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Analysis of Publications Profile of Indian Mission-oriented R&D Sector

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ABSTRACT

The mission-oriented R&D sector covers institutions both under R&D agencies/ departments and socio-economic ministries/departments of the Government of India. The paper describes the role and contribution of mission-oriented R&D in the overall research output of the country. The paper analyses various features of R&D sector such as its publications growth and output, impact of research, strong and week subject areas, collaboration profile, and major institutions and their quality.

Keywords: Mission-oriented, R&D sector, publications, *science citation index*

1. INTRODUCTION

The mission-oriented R&D sector in India comprises two categories of research institutions: those managed by autonomous R&D agencies/departments, and those managed by socio-economic ministries/departments under the central/state governments. The important R&D agencies/departments in the country are: Council of Scientific & Industrial Research (CSIR), Indian Council of Agricultural Research (ICAR), Indian Council of Medical Research (ICMR), Defence Research & Development Organisation (DRDO), Department of Science & Technology (DST), Department of Atomic Energy (DAE), Department of Space (DoS), Department of Biotechnology (DBT), Department of Electronics (DoE), and Department of Ocean Development (DOD).

The autonomous R&D agencies/ departments have a specific mandate to plan and organise R&D activities in the country and are required to play a significant role in strengthening the knowledge economy of the country. The primary aim of these agencies/ departments are to carry out basic and applied research, besides making direct contribution to the technological needs of the country in

the chosen areas like atomic energy, space sciences, engineering, medicine, agriculture, etc. These agencies have established a vast network of research institutions across the country for pursuing R&D. They also provide extramural funding to institutions from other S&T sectors, enabling them to undertake research pursuits of interest and relevance to the country. Some of the institutions under these agencies/departments also undertake postgraduate and PhD programmes and are recognised as 'deemed universities' by the University Grants Commision.

The research institutions under the socio-economic ministries/departments of the central/ state governments undertake research in selected subjects relevant to their parent ministries/departments. The major socio-economic ministries/departments are: Ministry of Health & Family Welfare (MHFW), Ministry of Mines (MoM), Ministry of Human Resource Development (MHRD), Ministry of Information & Communication Technology (MoIT), Ministry of Environment, Forests & Wildlife (MoEN), Ministry of Textiles (MoTX), Ministry of Water Resources (MWR), Ministry of Non-Conventional Energy Sources (MNES), Ministry of Power (MoP), Ministry of Petroleum & Natural Gas (MPNG), and Department of Culture (DoCU). They have also established a small network of research institutions across the country for pursuing their R&D agenda and also provide extra-mural funding to institutions from other S&T sectors, but mainly to address their own research needs.

2. MAIN OBJECTIVES

The main objectives of this paper are:(i) to analyse the overall status of R&D institutions; (ii) to identify the areas of their strength and weakness; (iii) to analyse the quality of research, as reflected in average impact factor and citations per paper; (iv) to analyse the collaborative profile; (vi) to make qualitative and quantitative assessment of the major participating institutions; and (vii) to compare the strength of R&D sector vis-à-vis other performing sectors in the country.

3. SOURCE DATABASE AND METHODOLOGY

The publications data used in the report is derived from *Science Citation Index (SCI)–Expanded Version* available online in *Web of Science*. Indian publications data of six years (1985-86, 1993-94, 2001-02) was downloaded from the above mentioned database. The total number of publications downloaded for the study were 85383. For measuring institutional productivity, the study used integer-counting method. Journal publications included in the study were classified by subject content, using the classification scheme of Thomson-ISI for defining the main subject fields and its sub-fields. Two types of indicators, namely absolute and relative have been used for bibliometric analysis of the publications data covered in the study.

4. ANALYSES AND RESULTS

Based on the coverage of Indian publications in the SCI, 23153 publications published in 1985-86, 27088 published in 1993-94, and 35142 published in 2001-02 were identified. These publications were contributed by various institutions belonging to different sectors such as institutes of national importance, universities and colleges, mission-oriented R&D organisations, industries and others.

The mission-oriented R&D sector institutions had contributed the second largest publications to the country's output in S&T in 1985-86, followed by INI, and industry sectors. However, universities and colleges contributed the largest share of publication to the country output in S&T. This pattern of contribution persisted during 1993-94 and 2001-02 also (Table 1).

The R&D agencies/departments contributed more publications compared to socio-economic ministries/departments. While the publications share of R&D agencies/departments increased gradually from 85.3 per cent in 1985-86 to 88.8 per cent in 2001-02, the publications share of socio-economic ministries/departments declined from 15.2 per cent in 1985-86 to 12.9 per cent in 2001-02 (Table 2).

Table 1. Sector-wise publications output by India (1985-86 to 2001-02)

S&T sectors	Publications output			Per cent share in total publication output			Growth rate 1985-86 to 2001-02
	1985-86	1994-95	2001-02	1985-86	1994-95	2001-02	
INI	3990	4978	7175	17.23	18.38	20.42	79.82
Univ & Coll.	12095	12324	16403	52.24	45.50	46.68	35.62
R&D	6569	9218	13329	28.37	34.03	37.93	102.91
Industry	411	496	708	1.78	1.83	2.01	72.26
Others	235	562	1237	1.01	2.07	3.52	426.38
Total	23153	27088	35142	100	100	100	51.78

Table 2. Publications output by type of R&D sector institutes (1985-86 to 2001-02)

R&D instt by type of funding	Publications output			Per cent share in publications output			Growth rate 1985-86 to 2001-02
	1985-86	1993-94	2001-02	1985-86	1993-94	2001-02	
R&D agency/deptts.	5606	8093	11844	85.34	87.80	88.86	111.27
Socio-economic ministries/deptts.	998	1177	1727	15.19	12.77	12.96	73.05
R&D sector (total)	6569	9218	13329	100	100	100	102.91

Compared to other S&T sectors, the mission-oriented R&D sector had shown the fastest publication growth rate (102.9 per cent) during 1985-86 to 2001-02. The R&D agencies/departments had shown faster publication growth (111.27 per cent) during 1985-86 to 2001-02, compared to the socio-economic ministries/departments (73.05 per cent). However, both had higher publications growth rates than the average growth rate of the country (51.78 per cent).

4.1 Profile of R&D Agencies/ Departments

Among the R&D agencies/departments, CSIR made the largest contribution (32.9 per cent) in 1985-86, 37.5 per cent in 1993-94 and 36.2 per cent in 2001-02, respectively. The DAE ranked 2nd and maintained steady publications share: 27.2 per cent in 1985-86, 26 per cent in 1993-94, and 26.7 per cent in 2001-02, respectively. The DST ranked 4th in 1985-86 and 3rd in 2001-02 by contributing 15.23 per cent publications share to R&D sector agencies/departments.

ICAR ranked 3rd in 1985-86 and 4th in 2001-02 in publications output. Its publications share, however, declined from 17.36 per cent to 10.08 per cent during the corresponding period. The DRDO ranked 6th and contributed 2.8 per cent publications share in 1985-86 and ranked 5th and contributed 4.5 per cent in 2001-02. The DoS ranked 5th in 1985-86, dropped to 6th rank in 2001-02, by contributing 4.74 per cent and 4.38 per cent publications share during the corresponding period. The ICMR had also shown decline in its publications output from 4.39 per cent to 3.57 per cent during the corresponding period. DBT though ranked 8th in the country, but its publications share showed a significant rise from 0.11 per cent in 1985-86 to 2.13 per cent in 2001-02 (Table 3).

Among the R&D agencies/departments, the DBT has shown the fastest publications growth rate during 1985-86 to 2001-02, followed by DoE (500 per cent), DST (263 per cent), DRDO (242 per cent), CSIR (132 per cent), DAE (107 per cent), DoS (95.1 per cent), ICMR (72 per cent), and ICAR (22.7 per cent). Except for DAE, DoS, ICMR and ICAR, all other R&D agencies/departments had shown publications growth rate above the average publication growth rate (111.2 per cent) of the R&D agencies/departments (Table 3).

Table 3. Publications output and growth of the R&D agencies/departments (1985-86 to 2001-02)

R&D agencies/ deptts.	Publications count			Per cent share in total publications output			Growth rate 1985-86 to 2001-02
	1985-86	1993-94	2001-02	1985-86	1993-94	2001-02	
CSIR	1848	3037	4288	32.96	37.53	36.20	132.03
DAE	1524	2109	3165	27.19	26.06	26.72	107.68
DBT	6	88	252	0.11	1.09	2.13	4100.00
DoE	2	59	12	0.04	0.73	0.10	500.00
DoS	266	379	519	4.74	4.68	4.38	95.11
DRDO	157	314	538	2.80	3.88	4.54	242.68
DST	497	1001	1804	8.87	12.37	15.23	262.98
ICAR	973	892	1194	17.36	11.02	10.08	22.71
ICMR	246	289	423	4.39	3.57	3.57	71.95
Total	5606	8093	11844	100.00	100.00	100.00	111.27

4.2 Profile of Socio-economic Ministries/Departments

Among the socio-economic ministries/ departments, the MHFW made the largest contribution (38.38 per cent) in 1985-86, 40.53 per cent in 1993-94 and 46.73 per cent in 2001-02, respectively. The MoM and MHRD ranked 2nd and 3rd by contributing 7.24 per cent and 6.21 per cent publications, respectively in 2001-02.

The MoIT, which was at the rock bottom in rank in 1985-86, with only 0.3 per cent publications share, ranked 4th in 2001-02, with 5.96 per cent share. The MoEN relatively maintained stagnancy (5.81 per cent in 1985-86 and 5.85 per cent in 2001-02), despite a slight dip in 1993-94 (4.93 per cent).

The MoTX had shown similar decline in publications share (from 5.41 per cent in 1985-86 to 2.37 per cent in 2001-02). The research institutions belonging to other socio-economic ministries/departments had contributed less number of publications (from 0.12 per cent to 1.9 per cent) during the corresponding periods (Table 4).

4.3 Impact of Research Output of R&D Sector

4.3.1 Is R&D Sector Publishing Enough Research Output in High-Impact Journals?

The mission-oriented R&D sector institutions had been publishing bulk of their research output in low impact factor (IF) journals (IF between 0.001 and 1.999), though their publications share in such journals had declined (from 77.8 per cent in 1985-86 to 80.1 per cent in 1993-94 and to 70 per cent in 2001-02). Their publications share in medium impact journals (IF between 2 and 3.999) had been relatively small, but rising (10.6 per cent in 1985-86, 12.3 per cent in 1993-94, and 19.3 per cent in 2001-02). Similarly, their share in high-impact journals (IF between 4 and above) had also been rising (1.25 per cent in 1985-86, 2.5 per cent in 1993-94, and 7.3 per cent in 2001-02). Besides, their publications share in zero-impact journals had been declining (10 per cent in 1985-86, 5 per cent in 1993-94, and 3.2 per cent in 2001-02). The gradual rise in publications share of mission-oriented R&D institutions in medium and high impact journals, coupled with their corresponding

decline in low and zero impact journals indicated a slight rise in the quality of their research output (Table 5).

4.3.2 How Does Research Output of R&D Sector Compares with Other Sectors?

The mission-oriented R&D sector showed the highest average IF per paper compared to other sectors in 2001-02. Their average impact factor per paper was 0.869 in 1985-86, 0.944 in 1993-94 and 1.454 in 2001-02 and was above the country's average impact factor of 0.748, 0.805, and 1.229 during the corresponding periods (Table 6). The R&D agencies/departments registered higher average IF in comparison to the socio-economic ministries/departments. Their average IF was above the average IF of the country and that of socio-economic ministries/departments was below the average IF of the country (Tables 7-9).

Of all the R&D agencies/departments, the DBT had shown the highest average impact factor per paper (1.398 in 1985-86, 1.986 in 1993-94, and 2.743 in 2001-02), followed by DST (1.334 in 1985-86, 1.193 in 1993-94, and 1.928 in 2001-02) and ICMR

Table 4. Publications output and growth of R&D institutions under socio-economic ministries/departments (1985-86 to 2001-02)

Socio-economic ministries/deptts.	Publications count			Per cent share in total publication output			Growth rate 1985-86 to 2001-02
	1985-86	1993-94	2001-02	1985-86	1993-94	2001-02	
MHFW	383	477	807	38.38	40.53	46.73	110.70
MHRD	62	68	104	6.21	5.78	6.02	67.74
MoEN	58	58	101	5.81	4.93	5.85	74.14
MoM	50	83	125	5.01	7.05	7.24	150.00
MoTX	54	25	41	5.41	2.12	2.37	-24.07
MoIT	3	43	103	0.30	3.65	5.96	3333.3
DCP	10	2	16	1.00	0.17	0.93	60.00
DoCU	9	6	2	0.90	0.51	0.12	-77.78
DoA	7	4	8	0.70	0.34	0.46	14.29
MoP	6	11	20	0.60	0.93	1.16	233.33
MPNG	7	21	9	0.70	1.78	0.52	28.57
MWR	7	13	18	0.70	1.10	1.04	157.14
Total	998	1177	1727	100	100	100	73.05

Table 5. Publications output of R&D institutions by journal impact factor

IF	IF range	Percentage of papers		
		1985-86	1993-94	2001-02
Zero-impact journals	0.000-0.000	10.28	5.06	3.23
Low-impact journals	0.0001-1.999	77.85	80.15	70.08
Medium-impact journals	2.000-3.999	10.63	12.30	19.37
High-impact journals	4.00 and more	1.25	2.50	7.32
Total		100.00	100.00	100.00

Table 6. Average impact factor per paper of publications output by S&T sectors

S&T sectors	Average impact factor per paper			Average citation per paper		
	1985-86	1993-94	2001-02	1985-86	1993-94	2001-02
INI	0.910	0.906	1.370	5.975	6.45	2.39
Universities and colleges	0.631	0.660	0.975	4.166	4.24	1.74
R&D	0.869	0.944	1.454	5.633	6.25	2.72
Industries	0.644	0.647	0.945	4.050	4.29	1.62
Others	0.621	1041	1.691	5.502	4.75	2.08
Total	0.748	0.805	1.229	4.92	5.255	2.149

Table 7. Publications output of the socio-economic ministries/departments by journal IF

IF	IF range	Percentage of papers		
		1985-86	1993-94	2001-02
Zero-impact journals	0.000-0.000	11.02	5.61	2.90
Low-impact journals	0.0001-1.999	82.06	85.63	77.36
Medium-impact journals	2.000-3.999	6.01	5.87	12.10
High-impact journals	4.000 and more	0.90	2.89	7.64
	Total	100.0	100.0	100.0

Table 8. Publications output of R&D agencies/departments by journal IF

IF	IF range	Percentage of papers		
		1985-86	1993-94	2001-02
Zero-impact journals	0.000-0.000	10.17	4.98	3.23
Low-impact journals	0.0001-1.999	77.02	79.34	68.87
Medium-impact journals	2.000-3.999	11.49	13.23	20.47
High-impact journals	4.000 and more	1.32	2.45	7.43
	Total	100.0	100.0	100.0

Table 9. Publications output of R&D institutions by average IF per paper

R&D sector groups	Average impact factor per paper			Average citation per paper		
	1985-86	1993-94	2001-02	1985-86	1993-94	2001-02
R&D agencies/deptt	0.901	0.971	1.479	5.956	6.517	2.847
Socio-economic ministries/deptt	0.706	0.768	1.357	3.858	4.529	1.907
All R&D sectors	0.869	0.944	1.454	5.633	6.247	2.72

(0.865 in 1985-86, 1.143 in 1993-94, and 1.846 in 2001-02) institutions. However, DAE, DoS, DRDO, ICAR, and DoE showed slight dip in 1993-94. Almost all the R&D agencies/ departments had shown a rising trend in their average impact factor per paper during period under study (Table 10).

Of all the socio-economic ministries/ departments, the MoIT had shown average impact factor per paper above the country's average in 1985-86 and 2001-02. The DoCI ranked 13th in 1985-86 and ranked at top position in 2001-02, showing a significant rise in the quality of its publications output.

Table 10. Impact factor per paper and average citation per paper by R&D agencies/departments

R&D agencies/ deptts.	Average IF per paper			Average citation per paper		
	1985-86	1993-94	2001-02	1985-86	1993-94	2001-02
DBT	1.398	1.986	2.743	8.500	12.466	3.464
DST	1.334	1.193	1.928	9.048	7.865	3.698
ICMR	0.865	1.143	1.846	7.866	8.322	3.038
DAE	1.309	1.257	1.795	6.763	7.942	3.438
DoS	1.115	0.842	1.573	5.782	5.908	2.511
CSIR	0.762	0.954	1.344	6.571	6.606	2.767
DRDO	0.787	0.633	0.731	3.376	4.277	1.424
ICAR	0.294	0.241	0.501	1.887	2.288	0.966
DoE	0.312	0.179	0.406	0.00	0.898	0.333
Total	0.901	0.971	1.479	5.956	6.517	2.847

The MHFW ranked 1st in publications output in 1985-86, slipped to 2nd position in 2001-02. The majority of the institutions of socio-economic ministries/departments had shown average impact per paper less than the average IF per paper of the country. It implies that they did not publish enough research papers in medium and high quality journals (Table 11).

4.3.3 How Frequently the Papers Published by the R&D Sector are Cited?

Nearly 93-94 per cent of R&D sector publications received either low to medium or zero citations. The share of highly cited papers had been relatively small (6.23 per cent in 1985-86 and 6.96 per cent in 1993-94). Nearly 28 per cent of its publications

Table 11. Impact Factor per paper and average citation per paper by socio-economic ministries/departments

Socio-economic ministries/ deptts	Average IF per paper			Average citation per paper		
	1985-86	1993-94	2001-02	1985-86	1993-94	2001-02
DoCU	0.317	0.686	4.500	2.889	3.444	23.5
MHFW	1.105	1.190	1.785	5.849	6.677	2.165
MoIT	0.834	0.239	1.372	0.333	5.698	3.087
MPNG	0.668	0.387	1.098	1.000	3.000	3.111
MHRD	0.364	0.572	0.872	1.016	3.5	1.269
MoEN	0.355	0.511	0.871	0.81	3.690	1.287
DCP	0.439	0.398	0.823	1.900	5.500	3.308
MoP	0.060	0.551	0.637	0.167	0.545	1.35
MoM	0.427	0.369	0.631	4.34	3.048	1.32
DCA	0.254	0.000	0.529	0.286	0.090	0.286
MoTX	0.325	0.312	0.512	2.704	1.56	0.439
MWR	0.357	0.287	0.498	1.714	1.615	0.833
Total	0.706	0.768	1.357	3.858	4.529	1.907

output in 1985-86, and 24.7 per cent in 1993-94 received zero citations. Nearly 39 per cent of its papers in 1985-86 and 38 per cent in 1993-94 were in the low citations frequency range, and nearly 26 per cent of its papers in 1985-86 and 29.9 per cent in 1993-94 in the medium citations frequency range. Thus, the bulk of output did not have high citation performance, as papers were published mainly in low to medium impact journals and not enough in high impact journals (Tables 12 and 13).

The citations performance of the R&D agencies/departments was also on the same pattern as of the R&D sector as a whole. However, for the socio-economic ministries/ departments, the citations trend was slightly different. Their share of high impact papers was still smaller, between 2.7 per cent and 3.7 per cent, compared to 6.8 per cent and 7.4 per cent, respectively for R&D agencies/ departments (Tables 14 and 15).

4.4 Subject Profile of R&D Sector Institutions

Physics, chemistry, engineering, and basic life sciences were the dominating areas of research in the R&D sector. Its publications share in these disciplines had been above the R&D sector's average (10 per cent) in

Table 12. Distribution of country's publications by average citations per paper

Range of impact	Citations range	Percentage of papers		
		1985-86	1993-94	2001-02
Zero-Impact Papers	0 – 0	30.08	28.09	44.28
Low-Impact Papers	1 – 4	40.68	39.68	42.44
Medium-Impact Papers	5 –19	24.44	26.83	12.31
High-Impact Papers	20 & more	4.80	5.40	0.97
Total		100.0	100.0	100.0

Table 13. R&D sector publications output by average citations per paper

Range of impact	Citations range	Percentage of papers		
		1985-86	1993-94	2001-02
Zero-impact papers	0 – 0	28.01	24.78	38.99
Low -impact papers	1 – 4	39.49	38.19	43.90
Medium-impact papers	5 –19	26.27	29.96	15.49
High-impact papers	20 & more	6.23	6.96	1.62
Total		100.0	100.0	100.00

Table 14. R&D agencies/departments publications output by average citation per paper

Range of impact	Citations range	Percentage of papers		
		1985-86	1993-94	2001-02
Zero-impact papers	0 – 0	26.44	23.24	37.79
Low-impact papers	1 – 4	39.40	38.22	44.23
Medium-impact papers	5 –19	27.29	31.06	16.23
High-impact papers	20 & more	6.87	7.48	1.75
	Total	100.0	100.0	100.0

each discipline and showed consistent rise during 1985-86 to 2001-02. The publications share increased in physics (from 18.7 per cent to 23 per cent), chemistry (from 17.2 per cent to 22.6 per cent), engineering (from 18.3 per cent to 19.1 per cent), and for basic life science (10.2 per cent to 12.2 per cent) during 1985-86 to 2000-01 (Table 16).

Compared to other S&T sectors, the activity index of the R&D sector publications in physics was 1.07 in 1985-86, but rose to 1.19 (19 per cent above the country average) in 2001-02, indicating the emergence of physics as a strong area in R&D. In basic life sciences, although its activity index was above the country's average (1.16), but it had remained stagnant during 1985-86 to 2001-02 (Table 17). The activity index of chemistry, compared to other S&T sectors, had been below the country's average (0.78 in 1985-86, 0.90 in 1993-94, and 0.92 in 2001-02), indicating that chemistry has still not emerged as a strong area of research of R&D. Likewise, R&D sector is also lagging in engineering, where its activity index had declined from 1.07 in 1985-86 to 0.96 in 2001-02. Similar decline in activity index (from 1.05 in 1985-86 to 0.72 in 2001-02) was noticed in clinical medicine. It indicates that R&D is loosing its grip in these subjects.

Agricultural sciences, earth & environmental sciences, biomedical sciences, biology, mathematics and computer science have been the low productivity areas of R&D sector. Its publications share in these subjects had been less than its average publication share

Table 15. Socio-economic ministries/departments publications output by average citation per paper

Range of impact	Citations range	Percentage of papers		
		1985-86	1993-94	2001-02
Zero-impact papers	0 – 0	36.27	35.54	46.50
Low-impact papers	1 – 4	40.18	37.93	41.63
Medium-impact papers	5 –19	20.84	22.79	11.00
High-impact papers	20 & more	2.71	3.74	0.87
	Total	100.0	100.0	100.0

Table 16. Publications output of R&D sector by subject

Main subjects	Number of publications			Per cent share in total publications output			Growth rate from 1985-86 to 2001-02
	1985-86	1993-94	2001-02	1985-86	1993-94	2001-02	
Agricultural Sci.	1040	1142	1357	15.83	12.39	10.18	30.48
Basic Life Sci.	673	1110	1626	10.25	12.04	12.20	141.60
Biology	639	479	642	9.73	5.20	4.82	0.4700
Biomedical Sci.	478	718	940	7.28	7.79	7.05	96.650
Chemistry	1131	1767	3015	17.22	19.17	22.62	166.58
Clinical Medicine	514	748	1140	7.82	8.11	8.55	121.79
Computer Sci.	53	80	106	0.81	0.87	0.80	100.00
Earth & Env. Sci.	642	908	1145	9.77	9.85	8.59	78.35
Engineering	1202	1699	2554	18.30	18.43	19.16	112.48
Mathematics	123	115	200	1.87	1.25	1.50	62.600
Multidis. Sci.	299	398	672	4.55	4.32	5.04	124.75
Physics	1228	2089	3077	18.69	22.66	23.09	150.57

per discipline and had declined over the years. The publications share of this sector declined in agriculture (from 15.8 per cent to 10.2 per cent), earth & environmental sciences (from 9.8 per cent to 8.6 per cent), biology (from 9.7 per cent to 4.8 per cent), and mathematics (from 1.9 per cent to 1.5 per cent) during 1985-86 to 2001-02. In computer science and biomedical sciences, its publications share has remained stagnant (Table 17).

Despite the declining publications share in agricultural sciences, the activity index (1.26 in 1985-86 and 1.06 in 2001-02) of this subject in R&D sector had been above the country's average. It indicates that the R&D sector has been gradually loosing its competitive edge in this subject. The activity index of the R&D sector in other subjects, such as biology, biomedical sciences, computer science, and mathematics had also been declined and was below the country's average (Table17). Earth & environmental sciences in spite of its declining publications share, continued to show activity index above the country's average (1.55 in 1985-86 and 1.33 in 2001-02). This shows that the R&D sector has maintained competitive edge in the subject (Table 17).

In sum, it may be stated that the R&D sector has competitive edge over other S&T sectors in physics, basic life sciences, and earth & environmental sciences. The growth rate of publications in agricultural sciences (30.8 per cent), earth & environmental sciences (78.3 per cent), biology (0.47 per cent), and mathematics (62.6 per cent) were far below the average growth rate of the country (102.9 per cent) during 1985-86 to 2001-02. Computer science, however, registered average growth rate (100 per cent) near to country's average. As agricultural sector is recognised as a major source of economy for the country, research in this area should be accorded top priority. It is worrying that R&D sector had witnessed consistent decline in its research efforts in agricultural sciences.

4.4.1. Publications Output of R&D Agencies/Departments

Physics, chemistry, and engineering had also been the leading areas of research of the R&D agencies/departments and their publication trends had shown similar pattern to total R&D sector institutions. The publications output in clinical medicine, however, had declined from 5.9 per cent in 1985-86 to 4.8 per cent in 2001-02 (Table 18).

Table 17. Publications activity index of R&D sector

Main subjects	R&D sector publications output			Country publications output			Activity index of R&D sector		
	1985-86	1993-94	2001-02	1985-86	1993-94	2001-02	1985-86	1993-94	2001-02
Agriculture	1040	1142	1357	2864	3461	3388	1.28	0.97	1.06
Basic Life Sci.	673	1110	1626	2043	2800	3711	1.16	1.16	1.16
Biology	639	479	642	2409	1476	1615	0.93	0.95	1.05
Biomed Sci.	478	718	940	1585	2008	2797	1.06	1.05	0.89
Chemistry	1131	1767	3015	5106	5791	8633	0.78	0.90	0.92
Clinical Medicine	514	748	1140	1724	2623	4166	1.05	0.84	0.72
Computer Sci.	53	80	106	302	601	660	0.62	0.39	0.42
Earth & Envir. Sci.	642	908	1145	1464	1942	2272	1.55	1.37	1.33
Engineering	1202	1699	2554	3955	5237	7031	1.07	0.95	0.96
Mathematics	123	115	200	803	842	1003	0.54	0.40	0.53
Multid. Sci.	299	398	672	1252	925	1433	0.84	1.26	1.24
Physics	1228	2089	3077	4035	5295	6795	1.07	1.16	1.19
Total	6569	9218	13329	23153	27088	35142	1.00	1.00	1.00

Compared to other S&T sectors, the activity index of the R&D agencies/departments in 2001-02 had been above the country's average in agricultural sciences, basic life sciences, chemistry, computer science, engineering, mathematics, and physics. This picture was quite different from that of activity index of total R&D sector institutions in chemistry, computer science, engineering and mathematics (Table 19). Among the various R&D agencies/departments, the contribution of CSIR had been the largest (1948 papers), followed by DAE (1524 papers), ICAR (973 papers), DST (497 papers), DoS (266 papers), and DRDO (157 papers) during 1985-86. The CSIR and DAE also remained at the top two positions during 1993-94 and 2001-02, followed by DST, DoS and DRDO during 1993-94 and

Table 18. Publications output of the R&D agencies/departments by subject

Main subjects	Number of publications			Per cent share in total publications output			Growth rate 1985-86 to 2001-02
	1985-86	1993-94	2001-02	1985-86	1993-94	2001-02	
Physics	1165	2028	2970	20.78	25.06	25.08	154.94
Chemistry	1047	1716	2890	18.68	21.2	24.40	176.03
Engineering	1102	1607	2391	19.66	19.86	20.19	116.97
Basic Life Sci.	560	987	1475	9.99	12.2	12.45	163.39
Agricultural Sci.	877	966	1249	15.64	11.94	10.55	42.42
Earth & Environ. Sci.	502	749	951	8.95	9.25	8.03	89.44
Biomedical Sci.	361	528	717	6.44	6.52	6.05	98.61
Multidisci. Sci.	243	341	601	4.33	4.21	5.07	147.33
Clinical Medicine	334	390	579	5.96	4.82	4.89	73.35
Biology	506	396	528	9.03	4.89	4.46	4.35
Mathematics	121	113	189	2.16	1.4	1.6	56.2
Computer Sci.	49	61	100	0.87	0.75	0.84	104.08
Total	5606	8093	11844	100.0	100.0	100.0	111.27

Table 19. Publications activity index of R&D agencies/departments by subject

Main subject	R&D agencies/deptts. publications output			R&D sector publications output			Publications activity index		
	1985-86	1993-94	2001-02	1985-86	1993-94	2001-02	1985-86	1993-94	2001-02
Agriculture	877	966	1249	1040	1142	1357	0.99	0.96	1.04
Basic Life Sci.	560	987	1475	673	1110	1626	0.97	1.01	1.02
Biology	506	396	528	639	479	642	0.93	0.94	0.93
Biomedical Sci.	361	528	717	478	718	940	0.88	0.84	0.86
Chemistry	1047	1716	2890	1131	1767	3015	1.08	1.11	1.08
Clinical Medicine	334	390	579	514	748	1140	0.76	0.59	0.57
Computer Sci.	49	61	100	53	80	106	1.08	0.87	1.06
Earth & Env. Sci.	502	749	951	642	908	1145	0.91	0.94	0.93
Engineering	1102	1607	2391	1202	1699	2554	1.07	1.08	1.05
Mathematics	121	113	189	123	115	200	1.15	1.12	1.06
Multidis. Sci.	243	341	601	299	398	672	0.95	0.98	1.01
Physics	1165	2028	2970	1228	2089	3077	1.11	1.11	1.09
Total	5606	8093	11844	6569	9218	13329	1.00	1.00	1.00

2001-02 (Tables 20 to 22). The priority areas of research, based on the number of papers published, during 1985-86 of R&D agency/ departments were as follows: (i) CSIR–Chemistry, engineering and basic life sciences, (ii) DAE–Physics, engineering and chemistry, (iii) DST–Physics, chemistry, and earth & environmental sciences, (iv) DOS–Engineering and earth & environmental sciences, (v) DRDO–Engineering and physics, and (vi) ICMR–Clinical medicine and biomedical sciences. The priority areas of research also remained the same during 1993-94 and 2001-02, with the following exceptions: DST gave higher priority to engineering compared to earth & environmental sciences, DoS to physics compared to engineering, and DRDO to chemistry compared to physics in 2001-02.

Thus, it is evident that the priority areas of various R&D agencies/departments are well defined and did not change much during sixteen years period from 1985-86 to 2001-02.

Table 20. Subject-wise publications output of R&D agencies/departments by funding agency during 1985-86

Main Subject	CSIR	DAE	DBT	DOE	DOS	DRDO	DST	ICAR	ICMR	Total
Agriculture Sci.	151	26	-	-	1	11	7	662	18	877
Basic Life Sci.	266	123	2	-	-	5	39	67	59	560
Biology	179	90		-	1	4	32	184	18	506
Biomedical Sci.	173	44	5	-	-	6	5	13	118	361
Chemistry	620	223	-	-	22	16	119	42	6	1047
Clinical Medicine	76	121	4	-	-	6	-	3	127	334
Computer Sci.	10	18	-	-	19	1	-	1	-	49
Earth & Environ. Sci.	224	72	-	-	82	6	75	43	6	502
Engineering	447	375	-	2	119	93	22	46	1	1102
Mathematics	14	93	-	-	6	-	1	8	-	121
Multidisciplinary Sci.	77	46	-	-	11	8	26	70	5	243
Physics	182	646	-	-	79	32	225	1	1	1165
Total	1948	1524	6	2	266	157	497	973	246	5606

Table 21. Subject-wise publication output of R&D agencies/departments by funding agency during 1993-94

Main Subject	CSIR	DAE	DBT	DoE	DoS	DRDO	DST	ICAR	ICMR	Total
Agric Sci.	203	25	14	11	1	22	7	659	32	966
Basic Life Sci.	495	175	56	-	-	26	85	86	76	987
Biology	181	45	8	-	-	10	21	114	20	396
Biomedical Sci.	248	50	38	-	-	24	18	26	133	528
Chemistry	1028	370	2	-	25	47	213	32	16	1716
Clinical Medicine	72	163	16	-	-	17	12	1	115	390
Computer Sci.	25	9	-	-	11	10	4	-	1	61
Earth & Envir. Sci.	359	72	-	3	127	26	107	51	5	749
Engineering	720	478	-	21	119	136	98	45	-	1607
Mathematics	5	87	-	-	4	2	2	6	5	113
Multidisci. Sci.	140	37	1	-	22	8	95	29	10	341
Physics	361	1045	-	20	139	69	438	5	-	2028
Total	3037	2109	88	59	379	314	1001	892	289	8093

Table 22. Subject-wise publication output of R&D agencies/departments by funding agency during 2001-02

Main Subject	CSIR	DAE	DBT	DOE	DOS	DRDO	DST	ICAR	ICMR	Total
Agric Sci.	255	33	11		6	26	24	865	34	1249
Basic Life Sci.	706	215	130		1	26	164	150	148	1475
Biology	221	46	22		2	16	46	165	23	528
Biomed. Sci.	323	61	72			46	38	50	161	717
Chemistry	1813	520	10		37	115	396	42	7	2890
Clinical Medicine	124	183	34			39	22	7	185	579
Computer Sci.	32	37		1	5	15	8			100
Earth & Envir Sci.	430	84	2		139	23	183	93	17	951
Engineering	1035	710	6	10	148	253	223	48	3	2391
Mathematics	5	152	2	1	4	6	8	10	1	189
Multidis. Sci.	216	79	20		64	56	122	51	25	601
Physics	355	1687	1	1	175	76	788	9		2970
Total	4288	3165	252	12	519	538	1804	1194	423	11844

4.4.2 Publications Output of Socio-economic Ministries/Departments

Clinical medicine and biomedical sciences had been the priority areas of research for institutions belonging to the socio-economic ministries/departments. In clinical medicine, the publications share increased from 18.5 per cent in 1985-86 to 35.8 per cent in 2001-02 and in biomedical sciences from 12.2 per cent to 15.9 per cent during the corresponding period. Besides, earth & environmental sciences, basic life sciences and engineering had also been the priority areas of research of this segment, but their publications share had declined/remained stagnant. This segment of R&D sector had shown significant decline in the publications share in biology (from 13.6 per cent to 7.1 per cent) and agricultural sciences (from 16.7 per cent to 7.0 per cent) during 1985-86 to 2001-02 (Tables 23 to 24).

Table 23. Publications output of socio-economic ministries/departments by subject

Main subject	Number of publications			Per cent share in total publications output			Growth rate from 1985-86 to 2001-02
	1985-86	1993-94	2001-02	1985-86	1993-94	2001-02	
Clinical Medicine	185	383	619	18.54	32.57	35.84	234.59
Biomedical Sci.	122	219	275	12.22	18.62	15.92	125.41
Earth & Environ. Sci.	154	158	213	15.43	13.44	12.33	38.31
Basic Life Sci.	116	135	208	11.62	11.48	12.04	79.31
Engineering	112	93	200	11.22	7.91	11.58	78.57
Chemistry	84	52	148	8.42	4.42	8.57	76.19
Physics	64	66	127	6.41	5.61	7.35	98.44
Biology	136	84	124	13.63	7.14	7.18	-8.82
Agricultural Sci.	167	179	121	16.73	15.22	7.01	-27.54
Multidis.Sci.	57	60	82	5.71	5.1	4.75	43.86
Mathematics	3	2	11	0.3	0.17	0.64	266.67
Computer Sci.	4	19	7	0.4	1.62	0.41	75
Total	998	1176	1727	100	100	100	73.05

4.5 Collaborative Research Profile of R&D Sector

The R&D sector showed significant rise in its collaborative research activity, at both national and international levels. Its collaborative share of papers increased from 8.52 per cent in 1985-86 to 46.8 per cent in 2001-02. A similar increase in their collaborative share (from 7.9 per cent to 46.2 per cent) was observed from R&D agencies/departments, but the socio-economic ministries/departments showed comparatively larger increase (from 15.9 per cent to 59.2 per cent) during the corresponding period (Tables 25 to 27). The growth in collaborative research output in the R&D sector had been higher (10.17 per cent) than for that of the country (72.96 per

Table 24. Publications output activity index of socio-economic ministries/deptt by subject

Main subject	Socio-economic ministries/deptts.			R&D sector			Activity index		
	1985-86	1993-94	2001-02	1985-86	1993-94	2001-02	1985-86	1993-94	2001-02
Agricultural Sci.	167	179	121	1040	1142	1357	1.06	1.23	0.69
Basic Life Sci.	116	135	208	673	1110	1626	1.13	0.95	0.99
Biology	136	84	124	639	479	642	1.40	1.37	1.49
Biomedical Sci.	122	219	275	478	718	940	1.68	2.39	2.26
Chemistry	84	52	148	1131	1767	3015	0.49	0.23	0.38
Clinical Medicine	185	383	619	514	748	1140	2.37	4.01	4.19
Computer Science	4	19	7	53	80	106	0.50	1.86	0.51
Earth & Envir. Sci.	154	158	213	642	908	1145	1.58	1.36	1.44
Engineering	112	93	200	1202	1699	2554	0.61	0.43	0.6
Mathematics	3	2	11	123	115	200	0.16	0.14	0.42
Multidisci. Sci.	57	60	82	299	398	672	1.25	1.18	0.94
Physics	64	66	127	1228	2089	3077	0.34	0.25	0.32
Total	998	1176	1727	6569	9218	13329	1.00	1.00	1.00

Table 25. Nature of collaboration in publications output of R&D sector

Period	TP	TCP	TNCP	TICP	%TCP	%TNCP	%TICP	Growth Rate in TP 1985-86 to 2001-02	Growth Rate in TCP 1985-86 to 2001-02
1985-86	6559	559	383	176	8.52	5.84	2.68		
1993-94	9218	1500	952	548	16.27	10.33	5.94		
2001-02	13329	6245	3896	2349	46.85	29.23	17.62	103.2%	1017.2%

TP = Total papers; TCP = Total collaborative papers; TNCP = Total nationally collaborative papers; TICP = Total internationally collaborative papers

Table 26. Nature of collaboration in publications output of R&D agencies/departments

Period	TP	TCP	TNCP	TICP	%TCP	%TNCP	%TICP	Growth Rate of TP 1985-86 to 2001-02	Growth Rate of TCP1985-86 to 2001-02
1985-86	5606	446	293	153	7.96	5.23	2.73		
1993-94	8093	1252	762	490	15.47	9.42	6.05		
2001-02	11844	5472	33337	2135	46.20	281.47	18.03	111.3%	1126.9%

TP = Total papers; TCP = Total collaborative papers; TNCP = Total nationally collaborative papers; TICP = Total internationally collaborative papers

Table 27. Nature of collaboration in publications output of socio-economic ministries/deptt

Period	TP	TCP	TNCP	TICP	%TCP	%TNCP	%TICP	Growth Rate (TP) 85-86 to 2001-02	Growth Rate in (TCP) 85-86 to 2001-02
1985-86	998	159	133	26	15.93	13.33	2.61		
1993-94	1177	310	247	63	26.34	20.99	5.35		
2001-02	1727	1024	771	253	59.29	44.64	14.65	73.0%	544.0%

TP = Total papers; TCP = Total collaborative papers; TNCP = Total nationally collaborative papers
TICP = Total internationally collaborative papers

cent) during 1985-86 and 2001-02. R&D agencies/ departments witnessed the similar trend and showed 11.27 per cent growth in collaborative papers and 11.1 per cent in their total papers during the corresponding period. The socio-economic ministries had shown growth (54.4 per cent) in their collaborative research output.

Among R&D agencies/departments, in collaborative research output the CSIR, DAE, and DST constituted the largest share during 1985-86, 1993-94, and 2001-02. The publications share of CSIR and DAE remained constant around (31-32 per cent), whereas DST showed a significant rise in its share from 10 per cent in 1985-86 to 19 per cent in 2001-02. The other scientific agencies/departments had contributed only a smaller and marginal publications share in the total collaborative output. The collaborative research by R&D sector, both at national and international levels, had undergone a marginal shift. Its ratio of national to international share in research output was 66:34 during 1985-86 and to 61:39 in both 1993-94 and 2001-02. It implies that the R&D sector had paid greater emphasis on international than national collaborative research activity in 2001-02, compared to 1985-86 (Tables 28 to 30).The DRDO and DBT largely confined collaborative research at national level. In collaborative research at international level, DAE contributed its largest publications share (43 per cent), followed by ICMR (36 per cent), DOS (35 per cent), DST (35 per cent), ICAR (30 per cent), and CSIR (27 per cent), respectively in 1985-86. In 1993-94, the ICMR ranked at the top (48.3 per cent), followed by DAE (47.6 per cent), DoS (44 per cent), ICAR (40 per cent), DST (38 per cent), DBT (36 per cent), and CSIR (28 per cent). In 2001-02, the DAE ranked at the top (48 per cent), followed by DST (43 per cent), ICMR (37 per cent), DoS (37 per cent), CSIR (31 per cent), DBT (30 per cent), ICAR (22 per cent), and DRDO (20 per cent)(Table 30).

Table 28. Collaborative papers of R&D agencies/deptt during 1985-86

R&D agency/ deptts	TP	TCP	TPCP	TICP	%TCP	%TNCP	%TICP	Per cent share of TCP	Ratio TNCP:TICP
CSIR	1948	139	102	37	7.14	5.24	1.90	31.17	73:27
DAE	1524	145	83	62	9.51	5.45	4.07	32.51	57:43
DBT	6	5	5	0	83.33	83.33	0.00	1.12	100:0
DoE	2	0	0	0	0.00	0.00	0.00	0.00	--
DoS	266	37	24	13	13.91	9.02	4.89	8.30	65:35
DRDO	157	10	10	0	6.37	6.37	0.00	2.24	100:0
DST	497	46	30	16	9.26	6.04	3.22	10.31	65:35
ICAR	973	37	26	11	3.80	2.67	1.13	8.30	70:30
ICMR	246	44	28	16	17.89	11.38	6.50	9.87	64:36
Total	5606	446	293	153	7.96	5.23	2.73	100.00	66:34

TP = Total papers; TCP = Total collaborative papers; TNCP = Total nationally collaborative papers;
TICP = Total internationally collaborative papers

Table 29. Collaborative papers of R&D agencies/departments during 1993-94

R&D agency/ deptts	TP	TCP	TPCP	TICP	%TCP	%TNCP	%TICP	Per cent share of TCP	Ratio TNCP:TICP
CSIR	3037	420	303	117	13.83	9.98	3.85	33.55	72:28
DAE	2109	403	211	192	19.11	10.00	9.10	32.19	52:48
DBT	88	33	21	12	37.50	23.86	13.64	2.64	64:36
DoE	59	3	3	0	5.08	5.08	0.00	0.24	
DoS	379	52	29	23	13.72	7.65	6.07	4.15	56:44
DRDO	314	48	45	3	15.29	14.33	0.96	3.83	94:6
DST	1001	236	147	89	23.58	14.69	8.89	18.85	62:38
ICAR	892	57	34	23	6.39	3.81	2.58	4.55	60:40
ICMR	289	91	47	44	31.49	16.26	15.22	7.27	52:48
ICSSR	18	2	2	0	11.11	11.11	0.00	0.16	100:0
Total	8093	1252	762	490	15.47	9.42	6.05	100.0	61:39

TP = Total papers; TCP = Total collaborative papers; TNCP = Total nationally collaborative papers; TICP = Total internationally collaborative papers

Table 30. Collaborative papers of R&D agencies/departments during 2001-02

R&D Agency/Deptt.	TP	TCP	TPCP	TICP	%TCP	%TNCP	%TICP	% Share of TCP	Ratio TNCP:TICP
CSIR	4288	1753	1206	547	40.88	28.13	12.76	32.04	69:31
DAE	3165	1749	908	841	55.26	28.69	26.57	31.96	52:48
DBT	252	159	112	47	63.10	44.44	18.65	2.91	70:30
DoE	12	9	9	0	75.00	75.00	0.00	0.16	–
DoS	519	286	179	107	55.11	34.49	20.62	5.23	63:37
DRDO	538	256	206	50	47.58	38.29	9.29	4.68	80:20
DST	1804	1056	598	458	58.54	33.15	25.39	19.30	57:43
ICAR	1194	345	270	75	28.89	22.61	6.28	6.30	78:22
ICMR	423	232	147	85	54.85	34.75	20.09	4.24	63:37
Total	11844	5472	3337	2135	46.20	28.17	18.03	100.0	61:39

TP = Total papers; TCP = Total collaborative papers; TNCP = Total nationally collaborative papers; TICP = Total internationally collaborative papers

4.6 Composite Quality Index of Leading R&D Institutions

In all, there were 26 R&D institutions, which published 100 or more papers during 1985-86, 1993-94, or 2001-02 (Table 31). The growth in publications output of these institutes, as reflected in the activity index from 1985-86 to 2001-02, showed the fastest growth in case of SN Bose National Centre for Basic Sciences (SNBNCBS), Kolkata, followed by Centre for Advanced Technology (CAT), Indore; Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR),

Table 31. Top 26 high productivity institutions in R&D sector

Instt code	Total papers				Activity index		
	1985-86	1993-94	2001-02	Total	1985-86	1993-94	2001-02
SNBNCBS	0	33	136	169	0.00	0.62	1.76
CAT	0	56	147	203	0.00	0.87	1.58
JNCASR	0	146	363	509	0.00	0.91	1.56
CLRI	38	61	174	273	0.62	0.71	1.39
IICT	98	292	562	952	0.46	0.97	1.29
RRL-TRIV	30	124	217	371	0.36	1.06	1.28
CECRI	5	103	152	260	0.09	1.25	1.28
IVRI	28	193	281	502	0.25	1.21	1.22
SINP	126	138	316	580	0.96	0.75	1.19
IGCAR	103	154	289	546	0.84	0.89	1.16
NGRI	58	79	143	280	0.92	0.89	1.12
IOP	28	125	142	295	0.42	1.34	1.05
PRL	107	155	226	488	0.97	1.00	1.01
TIFR	388	551	803	1742	0.99	1.00	1.01
NCL	348	428	658	1434	1.08	0.94	1.00
IACS	219	367	481	1067	0.91	1.09	0.98
CCMB	48	119	136	303	0.70	1.24	0.98
VSSC	85	98	146	329	1.15	0.94	0.97
IIA	73	85	125	283	1.14	0.95	0.96
BARC	716	832	1076	2624	1.21	1.00	0.90
ITRC	109	98	133	340	1.42	0.91	0.85
CFTRI	180	193	222	595	1.34	1.02	0.82
NIO	113	173	163	449	1.12	1.22	0.79
IARI	280	153	245	678	1.83	0.71	0.79
NPL	155	239	199	593	1.16	1.27	0.73
CDRI	259	184	217	660	1.74	0.88	0.72

Bangalore; Central Leather Research Institute (CLRI), Chennai; Indian Institute of Chemical Technolgy (IICT), Hyderabad; Regional Research Laboratory (RRL), Trivandrum; and Central Electrochemical Research Institute (CECRI), Karaikudi; etc. There was no perceptible change in their activity index in case of Physical Research Laboratory (PRL), Ahmedabad and Tata Institute of Fundamental Research (TIFR), Mumbai, whereas there was a decline in the activity index in case of Vikram Sarabhai Space Centre (VSSC), Trivandrum, Indian Institute of Astronomy (IIA), Bangalore, Bhabha Atomic Research Centre (BARC), Mumbai, Indian Toxicological Research Centre (ITRC), Lucknow, and National Physical Laboratory (NPL), New Delhi.

In terms of average IF per paper of the 26 major S&T sector institutions, seven institutions registered IF per paper as 2 and above during 2001-02. These included JNCASR, Bangalore; CCMB, Hyderabad; IIA, Bangalore; PRL, Ahmedabad; Institute of Physics, Bhubaneshwar; TIFR, Mumbai; University of Hyderabad; and Saha Institute of Nuclear Physics, Kolkata. Other institutions like SNBNCBS, Kolkata; NCL, Pune; IICT, Hyderabad; IACS, Kolkata; and CDRI, Lucknow registered IF per paper between 1.5 and 2. In terms of

rise in IF per paper of institutions from 1985-86 to 2001-02, the significant increase was found in JNCASR, Bangalore followed by CAT, Indore; CCMB, Hyderabad; RRL, Trivandrum; and NCL, Pune (Tables 31 and 32).

In terms of citations received per paper published during 1993-94, CCMB, Hyderabad; JNCASR, Bangalore; TIFR, Mumbai; NCL, Pune; IOP, Bhubaneswar; SNBNCBS and IACS both in Kolkata; CAT, Indore; and IIA, Bangalore received 8 or more citations per paper. In terms of improvement in citation per paper of the top S&T sector institutions from 1985-86 to 1993-94, major increase was observed in JNCASR, Bangalore, SNBNCBS, Kolkata, CAT, Indore, RRL, Trivandrum, and NPL, New Delhi (Table 32). Based on composite quality index, 10 major institutions in the country in 2001-02 were:

Table 32. Impact Factor per paper, citations per paper, and composite quality index of top high productivity institutions in R&D sector

Institutes	TPIF			TPTC			CQI		
	1985-86	1993-94	2001-02	1985-86	1993-94	2001-02	1985-86	1993-94	2001-02
BARC	0.96	0.98	1.33	5.02	6.54	2.94	0.77	0.94	1.03
CAT	0.00	1.42	1.20	0.00	8.79	2.02	0.00	1.71	0.93
CCMB	1.52	2.25	2.68	13.58	12.38	4.16	1.16	1.59	1.34
CDRI	0.74	0.93	1.53	4.92	5.15	2.67	1.14	1.21	0.97
CECRI	0.66	0.93	0.67	8.0	5.78	1.07	1.13	0.62	0.66
CFTRI	0.59	0.75	0.95	7.37	5.92	1.97	0.79	0.67	0.61
CLRI	0.91	1.31	1.02	7.42	7.41	2.12	0.67	1.07	0.69
IACS	1.42	1.07	1.59	10.61	9.08	3.29	1.45	1.07	1.27
IARI	0.35	0.37	0.68	2.39	3.72	1.40	0.48	0.64	0.54
IGCAR	0.92	0.84	1.05	6.55	5.94	1.94	0.68	0.68	0.89
IIA	1.85	1.39	2.45	5.81	8.02	2.2	1.58	1.71	1.52
IICT	0.84	0.99	1.69	7.52	7.28	4.21	1.19	0.81	0.98
IOP	1.97	1.75	2.26	9.68	9.95	3.97	1.00	1.36	1.74
ITRC	0.99	0.95	1.15	7.96	4.16	2.14	1.59	0.74	0.81
IVRI	0.31	0.16	0.38	1.07	1.31	0.88	0.45	0.17	0.35
JNCASR	0	1.69	2.69	0	11.69	7.37	0.00	2.65	1.76
NCL	0.81	1.33	1.78	6.49	10.10	4.10	0.80	1.19	1.05
NGRI	0.82	1.01	1.16	7.83	6.28	1.50	0.85	0.98	0.68
NIO	0.48	0.56	1.01	4.48	6.32	1.82	0.54	0.66	0.88
NPL	0.57	0.93	0.98	3.74	6.17	3.26	0.62	1.10	1.18
PRL	1.73	1.3	2.41	8.01	9.12	3.95	2.37	1.48	1.62
RRL-TRIV	0.38	0.83	1.37	4.87	7.51	3.16	0.32	1.00	1.15
SINP	1.62	1.49	2.1	4.97	7.14	3.411	0.97	1.26	1.35
SNBNCBS	0	2.29	1.92	0	9.85	3.12	0.00	1.81	1.33
TIFR	1.94	1.60	2.23	10.49	11.21	4.23	2.58	2.07	1.73
VSSC	0.66	0.61	1.05	5.71	4.41	1.56	0.62	0.55	0.75
Total	0.87	0.94	1.45	5.63	6.25	2.72	1.00	1.00	1.00

TPIF = Impact factor per paper; TPTC = Citations received per paper; CQI = Composite quality index

JNCASR, Bangalore, IOP, Bhubaneswar, TIFR, Mumbai, PRL, Ahmedabad, IIA, Bangalore, SINP, Kolkata, CeCMB, Hyderabad, SNBNCBS, Kolkata, IACS, Kolkata and NPL, New Delhi (Table 32).

5. FINDINGS AND RECOMMENDATIONS

Of all the S&T sectors in the country, the R&D sector is the second largest in terms of publications output in S&T. Two main constituents of the R&D sector differ in their research priorities. The R&D sector comprises two main constituents: R&D agencies/ departments and their institutions and R&D institutions of socio-economic ministries/ departments.

Physics, chemistry and engineering are the priority areas of the R&D agencies/ departments. Clinical medicine and biomedical sciences are the priority areas of institutions of socio-economic ministries/departments. R&D sector has performed better, compared to other sectors of S&T, in physics, basic life sciences, and earth & environmental sciences. The R&D sector has gained competitive edge in these particular areas over other S&T sectors, in terms of overall publications activity. However, in other areas, it loses out to other S&T sectors. Biomedical sciences, chemistry, clinical medicine, computer science, engineering, and mathematics are the low priority areas of the R&D sector, compared to other S&T sectors. Although the sector's output in chemistry and engineering had been quiet high, but still it was below the country average in terms of activity index.

R&D sector has shown the fastest publications growth rate of 102.9 per cent during 1985-86 to 2001-02, compared to other S&T sectors. Its growth rate was twice the average publications growth rate for the country's output of all S&T sectors (51.7 per cent). The INI sector ranked 2nd (79.8 per cent), followed by Industry (72.26 per cent), and universities and Colleges (35.6 per cent) sectors. Of all the socio-economic ministries/ departments in the R&D sector, the MHFW had made the largest contribution. It contributed 38.3 per cent publications share in 1985-86, 31.6 per cent in 1993-94 and 46.7 per cent in 2001-02. Of all the R&D agencies/departments in the R&D sector, CSIR had been the largest contributor, followed by DAE, DST, ICAR, DRDO, DoS, ICMR, and DBT.

Nearly three-fourth of the R&D sector publications output continues to be published in low impact journals. The R&D sector published nearly 77 per cent output in low impact journals in 1985-86, 80 per cent in 1993-94 and 70 per cent in 2001-02, but its publications share in such journals has shown consistent decline. Average impact factor per paper of R&D agencies/departments is more than the publications of socio-economic ministries/ departments. The average factor per paper of R&D agencies/departments was 0.901 in 1985-86, 0.971 in 1993-94, and 1.479 in 2001-02, whereas for socio-economic ministries, it was 0.706, 0.768, and 1.357 respectively. The DoCU, MHFW, and MICT showed average impact factor per paper above the country's average in 2001-02. R&D agencies/departments showed better citations performance, compared to the socio-economic ministries/departments. The share of research output by R&D agencies/ departments that received 20 or more citations per paper was 6.8-7.4 per cent, higher compared to 2.7-3.7 per cent of socio-economic ministries/ departments.

In terms of citation impact, DST institutions ranked at the top among the R&D agencies/ departments. In 2001-02, it received highest citations per paper (3.698), followed by DBT (3.464), DAE (3.438), ICMR (3.038), CSIR (2.767), DoS (2.511), DRDO (1.424), ICAR (0.966), and DoE (0.333). The citations window used for computing citations performance of various R&D agencies/departments was 2 to 3 years. In terms of citations impact, DoCU supported institutions ranked at the top among the various socio-economic ministries, as their research output received the highest citations per paper (23.5) in 2001-02, followed by DCP (3.31), DoC (3.17), MPNG (3.11), MoIT (3.09), MHFW (2.16), MoP (1.35), MoM (1.32), MoEN (1.29), DoCO (1.29), MoE (1.27), MWR (0.83), MoTX (0.44), MoT (0.43), and DCA (0.29). The citations window used for

computing citations performance of various socio-economic ministries was 2 to 3 years.

Collaborative research profile of the socio-economic ministries is better, compared to R&D agencies/departments. The R&D agencies/ departments contributed 7.96 per cent share of collaborative papers in the total output in 1985-86, 15.45 per cent in 1993-94, and 46.2 per cent in 2001-02. On the other hand, socio-economic ministries contributed 15.9 per cent, 26.3 per cent, and 59.2 per cent during the corresponding periods. CSIR, DAE, and DST continue to dominate their counterparts in terms of their publications output from collaborative research. Their share had been largest compared to other agencies during 1985-86, 1993-94, and 2001-02. But the collaborative publications share of CSIR and DAE remained constant (around 31-32 per cent) during the three periods of study. DST, however, showed a significant rise in its collaborative share from 10 per cent in 1985-86 to 19 per cent in 2001-02. Other agencies contributed only smaller share in the total collaborative output.

Collaborative research output is growing faster than the rate at which the total output is growing. The R&D sector as a whole had shown faster growth in collaborative research output (10.17 per cent), compared to total output by the sector (10.3 per cent) during sixteen years between 1985-86 and 2001-02. Both the segments of the R&D sector had shown the similar trends. However, the growth in collaborative research output of R&D agencies/departments (11.26 per cent) was higher than that of socio-economic ministries (54.4 per cent).

Collaborative research at the international level is growing faster than at national level in the R&D sector. In 1985-86, contribution of R&D sector at national and international levels was in the ratio of 66:34, which changed to 61.39 in 2001-02. It implies that collaborative research at international level received greater attention in 2001-02.

R&D agencies/departments seem to be pursuing the same agenda, since 1985-86. This is evident from the fact that the priority areas for research of various agencies/ departments did not change significantly during 16 years period from 1985-86 to 2001-02. The R&D sector has 26 high-productivity institutions, which published 100 or more papers during 1985-86, 1993-94, or 2001-02. Of these, the top 10 institutes ranked on composite quality index are Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bangalore; Institute of Physics (IOP), Bhubaneswar; Tata Institute of Fundamental Research (TIFR), Mumbai; Physical Research Laboratory (PRL, Ahmedabad; Indian Institute of Astronomy (IIA), Bangalore); Saha Institute of Nuclear Physics (SINP), Kolkata; Centre for Chemical and Molecular Biology (CCMB), Hyderabad; SN Bose National Centre for Basic Sciences (SNBNCBS), Kolkata; Indian Association for the Cultivation of Sciences (IACS), Kolkata; and National Physical Laboratory (NPL), New Delhi.

Given the special role played by agricultural sector in strengthening the GDP of the country and seeing the consistent decline in agricultural sciences publications, it is desirable that agricultural research be accorded higher priority in research. Collaborative research in the R&D sector, especially at international level, must be encouraged for accelerating the pace of growth in S&T and for ensuring quality and quantity output. The R&D sector may place special focus on its weaker areas of research, such as biomedical science, chemistry, clinical medicine, computer science, engineering, and mathematics to improve the performance of the country in these areas.