Is mathematics research in India on the decline?

In two recent letters to this journal, I have shown that the number of scientific research papers published from India is on the decline[1]. The conclusion was drawn essentially based on papers indexed in the multidisciplinary database *Science Citation Index* (and *The Web of Science*).

Now I present data on the number of papers indexed in *MathSciNet*, the web database of the American Mathematical Society, covering mathematics, statistics, operational research and related fields. *MathSciNet* indexes about 1700 journals, as well as many conferences, and books and book chapters. For this study, I have counted all these items. A few years ago I collected some data from *MathSci* database on CD-ROM for the Department of Scientific and Industrial Research[2].

In Table 1, I compare the number of papers published from India, Israel, Brazil, the People's Republic of China and South Korea in the 21 years, 1980–2000. In 1986, China had published 71% more papers than India. This difference grew to 362% in 2000. Between 1990 and 2000, the number of papers from India remained virtually the same, hovering between 1400 and 1600 (1992 was an exception with 1691 papers), whereas the number of papers from China grew steadily from 3472 in 1990 to 6552 in 2000 – an 88% rise. During the same period, the number of papers doubled in Brazil, more than quadrupled in South Korea and rose by 47% in Israel. The world's total output of papers rose by about 19%.

In Figure 1, India's share of the world's publication over the 15-year period, 1985–1999, is compared with that of other countries. It clearly shows the dramatic growth in the volume of literature published in China and the stagnancy in India.

Even well-known institutions in India are unable to attract bright students for research. The Institute of Mathematical Sciences, Chennai and The Harish-Chandra Research Institute, Allahabad, consider themselves lucky if they are able to find one or two Ph D candidates in mathematics every year. Often they do not get even one. It is not as if students are not coming forward. Actually, about 300 students applied for admission to doctoral programmes in these two institutions this year. But only less than 40 could get past the common entrance examination and hardly anyone of them could get selected at the interview. A recent issue of *Outlook* has drawn attention to the sorry state of affairs: The National Science Talent Search could award only 12% of the 60 scholarships last year, as the rest of the candidates did not meet the requirements; at Indian Institute of Technology Bombay, there was no Ph D scholar for basic sciences last year; and the Tata Institute of Fun-

Table 1. Number of papers from five countries indexed in *MathSciNet* distributed by publication year (PY)*

PY	India	China	Israel	Brazil	South Korea	World contribution
1980	66	51	3	3	0	42941
1981	86	41	7	12	7	40782
1982	291	255	37	35	11	41362
1983	826	966	402	158	34	43116
1984	1107	1628	623	235	56	47392
1985	1111	2081	606	258	71	48782
1986	1233	2110	676	303	140	48759
1987	1299	2587	609	341	139	51520
1988	1435	3150	762	362	184	54714
1989	1339	3379	756	373	228	56382
1990	1434	3472	742	406	211	56423
1991	1598	3943	703	449	245	57201
1992	1691	4157	799	466	329	58136
1993	1517	4460	899	480	358	56453
1994	1552	4654	1006	481	454	57421
1995	1589	5197	1024	554	630	60780
1996	1563	5363	1121	601	805	61837
1997	1519	5743	1174	729	862	65024
1998	1541	6357	1170	798	959	66057
1999	1407	6547	1242	827	878	67043
2000	1419	6552	1196	881	977	66885

*All documents indexed in *MathSciNet* are taken into account. The number of papers shown for 2000 may increase, as papers published in the last few weeks of 2000 may not yet have been indexed in *MathSciNet*.

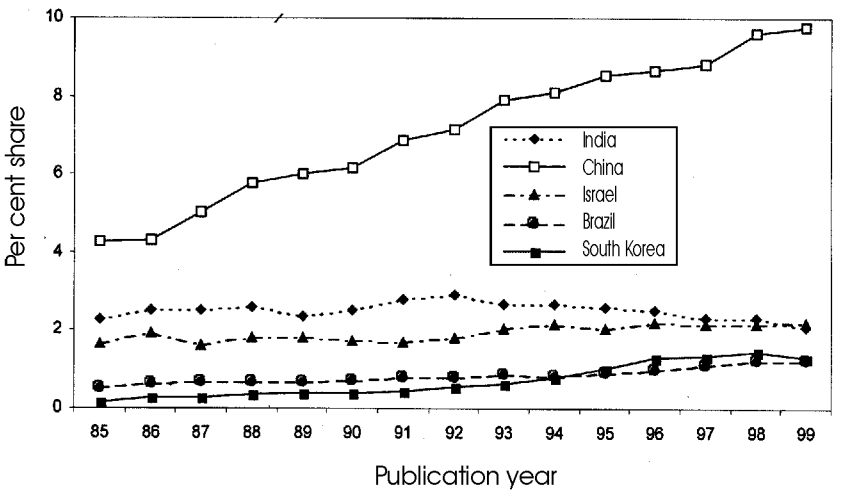

Figure 1. Growth of mathematics research in India and four other countries.

damental Research is conducting campus interviews to find suitable candidates for its Ph D programmes in basic sciences[3].

It will be interesting and necessary to find out why India is stagnating while countries like China and Korea are moving forward and publishing more papers. What will be the long-term effect of such neglect of mathematics on higher education as a whole? A senior professor and Bhatnagar-award winner told me that the teaching at the Master's level in most Indian universities is inadequate. A mathematics professor at IIT Madras, told me that the quality of students coming for Master's programmes in mathematics is poor. They are not sufficiently motivated. I was also told that many applied mathematicians are unable to choose challenging problems and are merely solving problems which have no bearing on real life situations.

Fortunately, several youngsters from India perform well in the Mathematics Olympiad. As Varadarajan[4] had pointed out several years ago, there is a virtual famine of well-motivated and qualified teachers at the college and university levels.

If the trend is not arrested immediately, we may soon reach a point of no return. A former president of one of our science academies told me that when he spoke about the alarming gap between India and China at a meeting, several people asked him why we should bother about what was happening in China, and said that we in India were doing rather well in our own way. Such complacency among senior scientists and policy-makers will only make matters worse.

1. Arunachalam, S., *Curr. Sci.*, 2002, **83**, 107–108; 195–196.
2. Arunachalam, S., *Scientometrics*, 2001, **52**, 235–259.
3. Sengupta, P., *Outlook*, 15 July 2002; p. 58.
4. Varadarajan, V. S., *Math. Intell.*, 1983, **5**, 38–42.

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An approach to sustainable food security

Food security is an essential feature of a country's independence and sustenance. It depends on self-production of food grains in sufficient quantities and ability to transport and store grains on a large scale, commensurate with population size, economic strength that allows import/export of grains in required quantities, and availability to meet the demand of grains in the international market. An efficient food security system should withstand challenges posed by calamitous weather conditions unfavourable for agricultural production over successive seasons. In the year 2001–02, India produced about 210 million tonnes of food grains, largely sufficient for its 1050 million population. India has proved to be a food-secure nation for about the last four decades. However, in recent years, the precariousness of Indian's food security has become apparent at times of natural disasters. Several approaches need to be pursued to strengthen India's food security.

Self-sustained food security system such as that aimed in India requires food grain production at a somewhat higher level than that which meets the immediate needs, safe storage of extra food grains to overcome any seasonal or prolonged deficiencies in production levels and periodic turnover of old grains in storage with grains from fresh harvests. India needs to develop/practice complementary/alternative approaches to achieve reliable food security.

First, India being highly populous and its agriculture characterized by very small per capita arable land size of 0.7 ha, it must progressively increase food grain production per unit area. Seeds of new high-yielding varieties and optimum use of irrigation water, fertilizers and pesticides are the means to achieve this objective. The water requirement of Indian agriculture is largely met by summer and winter monsoons. Any large-scale disturbance in the rainfall patterns leads to drought conditions, adversely affecting the productivity of agriculture practised in different parts of India. Indian plant breeders need to develop varieties of food grains that are resistant to varying levels of drought. The meteorological studies of Indian agro-climates also need strengthening so that whenever necessary, the forecast-dependent, drought-tolerance cultivars may be sown in time during inclement seasons. India must also reduce loss of grains which is estimated at about 10% of the total annual produce under various stages of post-harvest processing and short-term storage.

Government-controlled agencies are responsible for the procurement and storage of food grains, mainly wheat and rice, and for channelization of stored grains to fair price shops distributed throughout the country, and on occasions to locations where disaster occurs. Such governmental effort is an essential requirement for food security. The total capacity of this system is estimated as equal to the food requirements of the Indian people for a period of about nine months. The system of storage seems to suffer from several kinds of deficiencies. The grains are liable to spoil on account of improper storage conditions. The turnover of old stock by the new one is being overlooked. In this regard, the storage needs to be monitored for quality on a regular basis. Proper record-keeping using modern computational tools and programmes will be helpful in this direction. There is also need for modernization of storage facilities and of new R&D work in this area.

The bulk of the Indian people continue to consume home-made food prepared from whole, broken or powdered rice,