, which has decreased from 18.40 during 1996-00 to 5.97 during 2006-10. The publication output in Indian neurosciences during 1996-2010 has been classified under 8 sub-fields (Table 20).

Dentistry

The national publication share of India in dentistry was 0.60% (1583 publications) during 1996-2010, which has increased from 0.52% during 1996-00 to 0.68%

Table 22. Distribution of health profession output by sub-fields, 1996-2010

Sub-field	TP	ACPP	Sub-field	TP	ACPP
Radiological &Ultrasound Technology	603	10.51	Physical Therapy, Sports Therapy &Rahabilitation	82	6.69
Health Profession (Miscell)	211	11.30	Pharmacy	15	0.86
Health Information Management	162	9.33	Optometry	10	0.53
Complementary & Manual Therapy	160	0.41	Speech & Hearing	6	1.08
Medical Lab Technology	87	4.61			

TP=Total papers; ACPP=Average citations per paper

Note. There is overlapping in the coverage of journals under various sub-fields. As a result, the combined output of all sub-fields may be more than total output of the main subject field



Table 23. Distribution of nursing output by sub-fields, 1996-2010

Sub-field	TP	ACPP	Sub-field	TP	ACPP
Nursing (miscellaneous)	385	11.52	Pharmacology (nursing)	11	0.27
Nutrition & dietetics	350	10.31	Critical care nursing	9	2.33
Psychiatric & mental health	109	11.50	Maternity & midwifery	9	1.83
Leadership & management	77	4.14	Medical & surgical nursing	9	0.63
Community & home care	53	0.65	Pediatrics	8	0.08
Fundamentals & skills	31	0.20	Issues, ethics & legal aspects	6	0.33
Research & theory	30	0.20	Emergency nursing	2	0.00
Oncology (nursing)	17	0.59	Gerontology	2	10.50
Advanced & specialized nursing	12	1.40	Nurse assisting	1	0.00

TP=Total papers; ACPP=Average citations per paper

Note. There is overlapping in the coverage of journals under various sub-fields. As a result, the combined output of all sub-fields may be more than total output of the main subject field

during 2006-10. The international collaborative publication share of India in dentistry was 24.43% during 1996-2010, which has decreased from 23.86% during 1996-00 to 21.23% during 2006-10. The world publication share of India in dentistry was 0.56% during 1996-2010, which has increased from 0.47% during 1996-00 to 1.12% during 2006-10. The average citation per paper registered by all Indian publications in dentistry was 10.71 during 1996-2010, which has decreased from 18.40 during 1996-00 to 5.97 during 2006-10. The publication output in Indian dentistry during 1996-2010 has been classified under 4 sub-fields (Table 21).

Health profession

The national publication share of India in health profession was 0.60% (1329 publications) during 1996-2010, which has increased from 0.52% during 1996-00 to 0.68% during 2006-10. The international collaborative publication share of India in health profession was 24.43% during 1996-2010, which has decreased from 23.86% during 1996-00 to 21.23% during 2006-10. The world publication share of India in health profession was 0.56% during 1996-2010, which has increased from 0.47% during 1996-00 to 1.12% during 2006-10. The average citation per paper registered by all Indian publications in health profession was 10.71 during 1996-2010, which has decreased from 18.40 during 1996-00 to 5.97 during 2006-10. The publication output in Indian health profession during 1996-2010 has been classified under 9 sub-fields (Table 22).

Nursing

The national publication share of India in nursing was 0.18% (937 publications) during 1996-2010, which has increased from 0.08% during 1996-00 to 0.24% during 2006-10. The international collaborative publication share of India in nursing was 20.53% during 1996- publication share of India in nursing was 0.32% during 1996-2010, which has increased from 0.16% during 1996-00 to 0.50% during 2006-10. The average citation per paper registered by all Indian publications in nursing was 5.36 during 1996-2010, which has decreased from 12.90 during 1996-00 to 2.40 during 2006-10. The publication output in Indian nursing during 1996-2010 has been classified under 18 sub-fields (Table 23).

Summary

India has published 533006 papers in science and technology during 2001-10. The annual Indian output in S&T grew from 20499 papers in 2001 to 71975 papers in 2010, showing an annual average growth rate of 9.52%. India's annual average publications growth increased from 3.14 % during 1996-00 to 14.28% during 2006-10. India ranks at 10th position in S&T among the top 20 most productive countries with 2.29% global publication share during 2001-10. India's global publication share in S&T increased from 1.83% to 2.96% from 1996-98 to 2008-10. The average Indian citation impact per paper in S&T was 6.03 during 2001-10. The international collaborative papers share of India in S&T during 2001-10 was 18.64% during 2001-10, which increased from 16.65% during 1996-00 to 19.69% during 2006-10.

Among the twenty broad areas of research in Indian S&T during 1996-10: (i) Medicine, chemistry, agricultural & biological sciences, biochemistry, genetics & molecular biology, physics & astronomy, materials science and engineering are the seven high productivity areas of India in S&T, with publishing share varying from 9.38% to 17.61%; (ii) Chemical engineering, environmental science, pharmacology, toxicology & pharmaceuticals, mathematics, earth & planetary sciences, computer science, immunology & microbiology and veterinary science are the eight medium productivity areas of India in S&T, with publishing share varying from 2.30% to 5.64% and ; (iii) Energy, neurosciences, dentistry, health profession and nursing are the five low productivity areas of India in S&T, with publishing share varying from 0.18% to 1.52%.

The largest increase (2.53% each) in national publication share of India was observed in pharmacology, toxicology & pharmaceuticals and medicine, followed by biochemistry, genetics & molecular biology (1.39%), computer science (0.89%), environmental science (0.86%), immunology & microbiology (0.44%), dentistry (0.42%), neurosciences and nursing (0.16% each), health profession (0.15%) and mathematics (0.06%), as against largest decrease of 4.12% in agricultural & biological sciences, followed by earth & planetary sciences (1.56%), chemistry (1.19%), engineering (1.09%), physics & astronomy (0.93%), veterinary science (0.85%), materials



science (0.43%), energy (0.08%) and chemical engineering (0.07%) from 1996-00 to 2006-10.

The world publication share of India was highest (6.38) in veterinary science, followed by chemistry (4.62), materials science (3.90), agricultural & biological sciences (3.71), pharmacology, toxicology & pharmaceuticals (3.41), environmental science (3.20), physics & astronomy (3.15), chemical engineering (2.95), energy (2.44), earth & planetary sciences (2.35), mathematics (2.31), immunology & microbiology (2.30), biochemistry, genetics & molecular biology (2.22), engineering (1.75), computer science (1.60), medicine (1.39), dentistry (1.31), health profession (0.77), neurosciences (0.56) and nursing (0.32) during 1996-2010. The highest increase (3.75%) of India in world publication share was in pharmacology, toxicology & pharmaceuticals, followed by dentistry (2.82%), chemistry (1.86%), immunology & microbiology (1.70), biochemistry, genetics & molecular biology (1.62), environmental science (1.51), materials science (1.27), physics & astronomy (1.08), medicine (0.92), health profession (0.76), neurosciences (0.65), engineering (0.54), energy (0.52), computer science (0.47), agricultural & biological sciences (0.36), chemical engineering (0.36), nursing (0.34), earth & planetary sciences (0.26), mathematics (0.23) and veterinary science (0.23) from 1996-00 to 2006-10.

The largest share of (30.76%) of international collaborative papers of India was observed in mathematics, followed by physics & astronomy (30.74%), computer science (30.17%), earth & planetary sciences (25.40%), neurosciences (24.42%), veterinary science (22.54%), immunology & microbiology (20.12%), nursing (20.53%), biochemistry, genetics & molecular biology (20.02%), engineering (20.02%), dentistry (19.83%), health profession (19.63%), materials science (19.14%), energy (17.18%), agricultural & biological sciences (17.05%), chemistry (14.76%), environmental science (14.50%), chemical engineering (13.34%), medicine (11.15%) and pharmacology, toxicology & pharmaceuticals (9.37%) during 1996-2010.

The largest increase (15.40%) in international collaborative publication share in India was observed in veterinary science, followed by nursing (11.67%), earth & planetary sciences (7.88%), health profession (5.98%), materials science (5.81%), agricultural & biological sciences (5.68%), pharmacology, toxicology & pharmaceuticals (3.12%), chemistry (2.97%), environmental science (2.93%), biochemistry, genetics & molecular biology (2.85%), medicine (2.73%), physics & astronomy (2.01%), engineering (1.85%) and mathematics (1.88%), as against largest decrease (28.76%) in dentistry, followed by computer science (8.15%), chemical engineering (2.72%), neurosciences (2.63%), energy (2.21%) and immunology & microbiology (0.86%) from 1996-10 to 2006-2010.

The largest citation impact (10.71) of Indian papers as reflected in citation per paper was observed in neurosciences, followed by biochemistry, genetics & molecular biology (8.95), immunology & microbiology (8.93), chemistry (8.84), chemical engineering (8.80), physics & astronomy (7.62), pharmacology, toxicology & pharmaceuticals (7.0), earth & planetary sciences (6.57), energy (6.31), environmental science (5.98), health profession (5.93), computer science (5.71), mathematics (5.40), nursing (5.36), agricultural & biological sciences (5.26), engineering (5.04), medicine (4.92), materials science (3.90), dentistry (2.78) and veterinary sciences (1.44) during 1996-2010.

The entire Indian S&T has been sub-divided into 20 broad fields and 231 sub-fields in the above presentation. In terms of research output, (i) 7 sub-fields have found to have publication output above 20,001 papers, (ii) 11 sub-fields between 10,001 to 20,000 papers, (iii) 26 sub-fields between 5,001 to 10,000 papers, (iv) 100 sub-fields between 1,001 to 5,000 papers, (v) 87 sub-fields less than 1000 papers during 1996-10. In terms of citation impact per paper: (i) 2 sub-fields have registered more than 20.01, (ii) 80 sub-fields between 10.01 to 20.0, (iii) 97 sub-fields between 5.01 to 10.0, (iv) 37 sub-fields between 1.01 to 5.00 and (v) 15 sub-fields 1 or less.

Suggestions

From the above presentation, it is observed that there is a need to increase the pace of Indian scientific research and also improve its quality compared with other developed and developing countries, such as China, South Korea, Taiwan and Brazil. 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 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 among S&T sectors, institutions and individual scientists, increased scientific cooperation with developed and developing countries and stricter evaluation and monitoring system in promotions, in awarding degrees, research grants and research projects.

There is a urgent need to draw out a more detailed long term and short term plans for R&D developments in the country. The country needs to organize goal-oriented and need-based programs at the institutional, regional and national level and initiate a national plan to strengthen linkages between low and medium productivity organizations and bigger organizations. It will benefit the smaller organizations to share the rich experience of bigger organizations and also use their equipment and facilities available in specific fields.

There is a need to 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. There is a need to review and strengthen current arrangements for international collaboration in S&T with developed and developing countries. Collaborating research, especially at international level must be encouraged for accelerating the pace of growth and for ensuring quality and quantity in research output. There is a need to introduce new models and improve the existing models of international collaboration, such as those existing between India and USA, France and Russia.

There is a need to strengthen the evaluation and monitoring system at the national level to ensure that the output from ongoing and extra-mural funded projects are reported in comparatively higher impact journals. Strict evaluation measures need to be evolved for ensuring good quality output from Ph.D. work and from extra-mural projects funded from national funding agencies. Provision of adequate budget to organizations for highering doctoral and post-doctoral students may help in increasing the research output of the country.

References

1. Arunachalam S, Srinivasan S and Raman V (1998) Science in India: A profile based on India's publications as covered by *Science Citation Index*, 1989-1992. *Cur. Sci.* 74(5), 433-441.
2. Garg KC and Dutt B (1992) Bibliometrics of Indian science as reflected through *Science Citation Index*. *J. Scientific & Indust. Res.* 51, 329-340.
3. Garg KC, Dutt B and Kumar S (2006) Scientometric profile of Indian science as seen through Science Citation Index. *Annals of Library & Information Studies*. 53,114-125.
4. Glanzel W and Gupta BM (2008) Science in India: A bibliometric study of national research performance in 1991-2006. *ISSI Quaterly*. 4(3), 42-48.
5. Gupta BM and Dhawan SM (2007) Mapping of Indian publications in S&T: A scientometric analysis of publications in Science Citation Index. *DESIDOC Bull. of Information Technol.* 27(1),17-34.
6. Gupta BM and Dhawan SM (2008a) A scientometric analysis of S&T publications output by India during 1985-2002. *DESIDOC Bulletin of Library & Information Technol.* 28(2), 73-85.
7. Gupta BM and Dhawan SM (2008b) Status of India in science and technology as reflected in its publication output in the Scopus international database,1996-2006. NISTADS, New Delhi.
8. Gupta BM and Dhawan SM (2009a) Status of India in science and technology as reflected in its publication output in the Scopus international database, 1997-2007. In: Science & Technology, 2008 (editor, Banerjee, P),pp:251-60, NISTADS, New Delhi.
9. Gupta BM and Dhawan SM (2009b) Status of India in science and technology as reflected in its publication output in the Scopus international database, 1996-2006. *Scientometrics*. 80(2), 473-498.
10. Gupta BM and Dhawan SM (2006) Measures of progress of science in India: an analysis of the publication output in science and technology. New Delhi: Office of the principal scientific adviser to the Government of India, New Delhi. Retrieved May 3, 2011, from http://psa.gov.in/writereaddata/11913286541_MPSI.pdf.
11. Gupta BM (2010) A comparative study of India, China and South Korea's publication output during 1999-2008. *Annals of Library and Information Studies*. 57, 207-221.
12. Gupta BM and Gupta P (2011) Analysis of India's S&T research capabilities and international collaborative strength, particularly in context of Indo-German collaboration, 2004-09. DFG India, German research foundation, New Delhi.
13. Kharbanda Ved P (2012) India should head but not fear China's science. Retrieved March 15, 2012 from www.scidev.net/en/south-asia/opinions/india-should-head-but-not-fear-china-s-science.html.
14. Parishwad Rajesh (2012) Indian science needs to raise its game. Retrieved March 15, 2012 from www.rsc.org/ChemistryWorld/News/2012/January/india-science-manmohan-singh-research-rd.asp.