DESIDOC Bulletin of Information Technology, Vol. 27, No. 1, January 2007, pp. 5-16

Indicators of S&T Publications Output: Developed versus Developing Countries†

B.M.Gupta, S.M.Dhawan* and R. P.Gupta**

National Institute of Science, Technology and Development Studies
Pusa Gate, Dr KS Krishnan Marg, New Delhi–110 012
E-mail: bmgupta1@yahoo.com; bmgupta@nistads.res.in

**Library & Information Consultant, 114 Dayanand Vihar, Delhi–110 092*
E-mail: smdhawan@yahoo.com

***Office of the Principal Scientific Adviser to the Government of India*
Vigyan Bhawan Annexe, Maulana Azad Road, New Delhi–110 011

ABSTRACT

The paper analyses the cumulative output in science and technology during 1993 to 2003 of different regions/countries in the world. It also analyses the contributions made by the developed and the developing countries in the different broad subject fields to identify their strengths in the different fields of research.

Keywords: *Science & technology, third world countries, developed countries, S&T publications*

1. INTRODUCTION

Science and Technology (S&T) efforts are far from evenly distributed around the world. The gross expenditure on research and development (GERD), GERD as a percentage of gross national product (GNP), and the broad indicators of the input into S&T manifest this picture. In terms of the expenditure on research and development (R&D), the less developed countries spent about 19 per cent of the total world expenditure compared to their 30 per cent share of the world's GDP (based on data from 1997 to 2000). On an average, 1.85 per cent of their national GDP was spent on R&D. The lesser developed countries devoted less than 1per cent (0.9 per cent) of their GDP to R&D. Although the less developed countries account for 79 per cent of the world's population, they represent only 27 per cent of the total number of researchers in the world. There are 10 times more researchers (per million inhabitants) in the developed countries than in the less developed countries.

Three out of every 1000 inhabitants in developed countries are researchers, while only three out of every 10,000 inhabitants are researchers in the less developed countries (UNESCO Institute of Statistics, 2003).

† The paper is a part of the study on Measures of the Progress of Science in India: An Analysis of the Publication Output in Science and Technology, sponsored by the Office of the Scientific Adviser to the Government of India.

Input data such as GERD, GERD per capita, GERD as a percentage of GDP, and researchers per million inhabitants are not adequate by themselves to make a pertinent evaluation of the efficiency and performance of a national S&T system. The output from the national S&T systems, considered equally important parameter of R&D evaluation, has been measured and evaluated in this paper using publication indicators[1].

2. LITERATURE REVIEW

Very few earlier studies attempted to make global comparison of world science, as reflected in the publications output. Eugene Garfield[2] carried out analysis of world output, with particular reference to third world publications of 1973, using *Science Citation Index* (SCI) database and their citations received (from 1973 to 1978). In this study, US was found to have shown the maximum share (43 per cent) of publications (and more than 50 per cent citations share), followed by the UK, the then USSR, FRG, France, Japan, and Canada. India (with 7888 papers and 15515 citations) and Argentina (with 4110 papers and 4110 citations) were the only two developing countries ranked 8th and 25th among top 25 countries. Out of the 353000 articles indexed in the 1973 SCI file, only 16000 articles were authored from 93 third world countries. India accounted for half the articles from the developing countries. However, India's contribution was comparatively poor, when citation impact of its research output was considered.

A comparative study, titled 'The Scientific Wealth of Nations' by May[3], based on SCI database covered 8.4 million papers and 72 million citations appeared in 4000 journals since 1981 to 1994 from 79 countries. It showed that from 1981 to 1994, the world's output of papers increased by 3.7 per cent per year; 15 countries (including G-7 countries) accounted for 81.3 per cent of the total papers. The US and the European Union (EU) published 35 per cent and 32 per cent papers of world share, respectively. India with 2.4 per cent and China with 0.9 per cent share of papers and 0.7 and 0.3 per cent share of citations were at the 8th and 13th position, respectively. In terms of percentage share of citations of these countries, the ranking was similar, except for India and China. In terms of relative citation impact (RCI, citations per paper divided by country's average), the US ranked first. The five major countries in terms of publication share invested more in R&D than the other countries. The smaller countries with high ranking in RCI, notably Switzerland and Sweden (2nd and 3rd rank by RCI) were relatively high investors in R&D. India and China had low R&D investment and also had a low RCI (0.27 each) and were ranked 66th and 65th, respectively. In terms of RCI data across 20 broad subject fields, USA ranked first by citation share in all the subject fields, while UK was second in 15 of the 20 subject fields. The rankings were more varied, when a better quality measure, revealed comparative advantage (RCA), was used. On the basis of this index, UK had comparative advantage in pharmacology, clinical medicine, plant and animal science, and neuroscience. The asian countries showed prominence in research related to certain industries, such as engineering, computing, chemistry, and materials. Some countries like Australia, Canada, New Zealand and South Africa showed prominence in research based on natural resources.

Another study, titled, 'The Scientific Impact of Nations', by David King[4] used publications and citations data reported in SCI. In this study, a more selective parameter was used; the top one per cent highly cited publications under seven categories including: clinical medicine, pre-clinical medicine and health, biological sciences, environment, mathematics, and physical sciences were studied. David King used data from 1993-97 and 1997-2001 for viewing the growth of scientific output. Thirty-one countries (including G8 and 15 countries from the European Union) together accounted for the 98 per cent of the world's highly cited papers, while remaining 162 countries contributed less than 2 per cent only. Among the US and the EU, the former had a higher disciplinary footprint than latter. The footprints from the EU were more symmetrical and slightly more than the US in physical

sciences and engineering, but less in life and medical sciences. Russia and Japan were relatively stronger in physical sciences and engineering, and France in mathematics. Germany had highest impact in the physical sciences in contrast to the UK, which had a strong impact in medical, life, and environmental sciences. The 2004 rank order places India at 22nd, China at 19th, South Korea at 20th and Russia at 16th, Brazil at 23rd, South Africa at 29th, and Iran at 31st place. According to David King, citation rankings could hide important developments, particularly in countries like China and India, which have developed their science base rapidly and effectively over the past few years.

Another review[5] analysed the impact factor (IF) per paper of the publications of major countries covered in SCI from 1999 to 2003. In this survey, US was placed at the top, followed by the UK, Canada, Germany, France, Italy, Japan, South Korea, Singapore, Taiwan, China, and India. Their ranking order did not change much, but their impact per paper had improved with time. For example, the average IF during 1999 to 2003 per paper improved in case of India (from 1.38 to 1.86), China (from 1.56 to 2.17), South Korea (from 2.0 to 2.62), Taiwan (from 1.85 to 2.42) and Singapore (from 1.92 to 2.56), respectively. Compared to developing countries, the average IF during 1999 to 2003 per paper had improved in the US (from 5.61 to 6.22), the UK (from 4.64 to 5.46), Germany (from 4.26 to 5.13), and France (from 4.08 to 4.75), respectively.

Another study published in *UNESCO UIS Bulletin* (2005)[6] presents a bibliometric analyses of 20 (1981-2000) years of world scientific production as reflected by the publications indexed in the SCI, with particular emphasis on developing countries.

According to this study, developing countries saw a steady increase in their share of scientific production from 7.5 per cent of world's papers in 1981 to 17.1 per cent in 2000, against the steady decrease of publications of developed countries from 93.6 per cent to 87.9 per cent during the corresponding period.

On comparing scientific output and R&D expenditure, North America showed a relative decline from 1990 to 2000 in both respects. Asia showed sharp increase in R&D expenditure and publications. Oceania and Latin America increased their share of publications, while maintaining an unchanged R&D expenditure. Europe also increased its share in publications, but lost ground in expenditure. Africa showed an alarming drop in both publications and expenditure. Also, the share of physics, chemistry and engineering papers was significantly higher in the new industrialised countries in Asia, while clinical medicine and biomedical research made a larger part of the publications of the developed countries.

A recent study on Academic Ranking of the World Universities–2003[7] ranked the top 500 universities among the 2000 world universities, based on more stringent criteria and the range of disciplines covered. The study used the following parameters to rank universities: (i) number of noble laureates on the faculty of physics, medicine, and economics from 1911 to 2002, (ii) highly cited researchers in 21 broad subject categories from 1981 to 1999, (iii) articles published in *Nature* and *Science* during 2000-2002, (iv) articles in the *SCI Expanded* and the *Social Science Citation Index*, and (v) the academic performance of each faculty member, where the indices (i) to (iv) were weighted by the number of the faculty members.

Based on equal weighting to the above five criterion, the top 100 universities in the world comprised 58 universities from the US, 29 from Europe, four from Canada, five from Japan, two from Australia and one from Israel. In Asia-Pacific among the top 90 universities, 35 were from Japan, 13 from China, 13 from Australia, eight from South Korea, six from Israel, five from Taiwan and three from India.

3. OBJECTIVES

The main objectives of the paper are to analyse: (i) the publications share of different regions/countries in world output, (ii) the comparative share of developed and developing

countries in different subjects, and (iii) the comparative strength of developing countries in publications output and citation impact by subject.

4. SOURCE AND METHODOLOGY

For comparative study of Indian research output with other countries, the 11 years combined publications and citation data of 146 countries during 1993 to 2003 were analysed. The publications data for the purpose were derived from the Web of Science database (downloaded in February 2004) and from ISI-Thomson Press Report on Essential Science Indicators.

5. ANALYSES AND RESULTS

5.1 Publications Share of Different Regions/Countries in World Output

For a decade, North America had been the largest contributor to the scientific publications output in the world. But more recently, Europe has overtaken it. It contributed the largest publications share (43.6 per cent world papers and 40.8 per cent world citations) of which 36.8 per cent world papers and 37.9 per cent world citations were from Western Europe and 7.3 per cent papers and 2.88 per cent citations from Eastern Europe. Compared to Europe, the America contributed 35.4 per cent world papers and 45.8 per cent world citations, of which 33.6 per cent papers and 44.7 per cent citations were from North America and only 1.84 per cent papers and 0.97 per cent citations were from Central/South America (Figs 1 and 2).

The Asian share of publications in the world output was 16.9 per cent (10.4 per cent world citations) of which the largest share (10.5 per cent papers and 7.55 per cent citations) was from far East Asia, followed by South Asia (2.06 per cent papers and 0.71 per cent citations), Middle East (1.48 per cent papers and 1.15 citations), and South East Asia (2.96 per cent papers and 0.99 per cent citations). The Oceania region contributed only 2.77 per cent share in world publications and 2.52 per cent citations share. In contrast, the smallest share (1.2 per cent papers and 0.58 per cent citations) to world output was from Africa (Figs 1 and 2).

India is one of the top 19 countries contributing one per cent share or more to the world output. These top 19 countries in the world account for 86.2 per cent world papers and 91.4 per cent world citations. Of these, the US contributed largest publications (29.18 per cent) and accounted for 40.13 per cent world citations. The UK, Japan Germany and France each contributed 5 per cent to 9 per cent of the world papers, whereas Canada, Italy and Russia contributed 3 per cent to 4 per cent each.

China, Australia, Spain and the Netherlands each contributed 2 per cent to 3 per cent of the world papers, while India, Sweden, Switzerland, South Korea, Belgium, Israel, and Poland each contributed one per cent to 2 per cent to the world papers. The next set of 19 countries contributed 0.25 per cent

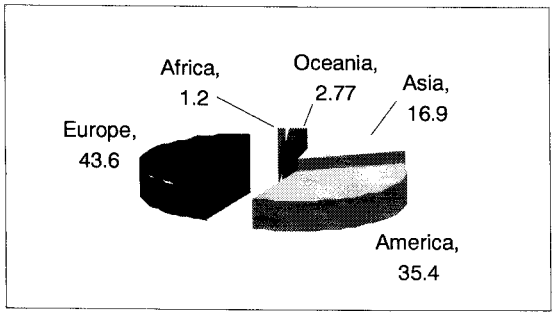


Figure 1. World publications share by geographical regions.

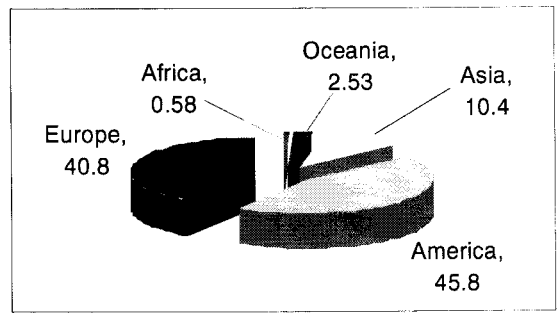


Figure 2. World citations share by geographical regions.

to 0.99 per cent share each to the world output. Their combined publications and citations share was 10.15 per cent and 6.8 per cent, respectively. Of these, 11 countries (Denmark, Finland, Austria, Turkey, Norway, Greece, Czech Republic, Hungary, Ukraine, Portugal, and Ireland) were from Europe, two (South Africa and Egypt) from Africa, two (Brazil and Argentina) from South America, two (Taiwan and Singapore) from Asia and one each from North America (Mexico) and Oceania (New Zealand) (Table 1).

5.2. Developed versus Developing Countries

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

Among the developed countries, the top seven accounted for 64.38 per cent world papers and 75.17 per cent world citations, the next seven countries accounted for 13.9 per cent world papers and 12.72 per cent world citations, and the next seven accounted for 5.45 per cent world papers and 4.8 per cent world citations. The combined output of these 21 developed countries was 83.8 per cent world papers and 92.74 per cent world citations (Table 1).Among the developing countries, the top seven countries accounted for 8.84 per cent world papers and 3.39 per cent world citations, the next seven countries accounted for 2.01 per cent papers and 1.07 per cent citations, and the next seven accounted for 0.8 per cent world papers and 0.33 per cent world citations. The combined output of these 21 countries was 11.65 per cent world papers and 4.78 per cent world citations (Table 2).

5.3 Developing Countries Share in World Output by Subject

The combined publication output of developing countries during 1993-2003 was classified into 19 broad subjects. Their publications share in world output and in world citations were analysed by these broad subject. Among the developing countries, materials science ranked top (21.60 per cent share) followed by agriculture (19.56 per cent), chemistry (17.75 per cent), engineering (17.39 per cent), physics (15.91 per cent), plant and animal sciences (15.76 per cent), mathematics (14.49 per cent), computer science (13.34 per cent), and pharmacology and toxicology (12.76 per cent) (Table 3).

The developing countries have acquired significant ranks among the top 20 in world output in select subjects. For example, India ranked first among developing countries in publications output in four subjects: agriculture (4^{th} rank in the world list, 5.63 per cent share to the world output), plant and animal sciences (8^{th} rank, 3.13 per cent share to the world output), energy and environment (11^{th} rank, 1.97 per cent share to the world output) and biology and biochemistry (14^{th} rank, 1.51 per cent share to the world output). It ranked 2^{nd} in materials science (8^{th} rank, 3.56 per cent share to the world output), chemistry (8^{th} rank, 3.62 per cent share to the world output), physics (9^{th} rank, 2.26 per cent share to the world output), geosciences (11^{th} rank, 2.31 per cent share to the world output), pharmacology and toxicology (13th rank, 1.89 per cent share to the world output), space sciences (13^{th} rank, 1.55 per cent share to the world output), mathematics (8^{th} rank, 3.56 per cent share to the world output), molecular biology and genetics (19^{th} rank and 0.76 per cent share to the world output), and immunology (20^{th} rank, 0.7 per cent share to the world output). It ranked 3^{rd} in engineering (11^{th} rank, 2.39 per cent share to the world output) and microbiology (17^{th} rank, 1.42 per cent share to the world output).

China ranked first among developing countries in materials science (4^{th} rank in the world list, 7.62 per cent world share), mathematics (5^{th} rank, 4.77 per cent world share), chemistry (7^{th} rank, 5.54 per cent world share), physics (7^{th} rank, 4.71 per cent world share), engineering (7^{th} rank, 3.86 per cent world share), computer science (8^{th}

Table 1. Contribution of top 38 Countries during 1993-2003

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

Table 2. Contributions of top 23 developing countries during 1993-2003

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

rank, 2.62 per cent world share), pharmacology and toxicology (10th rank, 2.01 per cent world share), space sciences (12th rank, 1.78 per cent world share), geosciences (10th rank, 2.76 per cent world share).

Brazil ranked first among developing countries in neurosciences and behaviour (13th rank in the world list, 1.17 per cent world share), molecular biology and genetics (16th rank, 0.93 per cent world share) and immunology (17th rank, 0.92 per cent world share). It ranked second in agriculture, plant and animal sciences and microbiology. South Korea ranked first rank among developing countries in microbiology (12th world rank, 1.75 per cent contribution), and 3rd rank onwards in all other subjects (Table 3).

The subjects (listed in order of ranking) that attracted more citations than the average for developing countries are: materials science (13.13 per cent), engineering (11.15 per cent), agriculture (9.63 per cent), chemistry (9.55 per cent), physics (9.1 per cent), mathematics (9.04 per cent), computer science (7.87 per cent), plant and animal science (7.58 per cent), space sciences (5.94 per cent), geosciences (5.72 per cent) and pharmacology and toxicology (5.46 per cent) (Table 3).

Developing countries that faired better in terms of relative citation impact in different subjects are shown in *Appendix I*. In fact, the developing countries (particularly India and China) that showed higher productivity have not done well in terms of relative citation

Table 3. Relative share of developed and developing countries by subject during 1993-2003

Subject	No. of Countries	World Total		Developed Countries		Developing Countries		No. of Countries	
		Papers	Citations	Papers	Citations	Papers	Citations	Developed	Developing
Chemistry	83	929294	8106317	82.25	58.63	17.75	9.55	42	41
Physics	80	1087058	8293558	84.01	91.90	15.91	9.10	36	44
Clinical Medicine	105	1985872	21934156	92.25	96.10	7.75	3.90	40	65
Mathematics	75	244376	659166	85.51	90.96	14.49	9.04	41	34
Materials Sci.	69	363116	1467958	78.40	86.87	21.60	13.13	31	38
Computer Sci	70	184190	467380	86.66	92.13	13.34	7.87	31	39
Space Science	59	169321	2037659	90.72	94.06	9.28	5.94	38	21
Geosciences	90	276855	2247815	88.72	94.28	11.28	5.72	37	53
Engineering	91	709698	2300714	82.61	88.85	17.39	11.15	47	44
Plant & Animal Sci	99	561159	3435784	84.24	92.42	15.76	7.58	35	64
Pharmacology & Toxicology	74	175622	1646157	87.24	94.60	12.76	5.46	38	36
Neuroscience & Behavior	69	316885	5246600	94.51	97.65	5.49	2.35	34	32
Multidisci. Sci	67	30293	142334	79.91	93.41	20.09	6.59	35	3
Mol. Biology & Genetics	80	304372	7793795	94.47	98.04	5.53	1.96	40	40
Microbiology	83	172326	2440718	89.59	94.95	10.41	5.05	37	46
Immunology	84	149974	2946898	93.03	96.45	6.97	3.55	32	52
Agriculture	93	167002	771336	80.44	90.37	19.56	9.63	36	57
Psychiatry/ Psychology	75	223844	1817341	96.67	98.37	3.33	1.63	36	39

impact. On the other hand, the Latin American countries, though contributed medium level research output, have done better in terms of relative citation impact compared to Asian and African countries. Among Asian countries, South Korea, Taiwan, and Singapore made greater relative citation impact in differrent subject fields than china, India, Thailand and Malaysia. Among Africa, only South Africa made high impact in few subject fields (*Appendix II*).

6. CONCLUSIONS

The developing countries contributed 12.73 per cent share to the global research output and attracted 5.36 per cent share in world citations as seen from the world output during 1993-2003. But in some select subjects their contributions are larger: materials science (21.60 per cent), agriculture (19.56 per cent), chemistry (17.75 per cent), engineering (17.39 per cent), physics (15.91 per cent), plant and animal sciences (15.76 per cent), mathematics (14.49 per cent), and computer science (13.34 per cent). Similarly, in select subjects they attracted higher citations share: materials science (13.13 per cent), engineering (11.15 per cent), agriculture (9.63 per cent), chemistry (9.55 per cent), physics (9.1 per cent), mathematics (9.04 per cent), computer science (7.87 per cent), plant and animal

science (7.58 per cent), space sciences (5.94 per cent), geosciences (5.72 per cent) and pharmacology and toxicology (5.46 per cent). Among the developing countries, China, India, Brazil, South Korea, etc., have gained top ranks, but in select subjects only. For example, China ranked 1st among developing countries in terms of its publications output in material science (4th rank in the world list), mathematics (5th rank), chemistry (7th rank), physics (7th rank), engineering (7th rank), computer science (8th rank), pharmacology and toxicology (10th rank), space sciences (12th rank), geosciences (10th rank), biology & biochemistry (15th rank), and psychiatry/ psychology (20th rank). Brazil acquired 1st rank among developing countries in neuroscience and behavior (13th rank in the world list), molecular biology and genetics (16th rank in the world list) and immunology (17th rank in the world list). South Korea acquired first rank among developing countries in publications output in only microbiology (12th rank in the world list).

Among developing countries, India ranked at the top in terms of research output in: agriculture (4th rank in world list, 5.63 per cent contribution), plant and animal sciences (8th rank, 3.13 per cent), energy and environment (11th rank, 1.97 per cent) and biology and biochemistry (14th rank, 1.51 per cent). It ranked 2nd following China in materials science, chemistry, physics, geosciences, pharmacology and toxicology, space sciences, mathematics, molecular biology and immunology. In terms of relative citations impact, both India and China lag behind other developing countries, particularly Latin American countries, South Korea, Taiwan, Singapore, and South Africa.Developing countries require concentrated efforts for improving the quality and quantity of research output. These countries need to build up more effectively their scientific capacity, competence, and knowledge base to bridge scientific and technological gap with developed countries. Achieving this will depend in part by increasing investment in R&D and higher education sector (strengthening educational and R&D infrastructure), and in part by increasing deployment of qualified and competent S&T manpower, greater interaction among the various S&T sectors, and increased scientific cooperation among developed countries.

REFERENCES

1. Borchart, Alexandra. Background report on research and education in resource-constrained countries. 2003.

2. Garfield, Eugene. Mapping science in the third world Pt 1. *Science & Public Policy,* 1983, **10**(3), 112-27.

3. May, Robert M. Scientific wealth of nations. *Science,* 1997, **275**, 793-96.

4. King, David. The scientific impact of nations. *Nature,* 2004, **430**, 311-16.

5. National Science Council Review–2004, Ch 2. National-wide scientific and Technological development. Available at http://nr.stpi.org.tw/ejournal/yearbook/93/eng/chapter2_pdf

6. What do bibliometric indicators tell us about world scientific output? *UIS Bull. Sci. Technol. Stat.,* 2005, 2, 1-4.

7. Academic ranking of world Universities-2003. Available at http://ed.sjtu.edu.cn/rank/ 2003.

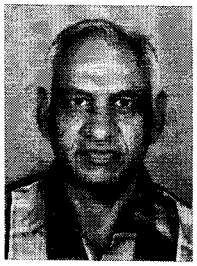
Developing countries in the top 20 world countries by different subjects during 1993-2003

Subject fields	World publications rank and percentage share of publications in world output
Agriculture	**India (4th rank, 5.63% papers)**, Brazil (12th rank, 2.36% papers)
Biology & Biochemistry	**India (14th rank**, 1.51% papers), China (15th rank, 1.5% papers), South Korea (16th rank, 1.16% papers)
Chemistry	China (7th rank, 5.54% papers), **India (8th rank, 3.62% papers)**, South Korea (13th rank, 1.90% papers), Brazil (20th rank, 0.97% papers)
Clinical Medicine	China (20th rank, 0.86% papers)
Computer Science	China (8th rank, 2.62% papers), Taiwan (9th rank, 2.53% papers), South Korea (10th rank, 2.48% papers), **India (16th rank**, 1.36% papers), Singapore (19th rank, 1.12% papers)
Engineering	China (7th rank, 3.86% papers), Taiwan (10th rank, 2.57% papers**), India (11th rank, 2.39% papers),** South Korea (12th rank, 2.3% papers), Singapore (19th rank, 1.095 papers)
Geosciences	China (10th rank, 2.76% papers**), India (11th rank, 2.34% papers)**, South Africa (18th rank, 0.89% papers), Brazil (20th rank, 0.8% papers)
Immunology	Brazil (17th rank, 0.92% papers**), India (20th rank, 0.7% papers)**
Materials Science	China (4th rank, 7.62%**), India (8th rank, 3.56%),** South Korea (9th rank, 3.15%)
Mathematics	China (4th rank, 7.62% papers), **India (8th rank, 3.56% papers),** South Korea (9th rank, 3.09% papers), Taiwan (13th rank, 1.84% papers), Singapore (20th rank, 0.9% papers)
Microbiology	South Korea (12th rank, 1.75% papers), Brazil (15th rank, 1.53% papers), **and India (17th rank, 1.42% papers)**
Molecular Biology & Genetics	Brazil (16th rank, 0.93% papers), **India (19th rank, 0.76% papers),** China (20th rank, 0.72% papers)
Neurobiology & Behavior	Brazil (13th rank, 1.17% papers)
Pharmacology & Toxicology	China (10th rank, 2.01% papers), **India (13th rank, 1.89% papers),** South Korea (14th rank, 1.7% papers), Taiwan (17th rank, 1.23% papers), Brazil (18th rank, 1.22% papers)
Physics	China (7th rank, 4.71% papers**), India (9th rank, 2.26% papers),** South Korea (13th rank, 1.98% papers), Brazil (16th rank, 1.44% papers)
Plant & Animal Sciences	**India (8th rank, 3.13% papers),** Brazil (12th rank, 1.7% papers), China (14th rank, 1.47% papers), South Africa (15th rank, 1.36% papers)
Psychiatry/ Psychology	China (20th rank, 0.45% papers)
Space Sciences	China (12th rank, 1.78% papers**), India (13th rank, 1.55% papers)**, Chile (14th rank, 1.23% papers), Brazil (16th rank, 1.14% papers), Mexico (18th rank, 1.10 papers)

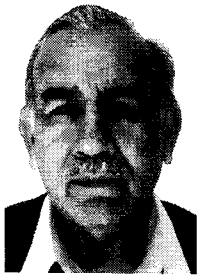
Relative Citations Impact (RCI) of various Countries during 1993-2003

Subject Fields	Name of the Countries along with RCI
Materials Science	South Africa (-14.3), Taiwan (-22.2), South Korea (-26.1), Morocco (-26.6), Argentina (-27.2), Singapore (-29.30), Mexico (-34.13), Brazil (-35.35), Columbia (-35.91), **India (-36.68),** Chile (-40.43), China (-50.13), Malaysia (-54.78), Venezuela (-54.99), Thailand (-55.98), Saudi Arabia (-57.55), Egypt (-57.6), Nigeria (-63.06), and Iran (-66.51)
Engineering	Venezuela (-4.0), Argentina (-10.5), Brazil (-16.6), Taiwan (-22.58), South Africa (-24.59), Chile (-25.88), Singapore (-31.68), South Korea (-39.45), Iran (-42.32), **India (-42.56),** Morocco (-42.57), Mexico (-44.1), Saudi Arabia (-44.78), China (-45.13), Egypt (-45.79), Thailand (-50.03), Nigeria (-65.02), and Malaysia (-66.48)
Agriculture	South Africa (-0.9), Indonesia (-4.53), Columbia (-8.9), Taiwan (-11.5), Argentina (-21.3), Mexico 9-24.87), Chile (-30.73), Kenya (-31.89), South Korea (-32.81), Malaysia (-34.39), Thailand (-39.91), China (-40.5), Morocco 9-42.16), Egypt (-52.05), Venezuela (-56.96), Nigeria (-64.6), Brazil 9-66.93), Iran (-68.84), Saudi Arabia (-69.03), and **India (-74.08)**
Chemistry	Singapore (-24.6), Venezuela (-32.7), Taiwan (-34.78), South Africa (-35.6), Mexico (-42.1), South Korea (-45.0), Brazil (-45.51), Argentina (-45.9), **India (-51.58)**, Chile (-52.01), Morocco (-55.08), Columbia (-56.14), Malaysia (-57.53), Iran (-58.15), China (-62.08), Saudi Arabia (-62.93), Thailand (-64.65), Egypt (-67.37), and Nigeria (-72.19)
Physics	Chile (-18.3), Argentina (-24.1), Columbia (-25.9), South Africa (-32.0), Brazil (-32.2), **India (-40.08),** Taiwan (-41.85), South Korea (-41.85), Venezuela (-45.64), Mexico (-46.07), Iran (-55.43), Morocco (-58.91), China (-59.02), Singapore (-60.21), Egypt (-64.40), Malaysia (-66.93), Saudi Arabia (-69.44), and Thailand (-76.43)
Mathematics	Chile (-7.6), South Korea (-7.7), Venezuela (-17.6), Taiwan (-23.4), Brazil (-25.0), Argentina (-28.17), South Africa (-33.40), Columbia (-40.91), China (-41.52), Saudi Arabia (-42.81), South Korea (-43.37), Mexico (-44.18), Egypt (-47.85), **India (-53.83)**, Morocco (-64.57), Iran (-66.65), and Malaysia (-68.19)
Computer Science	Argentina (-23.8), Singapore (-30.5), Chile (-30.9), Taiwan (-32.74), **India (-34.8)**, South Africa (-36.01), Columbia (-41.73), Brazil (-41.99), Tunisia (-42.8), Mexico (-47.76), Egypt (-49.48), Venezuela (-49.69), Saudi Arabia (-49.98), Thailand (-52.05), South Korea (-54.12), China (-55.19), Iran (-65.83), Malaysia (-67.48), and Morocco (-74.83)
Plant & Animal Sciences	Singapore (-24.75), Taiwan (-33.74), Kenya (-33.99), Columbia (-34.50), Thailand (-34.98), South Africa (-37.09), South Korea (-39.86), Chile (-43.04), Argentina (-43.48), Malaysia (-45.58), Mexico (-46.68), Morocco (-55.07), China (-56.40), Brazil (-59.79), Egypt (-64.36), Saudi Arabia (-64.87), Nigeria (-66.02), Venezuela (-70.08), **India (-73.50),** and Iran (-79.16)
Space Sciences	Chile (-14.7), South Africa (-17.4), Venezuela (-23.7), Mexico (-25.5), Brazil (-29.7), South Korea (-33.13), Taiwan (-34.04), Argentina (-39.04), **India (-56.69)**, Morocco (-61.66), China (-64.15), Nigeria (-68.11), Egypt (-78.26)
Pharmacology & Toxicology	Chile (-38.0), Mexico (-40.3), Croatia (-41.6), Taiwan (-43.1), Brazil (-44.8), South Africa (-44.84), Singapore (-44.84), Argentina (-50.32), Saudi Arabia (-56.90), South Korea (-60.52), Thailand (-60.55), Venezuela (-62.13), **India (-66.97**), Malaysia (-67.67), China (-68.39), Egypt (-70.96), Iran (-72.49), Morocco (-75.15), Nigeria (-79.45)

Contributors



Dr B.M. Gupta received his PhD in Scientometrics from Karnataka University in 1999 and is working in this area since last 30 years. His areas of interest include measurement of Indian S&T, international collaboration, productivity of scientists, growth and obsolescence. Presently, he is working as Senior Scientist at the National Institute of Science, Technology and Development Studies, a national institute under the Council of Scientific and Industrial Research.



Dr S.M. Dhawan is a senior member of the library profession having special interests in areas such as special library management, library applications of information technology, and scientometric studies. Currently, he is serving the profession as library and information consultant. Formerly, he was Scientist F and Head, Library and Information Services, National Physical Laboratory. Dr Dhawan designed, developed, and hosted the website of the National Physical Laboratory. He has to his credit several papers published in national and international journals. He had chaired several technical sessions at national and international conferences and was in the Editorial Boards of *ILA Bulletin*, *Annals of Library Science and Documentation*, and *Libraries, Information and Knowledge*. He has also edited ILA's Conference Volume–Quest for Quality, and authored a festschrift, Library and Information Studies in Cyber Age. He had been in the committees for CSIR e-Journal Consortium, National Science Digital Library, and National Knowledge Commission, and has carried out research projects on scientometric studies for NISSAT and Office of the Principal Scientific Adviser to the Govt of India, New Delhi.

Dr R.P. Gupta received his PhD in Mathematics from Lucknow University in 1985. His areas of interest include scientometrics and fluid dynamics. He is currently working as Scientist in the Office of the Principal Scientific Adviser to the Govt of India, New Delhi.