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## **S&T Publications Output of India: A Scientometric Analyses of Publications Output, 1996-2011**

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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, 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 suggests 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: India, Publication output, Scientometric.

### **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 the 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 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 and telecommunications and more recently in biotechnology and information technology<sup>1</sup>.

India currently spends 0.9% of GDP on research and development compared to 2.7% by USA. While the bulk of India's research funding continues to flow from the government, public funding as a proportion of total R&D expenditure fell from over 80% in 1990-09 to 66% by 2007-08. Over the same period, research investment by business rose from about 14% to around 30%. Most of the government's meager research funding goes to the research institutes rather than to universities – with just 10% of the total public research budget spent at higher education institutions<sup>2</sup>. In 1950, education had 7.92% share of total public expenditure, which was 0.64% of GDP. In 2009, it stood at 13.63% of the total public expenditure and 3.77% of GDP. Of this, the higher education got 32.3% share. In 1950 the total number of universities and colleges were 30 and 695. By 2011, they rose to 634 and 33023. In terms of student enrollment, the enrollment in higher education institutions has increased from 3, 97,000 in 1950 to 1, 69, and 75,000 in 2010, almost doubled in the last decade. Talking about enrollment by stages, 86% of the students complete their graduation, while only 12% opt for post-graduate programs and only 1% for research. By 2011, there are 634 degree awarding institutions in the country, of these 47% (297) are state universities, followed by deemed universities (20%, 129), institutes of national importance (10%) and central universities (7%). Interestingly the private universities are just 100 in number accounting for 16% share<sup>3</sup>.

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, etc. covering several disciplines

Several bibliometric studies have so far attempted to look at indicators as required for understanding the status of science and technology in India (Arunachalam, Srinivasan and Raman<sup>4</sup>, 1998, Garg & Dutt<sup>5</sup>, 1992, Garg, Dutt and Kumar<sup>6</sup>, 2006, Glanzel & Gupta<sup>7</sup>, 2008, Gupta & Dhawan<sup>8</sup>, 2007, Gupta & Dhawan<sup>9</sup>, 2008A, Gupta & Dhawan<sup>10</sup>, 2008B, Gupta & Dhawan<sup>11</sup>, 2009A, Gupta & Dhawan<sup>12</sup>, 2009B). They had focused on developing indicators on institutional productivity, national productivity, scattering of research across Indian & foreign journals, quality of research, and nature of collaboration, etc.

### **Objectives**

Indian publications for the period 1996-2011 has been examined with the objective: (i) to analyze India's publications growth rate, research impact and global share in comparison with select leading countries; (ii) to identify its share of its international collaborative papers and (iii) to analyze its research priorities as reflected in its subject areas distribution of publications output by broad and narrow subject areas and by sub-fields.

### **Methodology**

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. 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 sciences include 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.

### **Publication Share and Rank of Top 20 Countries**

India ranks 10<sup>th</sup> among the top 20 productive countries in science and technology, with its global publications share of 2.46% as computed from cumulative world publications data for 1996-2011 (Table 1). The other countries in the top 20 list that contributed world share similar to that of India are Spain (with 2.58%), Australia (2.30%) and Russia Federation (2.05%). In overall, the global publication shares of the top 20 productive countries in S&T from 1996-2011 ranged from 1.04% to 23.86%. The United States tops the list with its global publication share of 23.86% during 1996-2011, followed far behind are China (8.73%), United Kingdom (6.64%), Japan (6.22%) and Germany (6.14%). The countries than rank between 6<sup>th</sup> and 12<sup>th</sup> positions are France, Canada, Italy, Spain, India, Australia and Russia Federation (with their publications share from 2.05% to 4.43%). The countries than rank between 13<sup>th</sup> and 20<sup>th</sup> position are South Korea, Netherlands, Brazil, Taiwan, Switzerland, Sweden, Poland and Turkey (with their publications share from 1.04% to 1.93%). The publications share of most developed countries has declined from 1996-08 to 2008-10, with maximum decline (3.29%) in United States, followed by Japan (1.55%), Russia Federation (0.71%), United Kingdom (0.53%), Germany (0.44%), France (0.35%) and Sweden (0.17%), as against increase in Turkey (0.57%), Spain (0.55%), Australia (0.44%), Canada (0.24%), Poland (0.17%), Italy (0.14%), Netherlands (0.06%) and Switzerland (0.06%). In contrast, all developing countries included in top 20 productive countries have shown rise in their publications share, with maximum increase (8.28%) in China, followed by South Korea (1.01%), India (0.90%), Brazil (0.78%) and Taiwan (0.61%) from 1996-03 to 2004-11. In terms of global ranking from 1996-03 to 2004-11, all developing countries have shown increase: China (from 6<sup>th</sup> to 2<sup>nd</sup>), followed by India 13<sup>th</sup> to 9<sup>th</sup>), South Korea (from 14<sup>th</sup> to 12<sup>th</sup>), Brazil (from 18<sup>th</sup> to 14<sup>th</sup>) and Taiwan (from 19<sup>th</sup> to 16<sup>th</sup>) (Table 1).

In terms of research impact as reflected in average citations per paper, Switzerland tops the list with citation impact of 20.50 (with global publication rank of 17<sup>th</sup>) during 1996-2011, followed by United States (18.63) at second position and 1<sup>st</sup> global publication rank, Netherlands(18.30) at 3<sup>rd</sup> position and 14<sup>th</sup> global publication rank, Sweden (18.13) at 4<sup>th</sup> position with 18<sup>th</sup> global publication rank, United Kingdom (16.31) at 5<sup>th</sup> position and 3<sup>rd</sup> global publication rank, Canada (15.73) at 6<sup>th</sup> position with 7<sup>th</sup> global publications rank, Germany (14.69) at 7<sup>th</sup> position and 5<sup>th</sup> 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 20<sup>th</sup> with 2<sup>nd</sup> global publication rank, India (with global citation impact rank of 18<sup>th</sup> with 10<sup>th</sup> global publication rank), Taiwan (with global citation impact rank of 8<sup>th</sup> with 16<sup>th</sup> global publication rank), South Korea and Brazil (with global citation impact rank of 12<sup>th</sup> and 13<sup>th</sup>) and 13<sup>th</sup> and 15<sup>th</sup> global publication rank (Table 1).

**Table1. Publication Productivity, Share and Citation Impact of Top 20 Most Productivity Countries, 1996-2011**

	Number of Papers			Share of Papers			TC	ACPP
	1996-03	2004-11	1996-011	1996-03	2004-11	1996-011		
United States	2579474	3569981	6149455	25.88	22.59	23.86	114546415	20.51
China	363579	1884699	2248278	3.65	11.93	8.73	9288789	6.00
United Kingdom	694340	1017538	1711878	6.97	6.44	6.64	27919060	18.03
Japan	715033	888984	1604017	7.17	5.62	6.22	18441796	12.09
Germany	638725	942704	1581429	6.41	5.97	6.14	23229085	16.19
France	462924	678081	1141005	4.64	4.29	4.43	16068688	15.58
Canada	327829	557368	885197	3.29	3.53	3.44	13928114	18.19
Italy	320857	530835	851692	3.22	3.36	3.30	11279167	15.00
Spain	224278	441699	665977	2.25	2.80	2.58	7640544	13.66
India	190255	444217	634472	1.91	2.81	2.46	3860494	7.71
Australia	202143	390390	592533	2.03	2.47	2.30	8180664	16.65
Russian Fed.	247813	279629	527442	2.48	1.77	2.05	2811862	5.49
South Korea	131211	366470	497681	1.31	2.32	1.93	3988716	10.32
Netherlands	185085	302699	487784	1.86	1.92	1.89	8928850	20.82
Brazil	103987	287602	391589	1.04	1.82	1.52	2884793	9.96
Taiwan	103027	248583	351610	0.96	1.57	1.32	2825736	10.08
Switzerland	131307	218946	335277	1.32	1.38	1.36	6873551	22.46
Sweden	140779	196356	337135	1.41	1.24	1.31	6111804	19.78
Poland	107022	196981	304003	1.07	1.24	1.18	2149143	8.13
Turkey	68285	199617	267902	0.69	1.26	1.04	1647043	7.92

#### Annual Publication Growth Rate in World Context

The developed and developing countries differ significantly in their annual average S&T publication growth rate as seen from their annual publications output data during 1996-2011 It was 1.75% to 12.74% for developed countries and 9.69% to 19.65% 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 (19.65%) was achieved by China during 1996-2011, followed by South Korea (13.15%), Brazil (12.66%), India (10.42%) and Taiwan (9.69%). Among developed countries, the fastest annual average growth rate (12.74%) was achieved by Turkey, followed by Spain (7.91%), Australia (7.39%), Poland (6.64%), Switzerland (5.69%), Italy (5.19%), Netherlands (5.13%), Canada (4.85%), Germany (4.63%), France (4.19%), U.K. (4.08%), Sweden (4.03%), USA (3.48%), Japan (2.31%) and Russia Federation (1.75%) during 1996-2011 (Table 2).

**Table 2. Annual Average Growth Rate of Publications in S&T of Top 20 Countries, 1996-2011**

Country	Growth Rate	Country	Growth Rate
United States	3.48	Australia	7.39
China	19.65	Russian Federation	1.75
United Kingdom	4.08	South Korea	13.15
Japan	2.31	Netherlands	5.13
Germany	4.63	Brazil	12.66
France	4.19	Taiwan	9.69
Canada	4.85	Switzerland	5.69
Italy	5.19	Sweden	4.03
Spain	7.91	Poland	6.64
India	10.42	Turkey	12.74

### International Collaborative Publications Share

The developed and developing countries differ significantly in their share of international collaborative papers during 1996-2011. It was 15.57% to 56.01% for developed countries and 15.30% to 29.33% for developing world. In general the developed countries have shown generally higher internationally collaborating papers share compared to developing countries among the top 20 most productive countries. Among developing countries, the largest share (29.33%) of international collaborative papers was achieved by Brazil during 1996-2011, followed by Taiwan (19.33%), India (17.83%), South Korea (13.91%) and China (15.30%). The international collaborative publications share has increased by 2.81% in South Korea, followed by Taiwan (2.67%), India (2.44%) as against decrease in Brazil (4.42%) and China (2.16%) from 1996-03 to 2004-11. Among developed countries, the highest share (56.01%) of international collaborative papers was achieved by Switzerland, followed by Sweden (47.14%), Netherlands (45.22%), Germany (40.70%), Canada (40.43%), Australia (39.14%), U.K. (37.83%), Italy (36.29%), Spain (35.43%), Poland (32.14%), Russia Federation (29.52%), USA (23.86%), Japan (21.30%), Turkey (17.24%), and France (15.57) during 1996-2011. The international collaborative publications share has increased by 13.06% in Sweden, followed by Switzerland (12.57%), U.K. (12.47%), Netherlands (12.15%), Germany (10.17%), Australia (10.09%), Canada (9.91%), Spain (9.12%), Italy (8.81%), USA (7.51%), Japan (6.83%), Russian Federation (5.44%), Turkey (0.95%) and Poland (0.70%) as against decrease in France (0.43%) from 1996-03 to 2004-11 (Table 3).

**Table 3. International Collaborative Papers Share of Top 20 Countries during 1996-2011**

Country	International Collaborative Papers Share			Country	International Collaborative Papers Share		
	1996-03	2003-11	1996-11				
United States	21.41	28.92	23.86	Australia	32.49	42.58	39.14
China	17.11	14.95	15.30	Russian Federation	26.63	32.07	29.52
United Kingdom	30.42	42.89	37.83	South Korea	23.84	26.65	15.91
Japan	17.52	24.35	21.30	Netherlands	37.68	49.83	45.22
Germany	34.64	44.81	40.70	Brazil	32.57	28.15	29.33
France	15.83	15.40	15.57	Taiwan	17.45	20.12	19.33
Canada	34.19	44.10	40.43	Switzerland	47.79	60.36	56.01
Italy	30.80	39.61	36.29	Sweden	39.53	52.59	47.14
Spain	29.38	38.50	35.43	Poland	31.69	32.39	32.14
India	16.12	18.56	17.83	Turkey	16.53	17.48	17.24

### India's Publications Output, Growth and International Collaboration

India's total publications output consisted of 634472 publications, compared to China (2248278), South Korea (497681), Brazil (391589) and Taiwan (351610) during 1996-2011. India's cumulative publication output grew from 190255 papers in 1996-03 to 444217 papers in 2003-11, witnessing a growth rate of

133.48%. Compared to India, the cumulative publication output grew in China from 363579 to 1884699, South Korea from 131211 to 366470, Brazil from 103987 to 287602 and Taiwan from 103027 to 248583 from 1996-03 to 2004-11, witnessing growth rates of 418.37%, 179.29%, 176.57% and 141.28%. The h-index value received by India was 281 during 1996-11, compared to China (353), South Korea (309), Brazil (285) and Taiwan (249) during the same period. The average citation receiver per paper of India was 5.24, which decreased from 7.36 during 1996-03 to 4.34 during 2004-11. Compared to India, the average citation receiver per paper registered was 8.04 for China, followed by South Korea (8.01), Brazil (7.37) and China (4.13). The share of India's international collaborative papers in its total output was 17.83, which grew from 16.12% during 1996-03 to 18.56% during 2004-11. Compared to India, the share of international collaborative papers was 29.33% for Brazil, followed by South Korea (25.91%), Taiwan (19.33%) and China (15.30%)(Table 4)

**Table 4. India's Publications Output, Citation Quality and International Collaboration, 1996-2011**

Year	TP	TC	ACPP	ICP	%ICP	World Share
1996	20504	195399	9.53	3539	17.26	1.81
1997	20970	195503	9.32	3584	17.09	1.81
1998	21709	217479	10.02	3923	18.07	1.86
1999	22853	227087	9.94	3558	15.57	1.96
2000	23189	254973	11.00	3566	15.38	1.89
2001	24138	250974	10.40	3239	13.42	1.84
2002	26403	277270	10.50	3562	13.49	1.92
2003	30489	315180	10.34	5692	18.67	2.13
2004	32278	310105	9.61	6604	20.46	2.04
2005	37811	320648	8.48	7623	20.16	2.16
2006	44935	328389	7.31	8592	19.12	2.44
2007	49456	310326	6.27	9669	19.55	2.55
2008	54888	266414	4.85	10615	19.34	2.72
2009	61557	214443	3.48	12059	19.59	2.92
2010	74855	130167	1.74	12793	17.09	3.38
2011	88437	46137	0.52	14504	16.4	3.78
96-03	190255	1400660	7.36	30664	16.12	1.91
04-11	444217	1926629	4.34	82458	18.56	2.81
96-11	634472	3327289	5.24	113121	17.83	2.46

### **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 9.33% to 17.61% in the cumulative national publications output of the country during 1996-2010.

**Medicine** - The national publication share of India in medicine was 17.61% (111730 publications) during 1996-2011, which has increased from 16.58% (31555 publications) during 1996-03 to 18.04% (80175 publications) during 2004-11. The international collaborative publication share of India in medicine was 13.46% during 2006-11, which has increased from 10.02% during 1996-03 to 14.81% during 2004-11. The world publication share of India in medicine was 1.59% during 1996-2011, which has increased from 1.08% during 1996-03 to 1.96% during 2004-11. The average citation per paper registered by all Indian publications in medicine was 4.95 during 1996-2011, which has decreased from 8.35 during 1996-03 to 3.61 during 2004-11.

The publication output in Indian medicine during 1996-2011 has been classified under 48 sub-fields (including miscellaneous sub-field). Of the 47 sub-fields, 3 sub-fields have field publication share above

5%, 12 sub-field's publication share between 3 to 5%, 12 sub-fields publication share between 1 to 2%, and rest of 20 sub-fields publication share less than 1%. Of the 47 sub-fields, 4 sub-fields have average citation per paper above 15, 9 sub-fields between 10 to 14.99, 25 sub-fields between 5 to 9.99 and rest 9 sub-fields between 0 to 4.99. Among the 47 sub-fields, the priorities assigned by India in terms of sub-field national share and research output are: (i) Pediatrics, perinatology & child health (10574 papers, 9.46% share), (ii) neurology (clinical) (6019 papers, 5.39% share), (iii) surgery (5620 papers, 5.03% share), (iv) dermatology (4930 papers)(4.41% share), (v) radiology, nuclear medicine & imaging (4720 papers, 4.22% share),(vi) ophthalmology (4558 papers, 4.08% share), (vii) cardiology & cardiovascular Medicine (4478 papers, 4.01% share), (viii) public health, environmental & occupational health (4376 papers, 4.01% share), (iv) oncology (4155 papers, 3.72% share), (vii) microbiology (medical)(4073 papers, 3.65% share), (viii) pharmacology (medicine)(3774 papers, 3.38% share), (ix) infectious diseases (3551 papers, 3.18% share), (vv) anesthesiology & pain medicine (3493 papers, 3.13% share), (x) obstetrics & gynecology (2977 papers, 2.66% share) and (xi) gastroenterology (2674 papers, 2.39% share).

**Table 4. Distribution of Indian Medicine Output by Sub-Fields, 1996-2011**

Sub-Field	Papers	ACPP	Sub-Field	Papers	ACPP	Sub-Field	Papers	ACPP
Anatomy	1695	6.52	Health Informatics	339	12.17	Pathology & Forensic Medicine	3774	5.77
Anesthesiology & Pain Medicine	3493	3.77	Health Policy	496	8.47	Pediatrics, Perinatology & Child Health	10574	3.99
Biochemistry (Medical)	427	8.40	Hematology	2183	8.37	Pharmacology (Medicine)	3830	7.05
Cardiology & Cardiovascular Medicine	4478	6.16	Heptatology	249	16.55	Physiology (Medical)	196	6.77
Complementary & Alternative Medicine	1346	10.57	Histology	892	4.78	Psychiatry & Mental Health	1947	12.06
Critical Care & Intensive Care Medicine	565	5.39	Immunology & Allergy	1135	10.51	Public Health, Environmental & Occupational Health	4376	8.29
Dermatology	4930	5.17	Infectious Diseases	3551	8.73	Pulmonary & Respiratory Medicine	1695	9.56
Drug Guides	4	1.50	Internal Medicine	1692	2.63	Radiology, Nuclear Medicine & Imaging	4720	4.98
Embryology	167	13.66	Microbiology (Medical)	4073	7.75	Rehabilitation	162	6.41
Emergency Medicine	516	8.64	Nephrology	859	8.91	Reproductive Medicine	283	10.45
Endocrinology, Diabetics & Metabolism	1252	17.55	Neurology (Clinical)	6019	7.37	Rheumatology	504	8.38
Epidemiology	371	19.99	Obstetrics & Gynecology	2977	7.06	Surgery	5620	6.65
Family Practice	2	0.0	Oncology	4155	10.81	Transplantation	853	5.73
Gastroenterology	2674	10.01	Ophthalmology	4558	8.79	Urology	2088	7.14
Genetics	1072	17.20	Orthopedics &	1343	9.51	Miscellaneous	26023	5.12

(Clinical)			Sports Medicine					
Geriatrics & Gerontology	414	10.09	Otorhinolaryngology	3401	2.07			

**Chemistry** - The national publication share of India in chemistry was 13.46% (27993 publications) during 1996-2011, which has decreased from 14.71% (190255 publications) during 1996-03 to 12.92% (444217 publications) during 2004-11. The international collaborative publication share of India in chemistry was 15.45% during 2006-11, which has increased from 13.42% during 1996-03 to 16.44% during 2004-11. The world publication share of India in chemistry was 4.98% during 1996-2011, which has increased from 4.01% during 1996-03 to 5.65% during 2004-11. The average citation per paper registered by all Indian publications in chemistry was 8.36 during 1996-2011, which has decreased from 13.33 during 1996-03 to 5.93 during 2004-11.

The publication output in Indian chemistry during 1996-2011 has been classified under 7 sub-fields (including miscellaneous sub-field). The publication share of these 6 sub-fields varies from 4.90% to 26.25% and their average citation per paper varies from 11.55 to 13.49. Among the 6 sub-fields, the priorities assigned by India in terms of sub-field national share and research output are: (i) organic chemistry (22418 papers, 26.25% share), physical & theoretical chemistry (18481 papers, 21.64% share), (iii) inorganic chemistry (8900 papers, 10.42% share), analytical chemistry (7060 papers, 8.27% share), spectroscopy (4738 papers, 5.55% share) and electrochemistry (4183 papers, 4.90% share).

**Table 5. Distribution of Indian Chemistry Output by Sub-Fields, 1996-2011**

Sub-Field	Papers	ACPP	Sub-Field	Papers	ACPP
Analytical Chemistry	7060	11.91	Physical & Theoretical Chemistry	18481	13.49
Electrochemistry	4183	12.25	Spectroscopy	4738	11.99
Inorganic Chemistry	8900	11.55	Miscellaneous	29804	7.89
Organic Chemistry	22418	11.73			

**Biochemistry, Genetics & Molecular Biology** - The national publication share of India in biochemistry, genetics & molecular biology was 11.18% (70955 publications) during 1996-2011, which has increased from 10.44% (19859 papers) during 1996-03 to 11.50% (51096 papers) during 2004-11. The international collaborative publication share of India in biochemistry, genetics & molecular biology was 20.26% during 1996-2011, which has increased from 18.70% during 1996-03 to 20.87% during 2004-11. The world publication share of India in biochemistry, genetics & molecular biology was 2.52% during 1996-2011, which has increased from 1.65% during 1996-03 to 3.18% during 2004-11. The average citation per paper registered by all Indian publications in biochemistry, genetics & molecular biology was 9.11 during 1996-2011, which has decreased from 15.27 during 1996-03 to 5.56 during 2004-11.

The publication output in India in biochemistry, genetics & molecular biology during 1996-2011 has been classified under 15 sub-fields (including miscellaneous sub-field). The publication share of these 14 sub-fields varies from 0.48% to 34.50% and their average citation per paper varies from 6.68 to 14.37. Among the 14 sub-fields, the priorities assigned by India in terms of sub-field national share and research output are are: (i) biochemistry (24478 papers, 34.50% share), (ii) biotechnology (12962 papers, 18.27% share), (iii) molecular biology (8102 papers, 11.42% share), (iv) genetics (7341 papers, 10.35% share), (v) cell biology (6305 papers, 8.89% share), (vi) structural biology (5813 papers, 8.19% share), (vii) biophysics (5781 papers, 8.15% share), (viii) molecular medicine (5430 papers, 7.65% share), (ix) clinical biochemistry (5049 papers, 7.12% share), (x) cancer research (3492 papers, 4.92% share), (xi) physiology (2739 papers, 3.86% share), (xii) endocrinology (2622 papers, 3.70% share), (xiii) developmental biology (1171 papers, 1.65% share) and aging (344 papers, 0.48% share)

**Table 7. Distribution of Indian Biochemistry, Genetics & Molecular Biology Output by Sub-Fields, 1996-2010**



Sub-Field	TP	ACPP	Sub-Field	TP	ACPP
Aging	344	14.37	Endocrinology	2622	12.03
Biochemistry	24478	14.32	Genetics	7341	14.05
Biophysics	5781	11.64	Molecular Biology	8102	14.94
Biotechnology	12962	12.20	Molecular Medicine	5430	7.53
Cancer Research	3492	11.77	Physiology	2739	8.29
Cell Biology	6305	12.20	Structural Biology	5813	6.68
Clinical Biochemistry	5049	10.19	Miscellaneous	8877	8.38
Developmental Biology	1171	13.98			

**Agricultural & Biological Sciences** - The national publication share of India in agricultural & biological sciences was 11.15% (70753 publications) during 1996-2011, which has decreased from 13.71% (26084 publications) during 1996-03 to 10.05% (44669 publications) during 2004-11. The international collaborative publication share of India in agricultural & biological sciences was 16.87% during 2006-11, which has increased from 13.81% during 1996-03 to 18.66% during 2004-11. The world publication share of India in agricultural & biological sciences was 3.98% during 1996-2011, which has increased from 3.62% during 1996-03 to 4.07% during 2004-11. The average citation per paper registered by all Indian publications in agricultural & biological sciences was 5.50 during 1996-2011, which has decreased from 7.96 during 1996-03 to 4.06 during 2004-11.

The publication output in Indian agricultural & biological sciences during 1996-2011 has been classified under 11 sub-fields (including miscellaneous sub-field). The publication share of these 10 sub-fields varies from 2.19% to 21.56% and their average citation per paper varies from 2.44 to 10.67. Among the 10 sub-fields, the priorities assigned by India in terms of sub-field national share and research output are: (i) plant science (15252 papers, 21.56% share), (ii) food science (12977 papers, 18.34% share), (iii) agronomy & crop science (11808 papers, 16.69% share), (iv) animal science & zoology (11024 papers, 15.58% share), (v) soil science (3937 papers, 5.56% share), (vi) horticulture (3561 papers, 5.06% share), (vii) aquatic science (3394 papers, 4.80% share), (viii) ecology, evolution behaviour & systematics (3298 papers, 4.66% share), (ix) forestry (2126 papers, 3.00% share) and insect science (1550 papers, 2.19% share).

**Table 6. Distribution of Indian Agricultural & Biological Sciences Output by Sub-Fields, 1996-2011**

Sub-Field	TP	ACPP	Sub-Field	TP	ACPP
Agronomy & Crop Science	11808	7.81	Horticulture	3561	8.07
Animal Science & Zoology	11024	2.44	Insect Science	1550	5.78
Aquatic Science	3394	10.59	Plant Science	15252	8.56
Ecology, Evolution Behavior & Systematics	3298	10.46	Soil Science	3937	10.67
Food Science	12977	9.68	Miscellaneous	17522	4.39
Forestry	2126	9.26			

**Physics & Astronomy** - The national publication share of India in physics & astronomy was 10.47% (66415 publications) during 1996-2011, which has decreased from 11.09% (21095 papers) during 1996-03 to 10.47% (45320 papers) during 2004-11. The international collaborative publication share of India in physics & astronomy was 30.95% during 1996-2011, which has increased from 29.85% during 1996-03 to 31.47% during 2004-11. The world publication share of India in physics & astronomy was 3.44% during 1996-2011, which has increased from 2.76% during 1996-03 to 3.89% during 2004-11. The average citation per paper registered by all Indian publications in physics & astronomy was 8.17 during 1996-2011, which has decreased from 13.30 during 1996-03 to 5.78 during 2004-11.

The publication output in India in physics & astronomy during 1996-2011 has been classified under 10 sub-fields (including miscellaneous sub-field). The publication share of these 9 sub-fields varies from 0.91% to 35.87% and their average citation per paper varies from 4.36 to 15.77. Among the 9 sub-fields, the priorities assigned by India in terms of sub-field national share and research output are: (i) condensed matter physics (23826 papers, 35.87% share), (ii) nuclear & high energy physics (7605 papers, 11.45% share), (iii) atomic & molecular physics and optics (6454 papers, 9.72% share), (iv) surfaces & interfaces (3409 papers, 5.13% share), (v) statistical & non-linear physics (2619 papers, 3.94% share), (vi) instrumentation (2123 papers, 3.20% share), (vii) radiation (1443 papers, 2.17% share), (viii) astronomy & astrophysics (1418 papers, 2.14% share) and (ix) acoustics & ultrasonics (602 papers, 0.91% share).

**Table 8. Distribution of Indian Physics & Astronomy Output by Sub-Fields, 1996-2011**

Sub-Field	TP	ACPP	Sub-Field	TP	ACPP
Acoustics & Ultrasonics	602	4.36	Nuclear & High Energy Physics	7605	15.77
Astronomy & Astrophysics	1418	12.41	Radiation	1443	7.38
Atomic & Molecular Physics and Optics	6454	10.38	Statistical & Nonlinear Physics	2619	9.41
Condensed Matter Physics	23826	9.30	Surfaces & Interfaces	3409	14.68
Instrumentation	2123	7.98	Miscellaneous	25564	8.87

**Materials Science** - The national publication share of India in materials science was 9.33% (59225 publications) during 1996-2011, which has decreased from 9.95% (18926 papers) during 1996-03 to 9.071% (40299 papers) during 2004-11. The international collaborative publication share of India in materials science was 19.90% during 1996-2011, which has increased from 17.03% during 1996-03 to 21.24% during 2004-11. The world publication share of India in materials science was 3.88% during 1996-2011, which has increased from 3.20% during 1996-03 to 4.31% during 2004-11. The average citation per paper registered by all Indian publications in materials science was 7.35 during 1996-2011, which has decreased from 11.11 during 1996-03 to 5.59 during 2004-11.

The publication output in India in materials science during 1996-2011 has been classified under 8 sub-fields (including miscellaneous sub-field). The publication share of these 7 sub-fields varies from 1.95% to 20.09% and their average citation per paper varies from 6.50 to 16.58. Among the 9 sub-fields, the priorities assigned by India in terms of sub-field national share and research output are: (i) electrical, optical & magnetic materials (11899 papers, 20.09% share), (ii) polymers & plastics (10809 papers, 18.25% share), (iii) materials chemistry (9274 papers, 15.66% share), (iv) metals & alloys (6653 papers, 11.23% share), (v) ceramics & composites (4699 papers, 7.93% share) (vi) surfaces, coatings & films (4127 papers, 6.97% share) and (vii) biomaterials (1155 papers, 1.95% share).

**Table 9. Distribution of Indian Materials Science Output by Sub-Fields, 1996-2011**

Sub-Field	TP	ACPP	Sub-Field	TP	ACPP
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Biomaterials	1155	16.58	Metals & Alloys	6653	6.50
Ceramics & Composites	4699	9.76	Polymers & Plastics	10809	7.63
Electrical, Optical & Magnetic Materials	11899	7.82	Surfaces, Coatings & Films	4127	12.19
Materials Chemistry	9274	11.45	Miscellaneous	24161	8.63

**Engineering** - The national publication share of India in engineering was 9.33% (59190 publications) during 1996-2011, which has decreased from 9.94% (18908 papers) during 1996-03 to 9.068% (40282 papers) during 2004-11. The international collaborative publication share of India in engineering was 19.06% during 1996-2011, which has increased from 17.67% during 1996-03 to 20.09% during 2004-11. The world publication share of India in engineering was 1.95% during 1996-2011, which has increased from 1.55% during 1996-03 to 2.16% during 2004-11. The average citation per paper registered by all Indian publications in engineering was 5.51 during 1996-2011, which has decreased from 7.95 during 1996-03 to 3.96 during 2004-11.

The publication output in India in engineering during 1996-2011 has been classified under 16 sub-fields (including miscellaneous sub-field). The publication share of these 15 sub-fields varies from 0.34% to 33.149% and their average citation per paper varies from 0.67 to 22.86. Among the 15 sub-fields, the priorities assigned by India in terms of sub-field national share and research output are: (i) electric & electronic engineering (19614 papers, 33.14% share), (ii) mechanical engineering (8759 papers, 14.80% share), (iii) industrial & manufacturing engineering (6013 papers, 10.16% share), (iv) control & system engineering (3603 papers, 6.09% share), (v) civil & structural engineering (3575 papers, 6.04% share) (vi) safety, risk reliability & quality (2711 papers, 4.58% share), (vii) mechanics of materials (2629 papers, 4.44% share), (viii) computational mechanics (2346 papers, 3.96% share), (ix) building & construction (1962 papers, 3.31% share), (x) biomedical engineering (1854 papers, 3.13% share), (xi) aerospace engineering (1308 papers, 2.21% share), (xii) ocean engineering (1248 papers, 2.11% share), (xiii) architecture (908 papers, 1.53% share), (xiv) media technology (345 papers, 0.58% share) and (xv) automotive engineering (200 papers, 0.34% share).

**Table 10. Distribution of Indian Engineering Output by Sub-Fields, 1996-2011**

Sub-Field	TP	ACPP	Sub-Field	TP	ACPP
Aerospace Engineering	1308	3.20	Electric & Electronic Engineering	19614	6.75
Architecture	908	0.67	Industrial & Manufacturing Engineering	6013	5.44
Automotive Engineering	200	4.06	Mechanical Engineering	8759	7.50
Biomedical Engineering	1854	15.01	Mechanics of Materials	2629	7.65
Building & Construction	1962	2.43	Media Technology	345	22.86
Civil & Structural Engineering	3575	7.14	Ocean Engineering	1248	3.42
Computational Mechanics	2346	6.93	Safety, Risk Reliability & Quality	2711	12.42
Control &	3603	9.17	Miscellaneous	12409	5.35

System Engineering					
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#### 4.4.2 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 2.13% to 5.41% in the cumulative national publications output of the country during 1996-2010.

**Chemical Engineering** - The national publication share of India in chemical engineering was 5.41% (34322 publications) during 1996-2011, which has decreased from 5.62% (10707 papers) during 1996-03 to 5.32% (23615 papers) during 2004-11. The international collaborative publication share of India in chemical engineering was 15.59% during 1996-2011, which has increased from 13.84% during 1996-03 to 16.38% during 2004-11. The world publication share of India in chemical engineering was 3.51% during 1996-2011, which has increased from 2.62% during 1996-03 to 4.14% during 2004-11. The average citation per paper registered by all Indian publications in chemical engineering was 9.31 during 1996-2011, which has decreased from 13.07 during 1996-03 to 7.61 during 2004-11.

The publication output in India in chemical engineering during 1996-2011 has been classified under 8 sub-fields (including miscellaneous sub-field). The publication share of these 7 sub-fields varies from 3.89% to 19.28% and their average citation per paper varies from 7.34 to 20.56. Among these 7 sub-fields, the priorities assigned by India in terms of sub-field national share and research output are: (i) bioengineering (6618, 19.28% share); (ii) process chemistry & technology (5368 papers, 15.64% share), (iii) catalysis (4304 papers, 12.54 % share), (iv) fluid flow & transfer processes (3669 papers, 10.69% share), (v) colloid & surface chemistry (2814 papers, 8.20% share), (vi) filtration & separation (1551 papers, 4.52% share) and (vii) chemical health & safety (1334 papers, 3.89% share).

**Table 11. Distribution of Indian Chemical Engineering Output by Sub-Fields, 1996-2011**

Sub-Field	TP	ACPP	Sub-Field	TP	ACPP
Bioengineering	6618	9.06	Filtration & Separation	1551	13.76
Catalysis	4304	14.83	Fluid Flow & Transfer Processes	3669	7.34
Chemical Health & Safety	1334	18.13	Process Chemistry & Technology	5368	20.56
Colloid & Surface Chemistry	2814	19.66	Miscellaneous	14479	7.79

**Environment Science** - The national publication share of India in environment science was 5.14% (32605 publications) during 1996-2011, which has increased from 4.88% (9279 papers) during 1996-03 to 5.25% (23326 papers) during 2004-11. The international collaborative publication share of India in environment science was 14.94% during 1996-2011, which has increased from 12.60% during 1996-03 to 15.87% during 2004-11. The world publication share of India in environment science was 3.59% during 1996-2011, which has increased from 2.71% during 1996-03 to 4.12% during 2004-11. The average citation per paper registered by all Indian publications in environment science was 6.21 during 1996-2011, which has decreased from 9.89 during 1996-03 to 4.74 during 2004-11.

The publication output in India in environment science during 1996-2011 has been classified under 12 sub-fields (including miscellaneous sub-field). The publication share of these 11 sub-fields varies from 0.62% to 24.72% and their average citation per paper varies from 5.14 to 34.51. Among the 11 sub-fields, the priorities assigned by India in terms of sub-field national share and research output are: (i) Environmental

Chemistry (8060 papers, 24.72% share); (ii) Ecology (6597 papers, 20.23% share), (iii) Water Science & Technology (4697 papers, 14.41% share), (iv) Environmental Engineering (3287 papers, 10.08% share), (v) Pollution (3251 papers, 9.97% share), (vi) Health, Toxicology & Mutagenesis (2552 papers, 7.83% share); (vii) Waste Management & Disposal (1187 papers, 3.64% share), (viii) Management, Monitoring, Policy & Law (1057 papers, 3.24% share), (ix) Nature & Landscape Conservation (478 papers, 1.47% share), (x) discrete Global & Planetary Change (319 papers, 0.98% share) and (xi) Ecological Modeling (203 papers, 0.62% share).

**Table 12. Distribution of Indian Environmental Science Output by Sub-Fields, 1996-2011**

Sub-Field	TP	ACPP	Sub-Field	TP	ACPP
Ecological Modeling	203	34.51	Management, Monitoring, Policy & Law	1057	11.69
Ecology	6597	5.14	Nature & Landscape Conservation	478	13.16
Environmental Chemistry	8060	9.68	Pollution	3251	8.76
Environmental Engineering	3287	14.04	Waste Management & Disposal	1187	13.50
Global & Planetary Change	319	17.63	Water Science & Technology	4697	11.66
Health, Toxicology & Mutagenesis	2552	10.33	Miscellaneous	13290	7.72

**Pharmacology, Toxicology & Pharmaceutics** - The national publication share of India in pharmacology, toxicology & pharmaceutics was 4.64% (29448 publications) during 1996-2011, which has increased from 3.10% (5894 papers) during 1996-03 to 5.30% (23554 papers) during 2004-11. The international collaborative publication share of India in pharmacology, toxicology & pharmaceutics was 9.42% during 1996-2011, which has increased from 8.0% during 1996-03 to 9.72% during 2004-11. The world publication share of India in pharmacology, toxicology & pharmaceutics was 4.30% during 1996-2011, which has increased from 2.12% during 1996-03 to 5.78% during 2004-11. The average citation per paper registered by all Indian publications in pharmacology, toxicology & pharmaceutics was 7.00 during 1996-2011, which has decreased from 14.61 during 1996-03 to 5.09 during 2004-11.

The publication output in India in pharmacology, toxicology & pharmaceutics during 1996-2011 has been classified under 5 sub-fields (including miscellaneous sub-field). The publication share of these 4 sub-fields varies from 14.35% to 39.86% and their average citation per paper varies from 11.20 to 12.80. Among the 4 sub-fields, the priorities assigned by India in terms of sub-field national share and research output are: (i) pharmacology (11737 papers, 39.86% share); (ii) pharmaceutical Science (10884 papers, 36.96% share), (iii) drug discovery (6442 papers, 21.88% share) and (iv) toxicology (4227 papers, 14.35% share).

**Table 13. Distribution of Indian Pharmacology, Toxicology & Pharmaceutics Output by Sub-Fields, 1996-2011**

Sub-Field	TP	ACPP	Sub-Field	TP	ACPP
Drug Discovery	6442	12.52	Toxicology	4227	12.80
Pharmaceutical Science	10884	11.20	Miscellaneous	3473	4.86

Pharmacology	11737	12.31			
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**Mathematics** - The national publication share of India in mathematics was 3.90% (24781 publications) during 1996-2011, which has increased from 3.82% (7278 papers) during 1996-03 to 3.94% (17503 papers) during 2004-11. The international collaborative publication share of India in mathematics was 29.92% during 1996-2011, which has decreased from 30.07% during 1996-03 to 29.85% during 2004-11. The world publication share of India in mathematics was 2.51% during 1996-2011, which has increased from 2.25% during 1996-03 to 2.64% during 2004-11. The average citation per paper registered by all Indian publications in mathematics was 5.74 during 1996-2011, which has decreased from 11.23 during 1996-03 to 3.45 during 2004-11.

The publication output in India in mathematics during 1996-2011 has been classified under 14 sub-fields (including miscellaneous sub-field). The publication share of these 13 sub-fields varies from 0.07% to 27.43% and their average citation per paper varies from 3.32 to 16.01. Among the 13 sub-fields, the priorities assigned by India in terms of sub-field national share and research output are: (i) applied mathematics (6798 papers, 27.43% share); (ii) mathematical physics (5526 papers, 22.30% share), (iii) theoretical computer science (4537 papers, 18.31% share), (iv) modeling & simulation (2237 papers, 9.03% share), (v) statistics & probability (2098 papers, 8.47% share), (vi) computational mathematics (2058 papers, 8.30% share) (vii) analyses (1535 papers, 6.19% share), (viii) numerical analysis (1062 papers, 4.29% share), (ix) algebra & number theory (992 papers, 4.00% share), (x) discrete mathematics & combinatorics (699 papers, 2.82% share), (xi) control & optimization (503 papers, 2.03% share); (xii) geometry & topology (360 papers, 1.45% share) and (xiii) logic (18 papers, 0.07% share).

**Table 14. Distribution of Indian Mathematics Output by Sub-Fields, 1996-2011**

Sub-Field	TP	ACPP	Sub-Field	TP	ACPP
Algebra & Number Theory	992	3.32	Logic	18	6.50
Analyses	1535	6.18	Mathematical Physics	5526	11.70
Applied Mathematics	6798	6.91	Modeling & Simulation	2237	7.77
Computational Mathematics	2058	6.87	Numerical Analysis	1062	6.10
Control & Optimization	503	8.87	Statistics & Probability	2098	5.88
Discrete Mathematics & Combinatorics	699	5.47	Theoretical Computer Science	4537	16.01
Geometry & Topology	360	6.94	Miscellaneous	5590	3.81

**Earth & Planetary Sciences** - The national publication share of India in earth & planetary sciences was 3.82% (24245 publications) during 1996-2011, which has decreased from 4.78% (9100 papers) during 1996-03 to 3.41% (23326 papers) during 2004-11. The international collaborative publication share of India in earth & planetary sciences was 27.04% during 1996-2011, which has increased from 22.78% during 1996-03 to 29.59% during 2004-11. The world publication share of India in earth & planetary sciences was 2.42% during 1996-2011, which has increased from 2.17% during 1996-03 to 2.60% during 2004-11. The average citation per paper registered by all Indian publications in earth & planetary sciences was 6.88 during 1996-2011, which has decreased from 10.20 during 1996-03 to 4.88 during 2004-11.

The publication output in India in earth & planetary sciences during 1996-2011 has been classified under 13 sub-fields (including miscellaneous sub-field). The publication share of these 12 sub-fields varies from 0.37% to 21.07% and their average citation per paper varies from 5.20 to 16.41. Among the 12 sub-fields, the priorities assigned by India in terms of sub-field national share and research output are: (i) space & planetary science (5109 papers, 21.07% share); (ii) atmospheric science (3544 papers, 14.62% share), (iii) Geochemistry & Petrology (3056 papers, 12.60% share), (iv) geotechnical engineering & engineering geology (2716 papers, 11.20% share), (v) oceanography (2468 papers, 10.18% share), (vi) Earth Surface Processes (2064 papers, 8.51% share); (vii) geophysics (1717 papers, 7.08% share), (viii) geology (1324 papers, 5.46% share), (ix) paleontology (1006 papers, 4.15% share), (x) computers in earth sciences (711 papers, 2.93% share), (xi) economic geology (117 papers, 0.48% share) and (xii) stratigraphy (89 papers, 0.37% share).

**Table 15. Distribution of Indian Earth & Planetary Science Output by Sub-Fields, 1996-2010**

Sub-Field	TP	ACPP	Sub-Field	TP	ACPP
Atmospheric Science	3544	9.64	Geotechnical Engineering & Engineering Geology	2716	5.20
Computers in Earth Sciences	711	9.80	Oceanography	2468	7.89
Earth Surface Processes	2064	12.73	Paleontology	1006	13.80
Economic Geology	117	7.96	Space & Planetary Science	5109	11.89
Geochemistry & Petrology	3056	11.61	Stratigraphy	89	16.41
Geology	1324	6.29	Miscellaneous	7057	5.97
Geophysics	1717	12.65			

**Computers** - The national publication share of India in computer science was 3.63% (23027 publications) during 1996-2011, which has increased from 2.68% (5109 papers) during 1996-03 to 4.03% (17918 papers) during 2004-11. The international collaborative publication share of India in computer science was 26.83% during 1996-2011, which has decreased from 32.51% during 1996-03 to 23.48% during 2004-11. The world publication share of India in computer science was 1.95% during 1996-2011, which has increased from 1.35% during 1996-03 to 2.24% during 2004-11. The average citation per paper registered by all Indian publications in computer science was 5.38 during 1996-2011, which has decreased from 13.30 during 1996-03 to 3.13 during 2004-11.

The publication output in India in computer science during 1996-2011 has been classified under 12 sub-fields (including miscellaneous sub-field). The publication share of these 11 sub-fields varies from 1.23% to 24.23% and their average citation per paper varies from 4.72 to 16.14. Among the 11 sub-fields, the priorities assigned by India in terms of sub-field national share and research output are: (i) hardware & architecture (5579 papers, 24.23% share); (ii) computer science applications (3599 papers, 15.63% share), (iii) computer networks & communications (3213 papers, 13.95 % share), (iv) software (3187 papers, 13.84% share), (v) computational theory & mathematics (2883 papers, 12.52% share), (vi) artificial intelligence (2733 papers, 11.87% share), (vii) information systems (1780 papers, 7.73% share), (viii) signal processing (1720 papers, 9.86%share), (ix) computer vision & pattern recognition (1099 papers, 4.77% share), (x) computer graphics & computer-aided design (967 papers, 4.20% share) and human-computer interactions (283 papers, 1.23% share).

**Table 16. Distribution of Indian Computer Science Output by Sub-Fields, 1996-2011**

Sub-Field	TP	ACPP	Sub-Field	TP	ACPP
Artificial Intelligence	2733	18.52	Hardware & Architecture	5579	4.72

Computational Theory & Mathematics	2883	14.79	Human-Computer Interactions	283	12.35
Computer Graphics & Computer-Aided Design	967	16.14	Information Systems	1780	10.91
Computer Networks & Communications	3213	8.32	Signal Processing	1720	9.86
Computer Science Applications	3599	9.81	Software	3187	5.13
Computer Vision & Pattern Recognition	1099	14.13	Miscellaneous	6988	2.66

**Immunology & Microbiology** - The national publication share of India in immunology & microbiology was 3.18% (20184 publications) during 1996-2011, which has increased from 3.05% (5796 papers) during 1996-03 to 3.24% (14388 papers) during 2004-11. The international collaborative publication share of India in immunology & microbiology was 19.99% during 1996-2011, which has increased from 18.94% during 1996-03 to 20.41% during 2004-11. The world publication share of India in immunology & microbiology was 2.57% during 1996-2011, which has increased from 1.71% during 1996-03 to 3.22% during 2004-11. The average citation per paper registered by all Indian publications in immunology & microbiology was 9.11 during 1996-2011, which has decreased from 15.41 during 1996-03 to 6.57 during 2004-11.

The publication output in India in immunology & microbiology during 1996-2011 has been classified under 6 sub-fields (including miscellaneous sub-field). The publication share of these 5 sub-fields varies from 7.78% to 36.99% and their average citation per paper varies from 9.10 to 17.49. Among the 5 sub-fields, the priorities assigned by India in terms of sub-field national share and research output are: (i) applied microbiology & biotechnology (7467 papers, 36.99% share); (ii) microbiology (6790 papers, 33.64% share), (iii) immunology (5417 papers, 26.84% share), (iv) parasitology (3202 papers, 15.86% share) and (v) virology (1570 papers, 7.78% share).

**Table 17. Distribution of Indian Immunology & Microbiology Output by Sub-Fields, 1996-2011**

Sub-Field	TP	ACPP	Sub-Field	TP	ACPP
Applied Microbiology & Biotechnology	7467	11.54	Parasitology	3202	9.10
Immunology	5417	13.28	Virology	1570	17.49
Microbiology	6790	11.35	Miscellaneous	177	6.26

**Veterinary Science** - The national publication share of India in veterinary science was 2.13% (13494 publications) during 1996-2011, which has decreased from 2.80% (5322 papers) during 1996-03 to 1.84% (6996 papers) during 2004-11. The international collaborative publication share of India in veterinary science was 18.54% during 1996-2011, which has increased from 12.74% during 1996-03 to 22.31% during 2004-11. The world publication share of India in veterinary science was 6.42% during 1996-2011, which has increased from 6.41% during 1996-03 to 6.43% during 2004-11. The average citation per paper registered by all Indian publications in veterinary science was 1.52 during 1996-2011, which has decreased from 2.14 during 1996-03 to 1.12 during 2004-11.

The publication output in India in veterinary science during 1996-2011 has been classified under 4 sub-fields (including miscellaneous sub-field). The publication share of these 3 sub-fields varies from 0.76% to



6.28% and their average citation per paper varies from 6.64 to 12.12. Among these 3 sub-fields, the priorities assigned by India in terms of sub-field national share and research output are: (i) food animals (848, 6.28% share); (ii) equine (114 papers, 0.84% share) and (iii) small animals (103 papers, 0.76% share).

**Table 18. Distribution of Indian Veterinary Science Output by Sub-Fields, 1996-2011**

Sub-Field	TP	ACPP	Sub-Field	TP	ACPP
Equine	114	10.59	Small Animals	103	12.12
Food Animals	848	6.64	Miscellaneous	12625	1.46

**Energy** - The national publication share of India in energy was 1.56% (9902 publications) during 1996-2011, which has increased from 1.53% (2906 papers) during 1996-03 to 1.57% (6996 papers) during 2004-11. The international collaborative publication share of India in energy was 15.64% during 1996-2011, which has decreased from 17.69% during 1996-03 to 14.79% during 2004-11. The world publication share of India in energy was 2.69% during 1996-2011, which has increased from 2.14% during 1996-03 to 3.02% during 2004-11. The average citation per paper registered by all Indian publications in energy was 6.58 during 1996-2011, which has decreased from 8.93 during 1996-03 to 5.43 during 2004-11.

The publication output in India in energy during 1996-2011 has been classified under 5 sub-fields (including miscellaneous sub-field). The publication share of these 4 sub-fields varies from 16.15% to 34.28% and their average citation per paper varies from 5.71 to 13.46. Among these 4 sub-fields, the priorities assigned by India in terms of sub-field national share and research output are: (i) nuclear energy & engineering (3394, 34.28% share); (ii) renewable energy, sustainability & environment (3143 papers, 31.74% share), (iii) energy engineering & power technology (2804 papers, 28.32% share) and (iv) fuel technology (1599 papers, 16.15% share).

**Table 19. Distribution of Indian Energy Output by Sub-Fields, 1996-2011**

Sub-Field	TP	ACPP	Sub-Field	TP	ACPP
Energy Engineering & Power Technology	2804	9.06	Renewable Energy, Sustainability & Environment	3143	13.46
Fuel Technology	1599	7.16	Miscellaneous	2205	8.57
Nuclear Energy & Engineering	3394	5.71			

#### **Low Productive Subject Areas of Research in India**

Neurosciences, dentistry, health profession and nursing are considered as the four low productivity areas in S&T, each contributing publishing share less than 1% in the cumulative national publications output of the country during 1996-2011.

**Neurosciences** - The national publication share of India in neurosciences science was 0.59% (3734 publications) during 1996-2011, which has increased from 0.52% (1000 papers) during 1996-03 to 0.61% (2734 papers) during 2004-11. The international collaborative publication share of India in neurosciences was 22.47% during 1996-2011, which has decreased from 22.70% during 1996-03 to 22.38% during 2004-11. The world publication share of India in neurosciences was 0.81% during 1996-2011, which has increased from 0.50% during 1996-03 to 1.03% during 2004-11. The average citation per paper registered

by all Indian publications in neurosciences was 10.72 during 1996-2011, which has decreased from 19.46 during 1996-03 to 7.53 during 2004-11.

The publication output in India in neurosciences during 1996-2011 has been classified under 8 sub-fields (including miscellaneous sub-field). The publication share of these 7 sub-fields varies from 0.24% to 13.66% and their average citation per paper varies from 4.19 to 16.26. Among these 7 sub-fields, the priorities assigned by India in terms of sub-field national share and research output are: (i) cellular & molecular neuroscience (510, 13.66% share); (ii) neurology (391 papers, 10.47% share), (iv) development neuroscience (246 papers, 6.59% share), (v) biological psychiatry (119 papers, 3.19% share), (vi) cognitive neuroscience (42 papers, 1.12% share); and (vii) (vi) sensory systems (9 papers, 0.24% share).

**Table 20. Distribution of Indian Neurosciences Output by Sub-Fields, 1996-2011**

Sub-Field	TP	ACPP	Sub-Field	TP	ACPP
Behavioural Neuroscience	280	16.29	Development Neuroscience	246	13.67
Biological Psychiatry	119	18.26	Neurology	391	14.84
Cellular & Molecular Neuroscience	510	17.72	Sensory Systems	9	4.19
Cognitive Neuroscience	42	11.78	Miscellaneous	2604	14.14

**Dentistry** - The national publication share of India in dentistry was 0.36% (2296 publications) during 1996-2011, which has increased from 0.06% (106 papers) during 1996-03 to 0.49% (2190 papers) during 2004-11. The international collaborative publication share of India in dentistry was 7.92% during 1996-2011, which has decreased from 28.3% during 1996-03 to 6.94% during 2004-11. The world publication share of India in dentistry was 2.12% during 1996-2011, which has increased from 0.25% during 1996-03 to 3.32% during 2004-11. The average citation per paper registered by all Indian publications in dentistry was 2.54 during 1996-2011, which has decreased from 14.92 during 1996-03 to 1.94 during 2004-11.

The publication output in India in dentistry during 1996-2011 has been classified under 4 sub-fields (including miscellaneous sub-field). The publication share of these 3 sub-fields varies from 0.26% to 4.18% and their average citation per paper varies from 2.06 to 4.0. Among these 3 sub-fields, the priorities assigned by India in terms of sub-field national share and research output are: (i) oral surgery (96 papers, 4.18% share); (ii) orthodontics (12 papers, 0.52% share) and (iii) periodontics (6 papers, 0.26% share).

**Table 21. Distribution of Indian Dentistry Output by Sub-Fields, 1996-2011**

Sub-Field	TP	ACPP	Sub-Field	TP	ACPP
Oral Surgery	96	2.06	Periodontics	6	4.0
Orthodontics	12	2.75	Miscellaneous	2247	9.16

**Health Profession** - The national publication share of India in health profession was 0.27% (1689 publications) during 1996-2011, which has increased from 0.16% (298 papers) during 1996-03 to 0.31% (1391 papers) during 2004-11. The international collaborative publication share of India in health profession was 19.36% during 1996-2011, which has increased from 18.46% during 1996-03 to 19.55% during 2004-11. The world publication share of India in health profession was 1.0% during 1996-2011, which has remained the same from 1.0% during 1996-03 to 1.0% during 2004-11. The average citation per paper registered by all Indian publications in health profession was 5.62 during 1996-2011, which has decreased from 14.02 during 1996-03 to 3.82 during 2004-11.

The publication output in India in health profession during 1996-2011 has been classified under 8 sub-fields (including miscellaneous sub-field). The publication share of these 7 sub-fields varies from 0.41% to

41.62% and their average citation per paper varies from 0.58 to 11.06. Among these 7 sub-fields, the priorities assigned by India in terms of sub-field national share and research output are: (i) radiological & ultrasound technology (703, 41.62% share); (ii) health information management (192 papers, 11.37% share), (iii) physical therapy, sports therapy & rehabilitation (104 papers, 6.16% share), (iv) medical lab technology (100 papers, 5.92% share), (v) pharmacy (20 papers, 1.18% share), (vi) optometry (13 papers, 0.77% share); and (vii) speech & hearing (7 papers, 0.41% share).

**Table 22. Distribution of Indian Health Profession Output by Sub-Fields, 1996-2011**

Sub-Field	TP	ACPP	Sub-Field	TP	ACPP
Health Information Management	192	9.84	Physical Therapy, Sports Therapy & Rehabilitation	104	7.53
Medical Lab Technology	100	4.99	Radiological & Ultrasound Technology	703	11.06
Optometry	13	0.58	Speech & Hearing	7	0.87
Pharmacy	20	1.12	Miscellaneous	300	11.45

**Nursing** - The national publication share of India in nursing was 0.18% (1164 publications) during 1996-2011, which has increased from 0.10% (189 papers) during 1996-03 to 0.22% (975 papers) during 2004-11. The international collaborative publication share of India in nursing was 24.40% during 1996-2011, which has increased from 14.0% during 1996-03 to 26.36% during 2004-11. The world publication share of India in nursing was 0.42% during 1996-2011, which has increased from 0.21% during 1996-03 to 0.52% during 2004-11. The average citation per paper registered by all Indian publications in nursing was 5.38 during 1996-2011, which has decreased from 14.14 during 1996-03 to 3.68 during 2004-11.

The publication output in India in nursing during 1996-2011 has been classified under 18 sub-fields (including miscellaneous sub-field). The publication share of these 17 sub-fields varies from 0.09% to 35.14% and their average citation per paper varies from 0.09 to 35.14. Among the 17 sub-fields, the priorities assigned by India in terms of sub-field national share and research output are: (i) nutrition & diabetics (409 papers, 35.14% share); (ii) leadership & management (87 papers, 7.47% share), (iii) community & home care (81 papers, 6.96% share), (iv) fundamental & skills (43 papers, 3.69 % share), (iv) research & theory (42 papers, 3.61% share), (v) psychiatric & mental health (36 papers, 3.09% share), (vi) oncology (nursing) (19 papers, 1.63% share), etc

**Table 23. Distribution of Indian Nursing Output by Sub-Fields, 1996-2011**

Sub-Field	TP	ACPP	Sub-Field	TP	ACPP
Advanced & Specialized Nursing	13	1.56	Medical & Surgical Nursing	9	0.75
Community & Home Care	81	0.89	Nutrition & Dietetics	409	11.0
Critical Care Nursing	10	2.14	Oncology (Nursing)	19	0.59
Emergency Nursing	5	0.0	Pediatrics	9	0.27
Fundamentals & Skills	43	0.29	Pharmacology (Nursing)	10	0.77
Gerontology	3	7.67	Psychiatric & Mental Health	36	4.66
Issues, Ethics & Legal Aspects	7	0.67	Research & Theory	42	0.29
Leadership & Management	87	4.54	Review & Exam Preparation	1	0.0
Maternity & Midwifery	12	12.05	Miscellaneous	482	11.88

## Summary and Results

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 9.33% to 17.61%; (ii) Chemical engineering, environmental science, pharmacology, toxicology & pharmaceuticals, mathematics, earth & planetary sciences, computer science, immunology & microbiology, veterinary science and energy are the nine medium productivity areas of India in S&T, with publishing share varying from 2.13% to 5.41% and ; (iii) Neurosciences, dentistry, health profession and nursing are the four low productivity areas of India in S&T, with publishing share varying from 0.18% to 0.59%.

The largest increase (2.20% each) in national publication share of India was observed in pharmacology, toxicology & pharmaceuticals, followed by medicine (1.46), computer science (1.35%), biochemistry, genetics & molecular biology (1.06%), dentistry (0.43%), environmental science (0.37%), immunology & microbiology (0.19%), health profession (0.15%), mathematics (0.12%), nursing (0.12%), neurosciences (0.09) and energy (0.04%), as against largest decrease of 3.66% in agricultural & biological sciences, followed by chemistry (1.79%), earth & planetary sciences (1.33%), veterinary science (0.96%), physics & astronomy (0.62%), chemical engineering (0.30%), materials science (0.23%) and engineering (0.26%) from 1996-03 to 2004-11.

The world publication share of India was highest (6.42) in veterinary science, followed by chemistry (4.98), pharmacology, toxicology & pharmaceuticals (4.30), agricultural & biological sciences (3.98), materials science (3.88), environmental science (3.59), chemical engineering (3.51), physics & astronomy (3.44), energy (2.69), immunology & microbiology (2.57), biochemistry, genetics & molecular biology (2.52), mathematics (2.51), earth & planetary sciences (2.42), dentistry (2.12), engineering (1.95), computer science (1.95), medicine (1.39), health profession (0.00), neurosciences (0.81) and nursing (0.42) during 1996-2011. The highest increase (3.66%) of India in world publication share was in pharmacology, toxicology & pharmaceuticals, followed by dentistry (2.07%), chemistry (1.64%), biochemistry, genetics & microbiology (1.53), chemical engineering (1.52), immunology & microbiology (1.51), environmental science (1.41), physics & astronomy (1.13), materials science (1.11), computer science (0.89), medicine (0.88), energy (0.88), engineering (0.61), neurosciences (0.53), agricultural & biological sciences (0.45), earth & planetary sciences (0.43), mathematics (0.39), nursing (0.31) and veterinary science (0.02) from 1996-00 to 2006-11.

The largest share of (30.95%) of international collaborative papers of India was observed in physics & astronomy, followed by mathematics (29.92%), earth & planetary sciences (27.04%), computer science (26.83%), nursing (24.40%), neurosciences (22.47%), biochemistry, genetics & molecular biology (20.26%), immunology & microbiology (19.99), materials science (19.90%), health profession (19.36%), engineering (19.06%), veterinary science (18.54%), agricultural & biological sciences (16.87%), energy (15.64%), chemical engineering (15.59%), chemistry (15.45%), environmental science (14.94%), medicine (13.46%), pharmacology, toxicology & pharmaceuticals (9.42%) and dentistry (7.92%), during 1996-2010.

The largest increase (12.36%) in international collaborative publication share in India was observed in nursing, followed by veterinary science (9.57%), earth & planetary sciences (6.81%), agricultural & biological sciences (4.85%), medicine (4.79%), materials science (4.21%), environmental science (3.27%), chemistry (3.02%), chemical engineering (2.54%), engineering (2.42), biochemistry, genetics & molecular biology (2.17%), pharmacology, toxicology & pharmaceuticals ( 1.72%), physics & astronomy (1.62%), immunology & microbiology (1.47%), health profession (1.09%), as against largest decrease (21.36% in dentistry, followed by computer science (9.03%), energy (2.9%), neurosciences (0.32) and mathematics (0.22) from 1996-10 to 2006-2010.

The largest citation impact (10.72) of Indian papers as reflected in citation per paper was observed in neurosciences, followed by chemical engineering (9.31), biochemistry, genetics & molecular biology (9.11), immunology & microbiology (9.11), chemistry (8.36), physics & astronomy (8.17), materials science (7.35), pharmacology, toxicology & pharmaceuticals (7.0), earth & planetary sciences (6.88), energy (6.58), environmental science (6.21), mathematics (5.74), health profession (5.62), engineering (5.51), agricultural & biological sciences (5.50), medicine (4.92), computer science (5.38), nursing (5.38), medicine (4.95), dentistry (2.54) and veterinary sciences (1.52) during 1996-2010.

The entire Indian S&T output has been sub-divided into 20 broad fields and 211 sub-fields in the above presentation. In terms of research output, (i) 3 sub-fields have found to have publication output above 20,001 papers, (ii) 12 sub-fields between 10,001 to 20,000 papers, (iii) 29 sub-fields between 50,01 to 10,000 papers, (iv) 94 sub-fields between 10,01 to 5,000 papers, (iii) 73 sub-fields less than 1000 papers during 1996-10. In terms of citation impact per paper: (i) 3 sub-fields have registered more than 20.01, (ii) 86 sub-fields between 10.01 to 20.0, (iii) 78 sub-fields between 5.01 to 10.0, (iv) 44 sub-fields less than 5.

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