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Bangladesh: A Scientometric Analysis of National Publications Output in S&T, 2001-10

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ABSTRACT

This study analyses the research output of Bangladesh in S&T during 2001-10 on several parameters including its growth and country publications share in the world's research output, country publications share in various subjects in the national and global context, pattern of research communication in core domestic and international journals, geographical distribution of publications, share of international collaborative publications at the national-level as well as across subjects and characteristics of high productivity institutions, authors, and cited papers. The *Scopus Citation Database* has been used to retrieve the publication data for 10 years. It concludes that Bangladesh needs to increase its output and bring about improvement in the quality of its research efforts further.

1. INTRODUCTION

The economy of Bangladesh is a rapidly developing market-based economy. Its per capita income in 2010 was est. US $1,700 (adjusted by purchasing power parity). According to the International Monetary Fund, Bangladesh ranked as the 43rd largest economy in the world in 2010 in purchasing power parity terms and 57th largest in nominal terms, among the Next Eleven or N-11 of Goldman Sachs and D-8 economies, with a gross domestic product of US$ 269.3 billion in purchasing power parity terms and US$ 104.9 billion in nominal terms[1].

The adult literacy rate in the country was 56 % in 2009. The public expenditure on education as a percentage of GDP was 2.4 % and public expenditure in education as percentage of government expenditure was 14 % in 2008[2]. The net percentage of enrollment at primary and secondary level was 86 % (in 2009) and 41 % (in 2007). The percentage of gross enrollment at tertiary level was 8 % in 2008[3]. Its HDI index was 0.469 in 2010, ranking at 132th level. The HDI of the country was 0.469 in 2010, ranked at 132th position in the world.

The history of modern higher education may be traced back to the establishment of Dhaka University in 1921. When Bangladesh emerged as a independent nation in 1971, the country had four general universities and two specialised universities. By 2006, Bangladesh had 26 public universities where 1241352 students study at undergraduate and postgraduate level. These include those studying at 1175 affiliated colleges. There were 51 professional colleges (Medical, Dental, Polytechnic, Law, etc.) where 82,000 students study. With the passage of 'Private University Act of Bangladesh' in parliament in 1992, it had 56 such private universities by 2008, where 124267 students persued their studies[4].

The overall science and technology (S&T) activity of the country is organised under two sectors. The first is the sector represented by institutions that are directly funded by the government and specifically created for R&D activities. The other sector covers technical universities in agriculture, engineering and other general universities. The R&D institutions carry out scientific research, that directly relate to nation's socio-economic goals. In the universities, both basic and applied research is carried out in addition to the teaching of S&T that aim at creating skilled personnel in different scientific professions[5].

The National Council for Science and Technology (NCST), created in 1983, is the main apex body for S&T at the highest level for policy-making on S&T in the country. It worked for three years to draft a policy, which was formally approved by the government in 1986. There is an Executive Committee of the NCST (ECNCST) headed by the Minister, Science and Information & Communication Technology. Although the ECNCST has been meeting in recent years, these bodies rarely met in the past. The Ministry of Science and Information & Communication Technology (MOSICT) acts as the secretariat for the NCST and is responsible for all matters connected with the growth and promotion of S&T in the country. The

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primary responsibility of this Ministry includes, among others, assistance to the NCST in policy planning and decision-making and effective management of R&D activities carried out by various research and development institutions under it[5]. Bangladesh has 74 organisations engaged in R&D till 2005. This list, however, includes universities, some government-run routine testing laboratories, medical-research-cum-hospital centres and scientific support service institutions. Some of the major organisations involved in R&D include Bangladesh Agriculture Research Institute, Bangladesh Jute Research Institute, Soil Resources Development Institute, Bangladesh Tea Research Institute, Bangladesh Space Research and Remote Sensing Organisation, Bangladesh Forest Research Institute, Bangladesh Livestock Research Institute, Institute of Post Graduate Medicine and Research, International Centre for Diarrhoeal Diseases Research, Atomic Energy Research Establishment, Bangladesh Council of Scientific and Industrial Research, Bangladesh National Scientific and Documentation Centre, Institute of Nuclear Medicine, and River Research Institute[5]. Only few scientometric studies have been carried output on Pakistan. Among these studies, Mehbuba and Rousseau[6] has compared Bangladesh, Pakistan, and Sri Lanka research output with India using three indicators, such as percentage of uncited articles, number of citations per document and h-indice. Mehbuba[7], et al. made a scientometric comparison between two health and population research organisations namely, the International Centre for Diarrhoeal Disease Research (ICDDR), Dhaka, Bangladesh and the National Institute of Cholera and Enteric Diseases (NICED), Kolkata, India during 1979-2008 in terms of various indicators. Gupta[8] , *et al.* analysed India's collaboration with South Asian countries during 1992-99 using SCI database. Miah[9] , *et al*. analysed articles published in three journals from Chittagong University to analyse the trends and measure the quality and authorship pattern in 194 articles on forestry research in Bangladesh. Ahmad & Rahman[10] examine the validity of Lotka's law to authorship distribution in the field of nutrition research during 1972-2006. Islam & Alam[11] explored 44 private university websites using Alta Vista search engine and identifies the number of web pages and link pages and calculates the overall web impact factor (WIF) and absolute WIF.

2. OBJECTIVES

The objectives of the present study are to analyse the performance of Bangladesh's S&T, as reflected in their publications output during 2001-10. In particular, it analyses:

(i) Publication growth rate and publication share

(ii) Most productive, medium productive, low productive and least productive areas of research

(iii) Share of international collaborative papers and identification of major collaborative partners

(iv) Publication productive of geographical regions

(v) Characteristics of its high productive institutions, authors and high cited papers and

(vi) Identification of leading medias of communication.

3. METHODOLOGY AND DATA SOURCE

This study is based on the Bangladesh publication data in S&T retrieved from the *Scopus Citation database*[12] for the 10 years (2001-10). The *Scopus* database is an international multi-disciplinary database indexing over 18000 titles from more than 5000 publishers, including 16500 peers reviewed journals, 600 trade publications, 350 book series, and 3.6 million international conference/seminar papers. *Scopus* has a worldwide coverage, of which more than half of the *Scopus* contents originate from Europe, Latin America and the Asia & the Pacific Region. For citations data, three years, two year and one year citations window has been used for computing average citations per paper during 2001-08, 2009 and 2010. For searching and calculating the total international collaborative papers, a separate search strategy, which combines Bangladesh's collaboration with 140 major countries, was prepared and this string was combined with the main string to generate India's total international collaborative output. For analysing institutional, individual and journals output, the separate search strategies for generating institutional, author and journal outputs were developed, which later combined with the main string to generate the desired output. The study has used a number of absolute publications, citation and collaborative measures for developing S&T indicators as needed for depicting Bangladesh's status in S&T from 2001 to 2010.

4. ANALYSIS

4.1 S&T Publications Output

Bangladesh has produced 11688 papers during the last ten years (2001-10), which are increasing at an annual average growth rate of 16.64 %. In terms of cumulative publications growth, the cumulative S&T publications output of Bangladesh had increased from 3535 publications during 2001-05 to 8153 publications during 2006-10, experiencing a growth rate of 130.63 per cent (Table 1). The h-index of its total publications during 2001-10 was 71 and the number of high-cited papers recorded was 39. Its average citation impact on a three year citation window for its total publications during 2001-10 was 2.71. The global publications share of Bangladesh during 2001-10 was 0.067 per cent, which has increased from 0.044 per cent in 2001 to 0.102 per cent in 2010 (Table 2).

Table 1. Annual publication growth, citation impact and ICP share

Year	Bangladesh			
	TP	ACPP	ICP	ICP share
2001	586	2.18	204	34.81
2002	542	2.94	196	36.16
2003	731	3.56	356	48.70
2004	774	4.25	429	55.43
2005	902	4.40	501	55.54
2006	1059	4.08	561	52.97
2007	1440	3.42	697	48.40
2008	1619	3.10	766	47.31
2009	1819	1.81	825	45.35
2010	2216	0.64	1039	46.89
2001-05	3535		1686	47.69
2006-10	8153		3888	47.69
2001-10	11688	2.71	5574	47.69

TP=Total papers; ACPP=Average citations per paper; ICP=International collaborative papers

Table 2. Gobal publication share of Bangladesh

Year	Count of papers		
	Bangladesh	World	Bangladesh world share
2001	586	1326979	0.044
2002	542	1371936	0.040
2003	731	1426444	0.051
2004	774	1579618	0.049
2005	902	1749574	0.052
2006	1059	1832242	0.058
2007	1440	1927447	0.075
2008	1619	2006228	0.081
2009	1819	2087381	0.087
2010	2216	2175243	0.102
Total	**11688**	**17483093**	**0.067**

4.2 Subject Profile in Science & Technology

As per the publications data for 2001-10, Bangladesh's research profile by broad disciplines emerges as follows. Engineering sciences subjects together contributed the highest publications share (32.13 %), followed by life sciences (32.10 %), health sciences (27.78 %) and physical sciences (26.04%). Its publications share has increased in engineering sciences from 25.60 per cent to 34.96 per cent and health sciences from 26.96 per cent to 28.14 per cent, as against decrease in physical sciences from 32.67 per cent to 24.98 per cent and life sciences from 33.97 per cent to 31.29 per cent from 2001-05 to 2006-10 (Table 3).

4.2.1 High Productivity Subject Areas

Medicine, agricultural & biological sciences, engineering and computer science are considered as the four high priority areas of Bangladesh in S&T, each contributing publication share between 12.36 per cent and 26.19 per cent in the cumulative national publication output of Bangladesh during 2001-10 (Table 4). The highest national publication share of Bangladesh was 26.19 per cent in medicine, followed by agricultural and biological sciences (19.11 %), engineering (16.60 %) and computer science (12.36 %). The national publication share of Bangladesh has witnessed the largest increase in computer science by 13.47 per cent (from 2.97 % to 16.44 %), followed by engineering by 5.26 per cent (from 12.93 % to 18.19 %) and medicine by 1.57 per cent (from 25.09 % to 26.67 %), as against decrease in agricultural & biological sciences by 1.32 per cent (from 20.03 % to 18.70 %) from 2001-05 to 2006-10. The highest global publications share (0.189) of Bangladesh in these high productivity subject areas was observed in agricultural & biological sciences, followed by computer science (0.102), medicine (0.064) and engineering (0.060) during 2001-10. The highest international collaborative publications share (54.99 %) of Bangladesh was observed in agricultural & biological sciences, followed by medicine (47.96 %), engineering (37.37 %) and computer science (33.29 %) during 2001-10. The highest average citation impact per paper (2.09) for all its publications in high productivity subject areas was observed in medicine, followed by agricultural & biological sciences (2.04), engineering (1.72) and computer science (0.66) during 2001-10. The highest *h*-index (52) of Bangladesh publications during 2001-10 was achieved by medicine, followed by agricultural & biological sciences (32), engineering (24) and computer science (12) during 2001-10. The largest number of high-cited papers (16) was recorded by Bangladesh in medicine, followed by agricultural & biological sciences (3), engineering (1), and computer science (0) during 2001-10.

4.2.2 Medium Productivity Subject Areas

Environmental science, biochemistry, genetics & molecular biology, physics, materials science, chemistry, immunology & microbiology, pharmacology, toxicology & pharmaceutics, chemical engineering and earth & planetary sciences are considered as the nine medium priority areas of Bangladesh in

Table 3. Distribution of papers by broad subject in Bangladesh, 2001-10

Broad Subject	Number of Papers			Publications share		
	2001-05	2006-10	2001-10	2001-05	2006-10	2001-10
Physical sciences	1154	2037	3191	32.67	24.98	27.30
Engineering sciences	905	2850	3755	25.60	34.96	32.13
Life sciences	1201	2551	3752	33.97	31.29	32.10
Health sciences	953	2294	3247	26.96	28.14	27.78

Table 4. World and national publication share, ICP share, ACPP, h-index and HCP in high productivity subject areas, 2001-10

Subject	National publication share (%)			World publication share (%)	ICP share (%)	ACPP	*h*-index	HCP
	2001-05	2006-10	2001-10	2001-10				
Medicine	25.09	26.67	26.19	0.064	47.96	2.09	52	16
Agricultural & biological sci.	20.03	18.70	19.11	0.189	54.99	2.04	32	3
Engineering	12.93	1.19	16.60	0.060	37.37	1.72	24	1
Computer science	2.97	16.44	12.36	0.102	33.29	0.66	12	1

ACPP=Average citations per paper; ICP=International collaborative papers; HCP=High cited papers

Table 5. World & national publication share, ICP share, ACPP, *h*-Index and HCP in medium productivity subject areas, 2001-10

Subject	National publication share (%)			World publication share (%)	ICP share (%)	ACPP	*h*-index	HCP
	2001-05	2006-10	2001-10	2001-10				
Environmental science	9.25	9.10	9.15	0.152	62.96	4.13	28	5
Biochemistry, genetics & molecular biology	8.26	8.59	8.49	0.047	68.75	3.71	35	5
Physics	11.17	7.02	8.27	0.050	54.71	2.13	21	0
Material Science	9.08	7.32	7.85	0.064	43.90	2.23	24	0
Chemistry	8.74	5.21	6.28	0.056	64.03	4.43	29	7
Immunology & Microbiology	7.10	5.30	5.84	0.121	78.92	6.81	39	5
Pharmacology, toxicology & pharmaceutics	3.37	5.24	4.67	0.088	44.51	2.83	25	1
Chemical engineering	3.99	3.63	3.74	0.056	52.40	2.39	20	2
Earth & planetary sciences	3.21	3.60	3.60	0.056	53.68	3.62	25	5

ACPP=Average citations per paper; ICP=International collaborative papers; HCP=High cited papers

S&T, each contributing publication share between 3.60 per cent and 9.15 per cent in the cumulative national publication output of Bangladesh during 2001-10 (Table 5).

The highest national publication share (9.15 %) of Bangladesh was recorded in environmental science, followed by biochemistry, genetics & molecular biology (8.49 %), physics (8.27 %), materials science (7.85 %), chemistry (6.28 %), immunology & microbiology (5.84 %), pharmacology, toxicology & pharmaceutics (4.67 %), chemical engineering (3.74 %) and earth & planetary sciences (3.60 %) during 2001-10. The national publication share of Bangladesh has witnessed the largest increase in pharmacology, toxicology & pharmaceutics by 1.87 per cent (from 3.37 % to 5.24 %) and biochemistry, genetics &

molecular biology by 0.33 per cent (from 8.26% to 8.59 %), as against decrease in environmental science by 0.15 per cent (from 9.25 % to 9.10 %), chemical engineering by 0.36 per cent (from 3.99 % to 3.63 %), earth & planetary sciences by 1.28 per cent (from 3.21% to 3.60 %), materials science by 1.76 per cent (from 9.08% to 7.32 %), immunology & microbiology by 1.80 per cent (from 7.10 % to 5.30 %), chemistry by 3.53 per cent (from 8.74 % to 5.21 %) and physics by 4.16 per cent (from 11.17 % to 7.02 %) from 2001-05 to 2006-10 (Table 5).

The highest global publications share (0.152) of Bangladesh in these medium productivity subject areas was observed in environmental science, followed by immunology & microbiology (0.121), pharmacology, toxicology & pharmaceutics (0.088), materials science (0.064), chemistry (0.056), earth & planetary sciences (0.056), chemical engineering (0.056), physics (0.050) and biochemistry, genetics & molecular biology (0.047) during 2001-10. The largest international collaborative publications share (78.92 %) of Bangladesh was observed in immunology & microbiology, followed by biochemistry, genetics & molecular biology (68.75 %), chemistry (64.03 %), environmental science (62.96 %), physics (54.71 %), earth & planetary sciences (53.68 %), chemical engineering (52.40 %), pharmacology, toxicology & pharmaceutics (44.51 %) and materials science (43.90 %) during 2001-10 (Table 5).

The highest average citation impact per paper (6.81) for all its publications in medium productivity subject areas was observed in immunology & microbiology, followed by chemistry (4.43), environmental science (4.13), biochemistry, genetics & molecular biology (3.71), earth & planetary sciences (3.62), pharmacology, toxicology & pharmaceutics (2.83), chemical engineering (2.39), materials science (2.23) and physics (2.13) during 2001-10. The highest *h*-index (39) of Bangladesh publications was achieved by immunology & microbiology, followed by environmental science (38), biochemistry, genetics & molecular biology (35), chemistry (29), pharmacology, toxicology & pharmaceutics (25), earth & planetary sciences (25), materials science (24), physics (21) and chemical engineering (20) during 2001-10. The largest number of high-cited papers (7) was recorded by Bangladesh in chemistry, followed by immunology & microbiology (5), biochemistry, genetics & molecular biology (5), environmental science (5), chemical engineering (2), pharmacology, toxicology & pharmaceutics (1) and in other subjects (0 each) during 2001-10 (Table 5).

4.2.3 Low Productivity Subject Areas

Mathematics, energy, veterinary science, and nursing are considered as the four low priority areas of Bangladesh in S&T, each contributing publication share between 1.28 per cent and 2.93 per cent in the cumulative national publication output of Bangladesh during 2001-10 (Table 6). The highest national publication share (2.93 %) of Bangladesh was recorded in mathematics, followed by energy (2.52 %), veterinary science (1.44 %) and nursing (1.28 %) during 2001-10. The national publication share of Bangladesh has witnessed the largest increase in mathematics by 0.83 % (from 2.35 % to 3.18 %) and nursing by 0.34 per cent (from 1.05% to 1.39 %), as against decrease in veterinary science by 0.09 per cent (from 1.50 % to 1.41 %) and energy by 0.21 per cent (from 2.66 % to 2.45 %) from 2001-05 to 2006-10. The highest global publications share (0.097) of Bangladesh in these low productivity subject areas was observed in veterinary science, followed by energy (0.074 %), nursing (0.057 %) and mathematics (0.040 %) during 2001-10. The largest international collaborative publications share (67.33 %) of Bangladesh was observed in nursing, followed by veterinary science (61.90 %), mathematics (44.44 %) and energy (40.48 %) during 2001-10. The highest average citation impact per paper (2.96) for all its publications in low productivity subject areas was observed in nursing, followed by veterinary science (2.23), energy (1.83) and mathematics (1.15) during 2001-10. The highest *h*-index (15) of Bangladesh publications was achieved each in energy and nursing, followed by veterinary science (12) and mathematics (10) during 2001-10.

Table 6. World & national publication share, ICP share, ACPP, h-index and HCP in Low productivity subject areas, 2001-10

Subject	National publication share (%)			World publication share (%)	ICP share (%)	ACPP	*h*-index	HCP
	2001-05	2006-10	2001-10	2001-10				
Mathematics	2.35	3.18	2.93	0.040	44.44	1.15	10	0
Energy	2.66	2.45	2.52	0.074	40.48	1.83	15	0
Veterinary science	1.50	1.41	1.44	0.097	61.90	2.23	15	0
Nursing	1.05	1.39	1.28	0.057	67.33	2.96	15	0

ACPP=Average citations per paper; ICP=International collaborative papers; HCP=High cited papers

4.2.4 Least Productivity Subject Areas of Research

Public health, neurosciences and dentistry are considered as the four least priority areas of Bangladesh S&T, each contributing publication share between 0.04 per cent and 0.64 per cent in the cumulative national publication output of Bangladesh during 2001-10 (Table 7).

The highest national publication share (0.64 %) of Bangladesh was recorded in public health, followed by neurosciences (0.27 %) and dentistry (0.04 %) during 2001-10. The national publication share of Bangladesh has witnessed the increase in neurosciences by 0.07 per cent (from 0.23 % to 0.29 %), as against decrease in public health by 0.58 per cent (from 1.05 % to 0.47 %) and dentistry by 0.02 per cent (from 0.06 % to 0.04 %) from 2001-05 to 2006-10. The highest global publications share (0.030 %) of Bangladesh in these least productivity subject areas was observed in public health, followed by neurosciences (0.007 %) and dentistry (0.005 %) during 2001-10. The largest international collaborative publications share (87.50 %) of Bangladesh was observed in neurosciences, followed by dentistry (80.00 %) and public health (62.67 %) during 2001-10 (Table 7).

The highest average citation impact per paper (3.72) for all its publications in low productivity subject areas was observed in neurosciences, followed by public health (3.20) and dentistry (1.80) during 2001-10. The highest *h*-index (14) of Bangladesh publications was achieved by public health during 2001-10 followed by neurosciences (7) and dentistry (2) during 2001-10. The number of high-cited papers recorded by Bangladesh was 1 in neurosciences and zero in other two subjects during 2001-10 (Table 7).

4.3 International Collaboration

The share of international collaborative papers in the Bangladesh research output was 47.69 per cent during 2001-10. Its share of internationally collaborative papers has remained the same during 2001-05 and 2006-10. In terms of citation impact of international collaborative papers, Bangladesh has achieved a citation impact of 4.55 per paper during 2001-10. Table 8 depicts the international collaborative linkages of Bangladesh with top 45 countries during 2001-10. The largest number of collaborative linkages (1486) of Bangladesh was with Japan with 26.78 per cent share, followed by USA (25.20% share), UK (15.83% share), India (8.53% share), Australia, Malaysia, Canada, South Korea, Sweden, Germany and Thailand (with share varying from 3.35% to 7.30%), China, Netherlands, Switzerland, Pakistan, Columbia, Italy and Belgium (with share varying from 2.05% to 2.78%), France, Nepal, Philippines, South Africa and Austria (with share varying from 1.10% to 1.62%) and other countries less than 1.0 per cent share during 2001-10.

Of the top 45 international collaborating countries, Bangladesh collaborative linkages have decreased with 14 countries, with largest decrease with United Kingdom by 3.25 per cent, followed by India (3.17 %), Germany (2.15 %), USA (1.89 %), Sweden (0.91 %), Austria (0.47 %), Kuwait (0.46 %), France (0.23 %), Belgium (0.20 %), Romania (0.17 %), New Zealand (0.08), Philippines (0.06 %), Jordan (0.01%) and Ukraine (0.01 %) from 2001-05 to 2006-10. In contrast, Bangladesh collaborative linkages has increased with 31 countries, with maximum increase of 4.06 per cent was with South Korea, followed by Malaysia (2.91 %), Australia (2.90 %), China (2.03 %), Canada (1.68 %), Japan (1.16 %), Thailand (1.15 %), Switzerland (0.86 %), Saudi Arabia (0.68 %), Sri Lanka (0.60 %), Egypt (0.60 %) and other countries less than 0.50 per cent share from 2001-05 to 2006-10.

On further grouping 45 collaborating countries, it was found that Bangladesh combined collaborating papers share was highest (72.67 %) with G-8 countries, followed by 18 developing countries (24.17 % share), 13 European countries (14.20 % share), 4 South Asian countries (10.99 % share) and 2 Pacific countries (7.82 %) during 2001-10. Among these five group of countries, Bangladesh combined collaborating papers share has decreased by 3.81 per cent with G-8 countries, 3.21 per cent with South Asian countries and 0.90 per cent with European countries, as against increase by 9.59 per cent in developing countries and 2.97 per cent with Pacific countries, 2.55 per cent from 2001-05 to 2006-10. (Table 8)

Table 7. World & national publication share, ICP share, ACPP, h-index and HCP in low productivity subject areas, 2001-10

Subject	National publication share (%)			World publication share (%)	ICP share (%)	ACPP	*h*-index	HCP
	2001-05	2006-10	2001-10	2001-10				
Public Health	1.05	0.47	0.64	0.030	62.67	3.20	14	0
Neurosciences	0.23	0.29	0.27	0.007	87.50	3.72	7	1
Dentistry	0.06	0.04	0.04	0.005	80.00	1.80	2	0

ACPP=Average citations per paper; ICP=International collaborative papers; HCP=High cited papers

Table 8. bangladesh collaborative linkages with top 45 countries, 2001-10

Collaborating country	Number of international collaborative papers			Share of international collaborative papers		
	2001-05	2006-10	2001-10	2001-05	2006-10	2001-10
Japan	438	1048	1486	25.98	27.14	26.78
USA	447	951	1398	26.51	24.62	25.20
UK	305	573	878	18.09	14.84	15.83
India	181	292	473	10.74	7.56	8.53
Australia	89	316	405	5.28	8.18	7.30
Malaysia	75	284	359	4.45	7.35	6.47
Canada	76	239	315	4.51	6.19	5.68
S. Korea	45	260	305	2.67	6.73	5.50
Sweden	100	194	294	5.93	5.02	5.30
Germany	114	178	292	6.76	4.61	5.26
Thailand	43	143	186	2.55	3.70	3.35
China	23	131	154	1.36	3.39	2.78
Netherlands	37	101	138	2.19	2.62	2.49
Switzerland	30	102	132	1.78	2.64	2.38
Pakistan	35	97	132	2.08	2.51	2.38
Columbia	38	90	128	2.25	2.33	2.31
Italy	33	82	115	1.96	2.12	2.07
Belgium	37	77	114	2.19	1.99	2.05
France	30	60	90	1.78	1.55	1.62
Nepal	22	57	79	1.30	1.48	1.42
Philippines	22	48	70	1.30	1.24	1.26
S.Africa	17	49	66	1.01	1.27	1.19
Austria	24	37	61	1.42	0.96	1.10
Singapore	15	36	51	0.89	0.93	0.92
Saudi Arabia	6	40	46	0.36	1.04	0.83
Sri Lanka	6	39	45	0.36	1.01	0.81
New Zealand	14	29	43	0.83	0.75	0.78
Brazil	10	32	42	0.59	0.83	0.76
Spain	12	29	41	0.71	0.75	0.74
Kuwait	16	19	35	0.95	0.49	0.63
Taiwan	9	25	34	0.53	0.65	0.61
Egypt	3	30	33	0.18	0.78	0.59
Mexico	5	27	32	0.30	0.70	0.58
Finland	7	20	27	0.42	0.52	0.49
Poland	3	19	22	0.18	0.49	0.40
Turkey	5	14	19	0.30	0.36	0.34
Czech Republic	1	17	18	0.06	0.44	0.32
Nigeria	2	15	17	0.12	0.39	0.31
Iran	2	15	17	0.12	0.39	0.31
Argentina	4	11	15	0.24	0.28	0.27
Romania	5	5	10	0.30	0.13	0.18
Russia	2	6	8	0.12	0.16	0.14
Slovenia	1	3	4	0.06	0.08	0.07
Ukraine	1	2	3	0.06	0.05	0.05
Jordan	1	2	3	0.06	0.05	0.05
Total	**1686**	**3862**	**5548**	**100.00**	**100.00**	**100.00**

4.4 Geographical Distribution of Papers

Dhaka and Rajshahi are the two most productive geographical areas in Bangladesh who have individually contributed 10.34 per cent to 63.92 per cent share (together 74.26 %) to the total research output of Bangladesh during 2001-10. The contribution of both the cities has decreased from 66.36 per cent to 62.86 per cent in case of Dhaka and from 10.61 per cent to 10.22 per cent in case of Rajshahi from 2001-05 to 2006-10 (Table 9). Mymemsing, Chittagong, Khulna, Gazipur, and Sylhet are the five medium productive geographical areas with their individual publication share between 3.63 per cent and 7.67 per cent (together 27.33 %) to the total research output of Bangladesh during 2001-10. The contribution has increased in Chittagong (from 6.34 % to 7.21 %), Khulna (from 2.63 % to 5.74 %), Gazipur (from 3.96 % to 4.44 %) and Sylhet (from 2.46% to 4.13%), as compared to decrease in case of Mymemsingh (from 8.01 % to 7.52 %) from 2001-05 to 2006-10 (Table 9).

4.5 Institutional Profile

4.5.1 Universities

The top 20 universities in Bangladesh together have published 7030 papers, which account for 60.15 per cent share of the total research output of Bangladesh during 2001-10. The output of individual universities, however, varied from 64 to 1646, with an average productivity of 394.8 papers per organisation. The international collaborative share of these 20 universities account for 44.82 per cent share (varying from 28.57 per cent to 83.54 %) of their total output during 2001-10. These 20 universities have achieved an *h*-index of 49 (varying from 3 to 39) and number of high-cited papers published was only 20 (varying from 0 to 13). A complete profile of these 20 universities is given in Table 10.

4.5.2 Research Institutes

The top 16 research institutes in Bangladesh together have published 2451 papers, which account for 20.97 per cent share of the total research output of Bangladesh during 2001-10. The output of individual research institutes, however, varied from 49 to 1124, with an average productivity of 154 papers per organisation. The international collaborative share of these 16 research institutes account for 59.53 per cent share (varying from 28.57 % to 83.54 %) of their total output during 2001-10. These 16 research institutes have achieved an h-index of 58 (varying from 5 to 54) and number of high-cited papers published was only 18 (varying from 0 to 15). A complete profile of these 16 research institutes is given in Table 11.

4.5.3 Medical Colleges and Hospitals

The top 9 medical colleges and hospitals in Bangladesh together have published 1141 papers, which account for 9.76 per cent share of the total

Table 9. Geographical distribution of papers of Bangladesh, 2001-10

Name of Bangladesh city	Number of papers			Share of papers		
	2001-05	2006-10	2001-10	2001-05	2006-10	2001-10
Dhaka	2346	5125	7471	66.36	62.86	63.92
Rajshahi	375	833	1208	10.61	10.22	10.34
Mymemsingh	283	613	896	8.01	7.52	7.67
Chittagong	224	588	812	6.34	7.21	6.95
Khulna	93	468	561	2.63	5.74	4.80
Gazipur	140	362	502	3.96	4.44	4.30
Sylhet	87	337	424	2.46	4.13	3.63
Kushtia	12	77	89	0.34	0.94	0.76
Dinajpur	16	37	53	0.45	0.45	0.45
Tangail	2	29	31	0.06	0.36	0.27
Pabna	6	19	25	0.17	0.23	0.21
Comilla	10	12	22	0.28	0.15	0.19
Bogra	7	13	20	0.20	0.16	0.17
Barisal	4	15	19	0.11	0.18	0.16
Nilphamari	4	13	17	0.11	0.16	0.15
Bandarban	3	6	9	0.08	0.07	0.08
Total of Bangladesh	**3535**	**8153**	**11688**	**100.00**	**100.00**	**100.00**

Table 10. Bangladesh: Top 20 most productive universities, 2001-10

S. No.	Name of the university	TP	*h*-index	HCP	ICP	% ICP
1.	University of Dhaka	1646	39	13	710	43.13
2.	Bangladesh University of Science & Technology, Dhaka	1519	31	3	550	36.21
3.	Rajshahi University	1013	22	0	415	40.97
4.	Bangladesh Agricultural University, Mymensingh	696	21	0	448	64.37
5.	Jahangirnagar University, Dhaka	638	22	2	360	56.43
6.	University of Chittagong	426	15	0	195	45.77
7.	Shahjalal University of Science & Technology, Sylhet	364	15	0	161	44.23
8.	Khulna University	245	12	1	98	40.00
9	East West University, Dhaka	203	8	0	56	27.59
10.	Khulna University of Engineering & Technology	192	6	0	91	47.40
11	BRAC University, Dhaka	115	7	0	34	29.57
12.	Rajshahi University of Engineering & Technology	118	9	1	56	47.46
13.	United International University, Dhaka	125	5	0	40	32.00
14.	Islamic University, Kushtia	91	6	0	45	49.45
15.	North South University, Dhaka	122	9	0	40	32.79
16.	Chittagong University of Engineering & Technology	82	7	0	40	48.78
17.	Bangabandu Sheikh Mujibur Rahman Agricultural University, Gazipur	73	7	0	31	42.47
18.	Independent University, Dhaka	81	5	0	34	41.98
19.	University of Asia & Pacific, Dhaka	83	4	0	39	46.99
20.	Ahsanullah University of Science & Technology, Dhaka	64	3	0	31	48.44

Table 11. Bangladesh: Top 16 most productive research institutes, 2001-10

S.No.	Name of the research institutes	TP	*h*-index	HCP	ICP	% ICP
1.	International Center for Diarhoeal Disease Research, Dhaka	1124	54	15	939	83.54
2.	Atomic Energy Center, Dhaka	115	12	0	40	34.78
3.	Institute of Nuclear Science & Technology, Dhaka	113	8	0	53	46.90
4.	Bangladesh Agricultural Research Institute, Gazipur	136	12	0	61	44.85
5.	Bangladesh Rice Research Institute, Gazipur	99	15	0	62	62.63
6.	Bangladesh Atomic Energy Commission, Dhaka	199	15	0	62	31.16
7.	Bangladesh Institute of Research & Rehabilitation in Diabetes, Endocrine & Metabolic Disorders, Dhaka	96	13	0	36	37.50
8.	Bangladesh Livestock Research Institute, Dhaka	66	6	0	27	40.91
9.	Atomic Energy Establishment, Dhaka	56	7	0	27	48.21
10.	National Institute of Preventive & Social Medicine, Dhaka	60	13	2	30	50.00
11.	BCSIR, Dhaka	135	10	0	60	44.44
12.	Bangladesh Rural Advancement Committee, Dhaka	68	12	1	44	64.71
13.	Bangladesh Jute Research Institute, Dhaka	39	5	0	15	38.46
14.	Bangladesh Institute of Nuclear Agriculture, Mymensingh	53	10	0	31	58.49
15.	Bangladesh Fisheries Research Institute, Mymensingh	53	8	0	22	41.51
16.	Institute of Child & Mother Health, Dhaka	49	8	0	14	28.57

TP=Total papers; ACPP=Average citations per paper; ICP=International collaborative papers; HCP=High cited papers

research output of Bangladesh during 2001-10. The output of individual medical colleges and hospitals, however, varied from 46 to 445, with an average productivity of 131 papers per organisation. The international collaborative share of these 9 medical colleges and hospitals account for 17.00 per cent share (varying from 7.94 % to 68.35 %) of their total output during 2001-10. These 9 medical colleges & hospitals have achieved an *h*-index of 26 (varying from 3 to 14) and number of high-cited papers published was only 1 (varying from 0 to 1). A complete profile of these 9 medical colleges and hospitals is given in Table 12.

4.6 Contribution and Citation Impact of Most Productive Authors

Fifteen authors have been identified as productive authors who have published 52 and above papers in science and technology. These 15 authors together contributed 1113 papers with an average of 74.2 papers per author and account for 9.52 per cent share in the cumulative publications output of Bangladesh during 2001-10. Six authors have published higher number of papers than the group average (74.2). These are: M.A. Khan with 128 papers, followed by M.M. Rahman (97 papers), F. Qadri (87 papers), S.E. Kabir (87 papers), S.P. Majumdar (84 papers) and A.A. Mamun (75 papers). Considering the citation/impact of papers, these productive authors have received a total of 4646 citations for these 1113 papers with an average of 4.17 citations per paper (varying from 0.57 to 11.0). Six authors have registered higher citation impact than the average impact of papers of all authors (Table 13). These are M. Yanus with average citation per paper of 11.0, followed by A.S.G. Faruque (9.96), F. Qadri (9.68), R. Jahan (4.88), M.A. Salam (4.79) and M.A.

Table 12. Bangladesh: Top 9 most productive medical colleges & hospitals, 2001-10

S. No	Medical colleges and hospitals	TP	*h*-index	HCP	ICP	% ICP
1.	Banglabandhu Sheikh Mujib Medical University, Dhaka	445	14	1	58	13.03
2.	Dhaka Medical College	180	9	0	35	19.44
3.	Mymensingh Medical College	126	6	0	10	7.94
4.	Dhaka Medical College & Hospital	140	11	0	50	35.71
5.	Dhaka Shishu Hospital	79	17	0	54	68.35
6.	Rajshahi Medical College	49	4	0	10	20.41
7.	Combined Military Hospital, Dhaka	63	3	0	15	23.81
8.	Sir Salimullah Medical College, Dhaka	51	6	0	16	31.37
9.	Chittagong Medical College	46	11	0	12	26.09

Table 13. Productivity and impact of 15 most productive Bangladeshi authors in S&T, 2001-10

Name of authors	Affiliation of authors	TP	TC	ACPP	*h*-Index
M.A. Khan	Atomic Energy Commission, Radiation & Polymer Chemistry Laboratory, Dhaka	128	282	2.20	12
M.M. Rahman	ICDDRR, Centre for Health & Population Research, Dhaka	97	214	2.21	11
F. Qadri	ICDDRR, Centre for Health & Population Research, Dhaka	87	842	9.68	21
S.E. Kabir	Jahangirnagar Univ., Dept. of Chemistry, Dhaka	87	258	2.97	11
S.P. Majumder	Bangladesh Univ. of Engineering & Technology, Dhaka	84	48	0.57	4
A.A. Mamun	Jahangirnagar Univ., Deptt. of Physics, Dhaka	75	301	4.01	12
A.S.G. Faruque	International Centre for Diarrheal Disease Research Bangladesh (ICDDR), Dhaka	73	727	9.96	19
M. Yunus	ICDDRR, Centre for Health & Population Research	72	792	11.00	20
M.A. Rashid	University of Dhaka, Deptt. of Pharmaceutical Chemistry	67	151	2.25	11
M.A. Salam	International Centre for Diarrheal Disease Research Bangladesh (ICDDR), Dhaka	66	316	4.79	14
M.A Wahab	Faculty of Fisheries, Mymensingh	60	261	4.35	12
R. Jahan	Univ. of Development Alternative, Dept. of Biotechnology & Genetic Engineering, Dhaka	59	288	4.88	8
M.S. Islam	University of Dhaka, Dept. of Pharmaceutical Technology, Dhaka	53	61	1.15	4
Q.D.M. Khosru	Bangladesh Univ. of Engineering & Technology, Dhaka	53	40	0.75	4
M. Rahmatullah	University of Dhaka, Dhaka	52	65	1.25	3
	Total	1113	4646	4.17	11.07
	Total of the country	11688			
	Share of 15 authors in country output	9.52			

Wahab (4.35). These 15 authors have received an average *h*-index of 11.07 (varying from 3 to 21). Seven authors have achieved the higher *h*-index value than the group average of 15.60. These are F. Qadri with an h-index of 21, followed by M. Yanus (20), A.S.G. Faruque (19), M.A. Salam (14), A.A. Mamun (12) and M.A. Khan (12).

4.7 Media of Communication

The top 12 most productive domestic journals publishing Bangladesh's research papers in S&T together contributed 1396 papers, which accounts for 11.94 per cent share in the cumulative publications output of Bangladesh during 2001-10. The cumulative publications share of these 12 most productive domestic journals showed increase in Bangladesh's publications output from 10.44 per cent during 2001-05 to 12.60 per cent during 2006-10 (Table 14). Similarly, the top 20 most productive foreign journals publishing Bangladesh's research papers in S&T together contributed 909 papers, which accounts for 7.78 per cent share in the cumulative publications output of Bangladesh during 2001-10. The cumulative publications share of these 20 most productive foreign journals showed decrease in Bangladesh's publications output from 10.83 per cent during 2001-05 to 6.45 per cent during 2006-10 (Table 15).

Table 14. Productivity of the top 20 most productive domestic

Name of journal	Number of papers		
	2001-05	2006-10	2001-10
Mymensingh Medical Journal	41	311	352
Bangladesh Journal of Botany	86	112	198
Bangladesh Medical Research Council Bulletin	81	104	185
Journal of Health, Population & Nutrition	57	123	180
Dhaka Journal of Pharmaceutical Sciences	0	88	88
Bangladesh Journal of Obstetrics & Gynecology	40	41	81
Bangladesh Renal Journal	53	20	73
Journal of Medicine	0	71	71
Plant Tissue Culture & Biotechnology	11	54	65
Journal of Biological Sciences	0	36	36
Bangladesh Journal of Plant Taxonomy	0	34	34
Advances in Natural & Applied Sciences	0	33	33
Total papers	369	1027	1396
Country's total papers	3535	8153	11688
Share of Top 12 domestic journals in country output	10.44	12.60	11.94

Table 15. Productivity of 20 most productive foreign journals

Name of journal	Number of papers		
	2001-05	2006-10	2001-10
Pakistan Journal of Scientific & Industrial Research	51	29	80
Pakistan Journal of Biological Science	0	76	76
Polymer Plastics Technology & Engineering	27	43	70
Lancet	26	38	64
Journal of Clinical Microbiology	38	20	58
American Journal of Tropical Medicine & Hygiene	8	40	48
Physics of Plasmas	24	22	46
Journal of Australasian Journal of Animal Science	37	8	45
Fitoterapia	31	11	42
Aquaculture	16	21	37
Journal of Applied Sciences	0	37	37
Emerging Infectious Diseases	17	19	36
Bulletin of the WHO	18	18	36
American Euroasian Journal of Sustainable Agriculture	0	36	36
Physics & Chemistry of Liquids	25	10	35
Aquaculture Research	10	23	33
Environment Science & Technology	12	21	33
Infection & Immunity	14	19	33
Biotechnology	12	20	32
American Journal of Clinical Nutrition	17	15	32
Total Papers	383	526	909
Country's total papers	3535	8153	11688
Share of top 20 foreign journals in country output	10.83	6.45	7.78

4.8 High Cited Papers of Bangladesh

Bangladesh has published 39 high-cited papers (receiving 100 or more citations) in S&T in last 10 years (2001-10) and these have received between 100 and 415 citations per paper. Of these 39 high-cited papers, 37 were international collaborative (28 bilateral and 9 multilateral) and 2 zero collaborative. Of the international collaborative papers, Bangladesh institutions were first author in only 7 papers and foreign institutions in 32 papers. Of the 39 high cited papers, 28 appeared as articles, 10 as review papers and 1 as conference paper. In overall, Bangladesh participation in these 37 papers was confined to 12 institutions, which includes 15 papers from International Institute of Diarroheal Disease Research, Dhaka, 13 papers from University of Dhaka, 3 papers from Bangladesh University of Engineering & Technology, 2 papers each from Jahangirnagar University, Center for Health and Population Research, Dhaka and National Institute of Preventive & Social Medicine, Dhaka and 1 paper each from 6 other institutions.

These 39 high cited papers appeared in 36 journals, including 5 papers each in Journal of Physical Chemistry B and Lancet, 3 papers in Environmental Science and Technology, 2 papers each in Applied Geochemistry, Geochimica et Cosmochimica Acta and New England Journal of Medicine and 1 paper each in 20 other journals.

5. SUMMARY AND CONCLUSIONS

Bangladesh has produced 11688 papers during the last ten years (2001-10), which are increasing at an annual average growth rate of 16.64 per cent. Its average citation impact on a three year citation window for its total publications during 2001-10 was 2.71. The global publications share of Bangladesh during 2001-10 was 0.067 per cent, which has increased from 0.044 per cent in 2001 to 0.102 per cent in 2010.

In terms of broad subjects, engineering sciences subjects together contributed the highest publications share (32.13 %), followed by life sciences (32.10 %), health sciences (27.78 %) and physical sciences (26.04 %). Its publications share has increased in engineering sciences from 25.60 per cent to 34.96 per cent and health sciences from 26.96 per cent to 28.14 per cent, as against decrease in physical sciences from 32.67 per cent to 24.98 per cent and life sciences from 33.97 per cent to 31.29 per cent from 2001-05 to 2006-10

Medicine, agricultural & biological sciences, engineering and computer science are the four high priority areas of Bangladesh contributing publication share each between 12.36 per cent and 26.19 per cent, environmental science, biochemistry, genetics & molecular biology, physics, materials science, chemistry, immunology & microbiology, pharmacology, toxicology & pharmaceutics, chemical engineering and earth & planetary sciences are the nine medium priority areas of Bangladesh contributing publication share each between 3.60 per cent and 9.15 per cent, mathematics, energy, veterinary science and nursing are the four low priority areas of Bangladesh contributing publication share each between 1.28 per cent and 2.93 per cent and public health, neurosciences and dentistry are the three least priority areas of Bangladesh in S&T contributing publication share each between 0.04 per cent and 0.64 per cent in the cumulative national publication output of Bangladesh during 2001-10.

The national publication share increased in computer science by 13.47 per cent, followed by engineering (5.26 %), pharmacology, toxicology & pharmacology (1.87 %), medicine (1.58 %), mathematics (0.83 %), earth & planetary science (0.39 %), nursing (0.34 %), biochemistry, genetics & molecular biology (0.33 %), and neurosciences (0.06 %), as against decrease in physics by 4.15 per cent, followed by chemistry (3.53 %), immunology & microbiology (1.80 %), materials science (1.76 %), agricultural & biological sciences (1.33 %), public health (0.58 %), chemical engineering (0.36 %), energy (0.21 %), environmental science (0.15 %), veterinary science (0.09 %) and dentistry (0.02 %) from 2001-05 to 2006-10.

The world share of various subjects varied from 0.005 to 0.189 during 2001-10, with maximum share (0.189 %) in agricultural & biological sciences, followed by environmental science (0.152 %), immunology & microbiology (0.121 %), computer science (0.102 %), veterinary science (0.097 %), pharmacology, toxicology & pharmaceutics (0.088 %), energy (0.074 %), medicine (0.064 %), materials science (0.064 %), engineering (0.060 %), etc.

The international collaborative publications share of various subjects varied from 33.29 per cent to 87.50 per cent, with maximum share (87.50 %) in neurosciences during 2001-10, followed by dentistry (80.0 %), immunology and microbiology (78.92 %), biochemistry, genetics & molecular biology (68.75 %), nursing (67.33 %), chemistry (64.03 %), environmental science (62.96 %), public health (62.67 %), veterinary science (61.90 %), agricultural and biological sciences (54.99 %), physics (54.71 %), etc.

The average citation impact per paper of various subjects varied from 0.66 to 6.81, with maximum citation impact (6.81) in immunology & microbiology during 2001-10, followed by chemistry (4.43), environmental science (4.13), neurosciences (3.72), biochemistry, genetics & molecular biology (3.71), earth & planetary sciences (3.62), public health (3.20), nursing (2.96), pharmacology, toxicology & pharmaceutics (2.83), chemical engineering (2.39), etc

The *h*-index of various subjects varied from 2 to 52, with maximum h-index (52) in medicine during 2001-10, followed by immunology & microbiology (39), biochemistry, genetics & molecular biology (35), agricultural & biological sciences (32), chemistry (29), environmental sciences (28), earth & planetary sciences (25), pharmacology, toxicology & pharmaceutics (25), materials science (24), engineering (24), physics (21), etc.

The number of high cited papers of various subjects varied from 0 to 16 during 2001-10, with maximum papers (16) in medicine, followed by chemistry (7), immunology & microbiology (5), biochemistry, genetics & molecular biology (5), environmental sciences (5), earth & planetary sciences (5), agricultural & biological sciences (3), chemical engineering (2), pharmacology, toxicology & pharmaceutics (1), engineering (1), computer science (1) and neurosciences (1).

The share of international collaborative papers in the Bangladesh research output was 47.69 per cent during 2001-10, which remained the same during 2001-05 and 2006-10. In terms of citation impact of international collaborative papers, Bangladesh has achieved a citation impact of 4.55 per paper during 2001-10.

The largest number of collaborative linkages (1486) of Bangladesh was with Japan with 26.78 per cent share, followed with USA, UK, India, Australia, Malaysia, Canada, South Korea, Sweden, Germany, and Thailand, etc. during 2001-10. Bangladesh

combined collaborating papers share was highest (72.67%) with G-8 countries, followed by 18 developing countries (24.17 %), 13 European countries (14.20 %), 4 South Asian countries (10.99 %) and 2 Pacific countries (7.82 %) during 2001-10.

In terms of geographical distribution of papers, Dhaka and Rajshahi are the two most productive geographical areas in Bangladesh contributing each between 10.34 per cent to 63.92 per cent share and Mymemsing, Chittagong, Khulna, Gazipur, and Sylhet are the five medium productive geographical areas contributing each publication share between 3.63 per cent and 7.67 per cent to the total research output of Bangladesh in S&T during 2001-10.

The top 20 universities, 16 research institutes and 9 medical colleges & hospitals (45 organisations) in Bangladesh together contributed 60.15 per cent, 20.97 per cent and 9.76 per cent share respectively to the total research output of Bangladesh in S&T during 2001-10.

These top 15 authors together contributed 1113 papers with an average productivity of 74.2 papers per author. These authors together account for 9.52 per cent share in the cumulative publications output of Bangladesh and recording an average citation impact per paper of 4.17 and an average *h*-index of 11.07 during 2001-10.

The top 12 domestic journals and 20 most productive foreign journals publishing Bangladesh's research papers accounted each for 11.94 per cent and 7.78 per cent share respectively in the cumulative publications output of Bangladesh during 2001-10.

Bangladesh has published 39 high-cited papers in science and technology in last 10 years (2001-10) and these have received between 100 and 415 citations per paper. Of these 39 high-cited papers, 37 were international collaborative (28 bilateral and 9 multilateral) and 2 zero collaborative. Bangladesh participation in these 37 papers was confined to 12 institutions and 36 journals. To increase its research output, it has to increase its investment in R&D and deployment of manpower, which is already very low. In addition, research climate has to be improved, besides expanding and modernising its infrastructure for R&D.

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