

Title of the Project: Assessing Science & Technology (Including Medicine & Agriculture)

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Executive Summary

- Science and Technology (S&T) indicators are analytical tools traditionally defined as a series of data designed to answer questions about the science and technology system (STS), its internal structure, its relation with the economy and society, and the degree to which it is meeting the goals of those who manage it, work within it, or are otherwise affected by its impacts.
- Is Indian science on the decline? Yes, no, maybe. There have been many different answers, and it all depends on the definition of Indian science, the time coverage, data source(s), and perhaps even the character of the researcher. There is consensus that Indian science means Indian based science, i.e. publications (co)authored by a person with an address (affiliation) in India. The journal papers are captured by international databases such as the Science Citation Index (Expanded), CABI, MEDLINE, INSPEC, SCOPUS. The analysis based only on these databases is lopsided.
- Therefore, there is a need that, total Indian research papers should be computed on the basis of papers from major global services along with papers published by Indian authors in foreign journals to generate need based Indian National Science Indicators/ reports for the national, and geographical productivity as well as subject wise productivity depicting the trend of research papers. With this background, for the present study a consolidated and comprehensive sound database on amount of work/research done in the field in India have been developed which has facilitated a quick access to various Indicators.
- This report provides a quantitative and qualitative analysis of the progress of Indian S&T, as reflected in its publications output reported in major global & national secondary services and some of the un-indexed but important national journals. The main objective of the present report is to examine the status of S&T in the country, its strong and weaker areas of research, quantity & quality of research output, and dynamics of research across institutions, geographical regions subjects and subfields, to identify core journals for Indian S&T publications. Such a study may prove useful for Indian science planners & policy-makers for gaining macro insights into the country's S&T system.
- While examining the status and progress of Indian S&T, this study also examines India's position vis-à-vis select developed and developing nations, in terms of its research output & citation visibility, type of collaboration, measurement of publications quality in terms of citations per paper.

- The study is based on India's unique S&T papers published in a journal, culled out from WoS, SCOPUS, MEDLINE, COMPENDEX, INSPEC, CABI and ISA during the period of 2005-2009. Besides, we also have collected India's contributions reported in other peer reviewed un-indexed journals by physically going through them. Scopus database was also used for international comparisons, where ever it was needed.
- All the research papers were captured from individual secondary services & journals.

- There were duplicate records within the databases of SCOPUS, CABI and ISA. Those were removed first, using the Remove duplicate÷ command of MS Excel (ver. 2010), this will delete duplicate rows from a sheet÷ We have specified the columns to be checked for duplicity e.g. Author field, Title field, Year of publication field and the Source name field, then afterwards the command was entered÷.
- Scopus covers other areas also like Social Sciences, Humanities, Geography, Literature and Management, these records were also deleted as the subjects were not in our Scope of the study.
- As we were analyzing only papers published in a Journals, so the further data cleaning was done to remove papers published in Conference proceedings (WoS & SCOPUS), Book Series (SCOPUS), Trade Journals (SCOPUS) and some of the House Bulletins (SCOPUS).
- The final data set, thus extracted from different databases were merged together, and then again duplicate records were removed through customized program in visual basic.net. The program scanned each and every record. Checks were introduced on four fields: Author, Title of the article, Journal Name and the year. There was an option for removing entries÷ on the basis of chosen database. The selection was WoS, Scopus, Medline, CABI, COMPENDEX, INSPEC and lastly ISA.
- As the database of WoS is very well structured, data capturing and further data cleaning & editing etc. is easy and straight. The database is designed so, that carrying out various bibliometric analyses becomes very easy, therefore the first choice was WoS then SCOPUS, MEDLINE and so on. CABI & ISA were the last choices.
- Finally, the database of Journal Research Papers on Indian S&T output, Indian National Science Indicators (INSI) was developed on a CD, through specially developed software using Microsoft Visual Studio 2005 with back end MS having a total of 343599 records. The database, thus developed (Indian National Science Indicators- INSI) was analyzed to generate various indicators along with SCOPUS also for international Comparisons, wherever it was needed.

The major findings of the Analysis based on INSI Database are as follows:

Publication Analysis

Science and technology (S&T) in the country is on the rise and heading towards faster Publications growth. At the Global Level÷ India is expected to rise to 6th position by 2018, as compared to 2005-09 (10th position) in terms of total papers published; China is expected to occupy top position followed by USA (on the basis of data captured from SCOPUS database).

- India published 54041 papers in the field of the Study during 2005, which rose to 74158 in 2009. The publications data in INSI database have achieved annual average growth of 8.51 per cent in S&T during 2005-2009.

Year	Total Papers (Total Journals)	Total Papers in Indian J (Total Indian Journals)	Total Papers in Foreign J (Total Foreign Journals)	Total Papers in JCR J (Total JCR Journals)
2005	54041 (4163)	24715 (643)	29326 (3520)	37594 (3503)

2006	73412 (5149)	42148 (990)	31264 (4159)	50313 (4019)
2007	65806 (5382)	28309 (774)	37497 (4608)	46839 (4221)
2008	76182 (6156)	28016 (798)	48166 (5358)	54260 (4631)
2009	74158 (6102)	22686 (574)	51472 (5528)	55935 (4738)
Total	3,43,599 (9618)	145874 (1648)	197725 (7970)	244941 (6674)

- The pace of country growth in research publications is accelerating. The data from INSI have indicated that the Annual Growth Rate during 2005-06 was 35.35 which changed to -11.10, then achieved an increase (14.34) during 2007-08.

India's subject-wise publications growth rate (as reflected in INSI) has been higher than its overall publications growth in multidisciplinary databases.

Top most areas of Indian S&T research in terms of total papers:

- Engineering & Technology, Chemical Sciences, Biological sciences and Medicine, have been the leading areas of research in India and have shown consistent rising trend in publications output. India's combined publications share in these disciplines has increased from 10.42% per cent to 15.93% per cent over 5 years from 2005 to 2009.
- The national growth rate in these disciplines during the same period of 5 years has been (34.97 per cent, 68.76 per cent, 55.55 percent and 56.53 per cent, respectively) above the country's average of 51.8 per cent.

Lower and middle level areas of Indian S&T research in terms of total papers:

- Agricultural sciences and Environmental sciences have been the medium productive areas of research in Indian science.
- Mathematics, Physical sciences and Earth & Atmospheric Sciences were the least productive areas.

Fast growing subject areas of Indian S&T Compared to other broad subjects,

- Medicine was the most productive subject area among Major Disciplines÷as classifies on the basis of SCOPUS classification (21 major disciplines) followed by Chemistry, Agricultural and Biological Sciences, Biochemistry, Genetics and Molecular Biology, Materials Science, Chemical Engineering, and Environmental Science.

Analysis on the subfield level of Major Discipline÷:

India has shown significant increase in its publications output in frontier and new emerging areas of S&T.

Total papers in each of the major disciplines÷through the years (2005-09) has also been computed.

The country has witnessed substantial rise (almost 3-fold) in its publications output in frontier and emerging areas, such as nanotechnology, biotechnology, drugs & pharmaceuticals, material sciences, and medical sciences during 2005-09. In medical sciences, significant increase in publications output was witnessed in

areas such as infectious diseases, Pediatrics or Perinatology & Child Health, Surgery, Neurology (clinical), Dermatology, Radiology, Nuclear Medicine & Imaging, Ophthalmology, Microbiology (medical), Public Health, Environmental & Occupational Health and Cardiology, Cardiovascular Medicine and Oncology.

The material science, which has several important applications to the industry also witnessed more than three-fold increase in publications output during the corresponding period. The top most area under this category is Electronic, Optical and Magnetic Materials followed by papers in the area of polymers & plastics, material chemistry, metals & alloys etc. Substantial increase was also reported in chemical engineering, telecommunications, and artificial intelligence.

In areas constituting earth & environmental sciences, increase in publications activity was reported in water resources and environmental engineering during 2005-09. The other subfield recording significant numbers were:

- In the category of Pharmacology, Toxicology & Pharmaceutics, after a initial lull during 2005 later years have shown encouraging activity towards publishing papers in all the major areas of this subject field like Drug Discovery, Pharmaceutical Sciences, Pharmacology, Pharmaceutics (miscellaneous) and Toxicology.
- Biochemistry, Molecular Biology & Genetics category has maximum papers in the field of Biotechnology, Genetics, Molecular Biology and Structural Biology.
- In the category of Chemical Engineering maximum papers were in the process chemistry & technology, bioengineering, studies related to catalysis and fluid flow & transfer processes.
- In the field of Computer Sciences, the area at the top was having papers in the field of hardware and architecture of computers followed by miscellaneous studies in the field of computer sciences, application of computers, computer networking, artificial intelligence and computational theory.
- In the category of Earth & Planetary Sciences, maximum papers appeared in the area of space and planetary sciences, apart from miscellaneous papers.
- The next category of papers in the field of Energy have maximum entries in the area of Renewable Energy, Sustainability and the Environment followed by Energy Engineering & Power Technology and Nuclear Energy & Engineering.
- In the category of agricultural sciences, the top most discipline contributing papers was Plant Sciences, Food Sciences, Agronomy & Crop Sciences and papers in the area of Animal Sciences.

Least and Low productivity areas of Indian S&T

- Some other very important areas of pollution, waste management & disposal, health toxicology & mutagenesis needs utmost attention of researchers as well as policy makers, more research should be carried out in these areas as presently (as reflected by published papers) the situation is not satisfactory

- The subfield of Dentistry, Mathematics & subjects dealing with different issues under Nursing÷ have also not attracted many researchers and are the least active fields from research point of view. It also needs attention of policy makers and academics. Physical Sciences are also not a very strong research field of Indian Researchers.

Journal Analysis:

India's publications in medium and high quality journals in science and technology have increased over the years as presented by percentage of JCR covered journals along with increased÷ distribution in different interdisciplinary journals, indicating a trend towards more interdisciplinary research.

- Total 9,618 journals published total of 3,43,599 papers during the whole study period (2005-09). The first 50% papers (around 1,71,770) appeared in a total of 382 journals with an average of approximately 449.65 papers per journal.
- The top most journal having 4,455 Papers was *Curr Sci* (1.31%) followed by *Acta Crystall Sect E*, *Indian Vet J*, *Indian J Anim Sci*, *Asian J Chem Sci*, *Environ Ecol*, *J Indian Chem Soc* and *Tetrahedron Lett*.
- The average paper being published in a Journal was maximum (14.26) during the year of 2006. During 2009 the publication of Indian papers per journal was minimum (12.15) showing greater distribution of papers in different journals. Rest of the years the value was 12.98 (2005), 12.38 (2008) and during 2007 the value was 12.23.

Geographical Analysis:

Total 34 states contributed papers in all the areas of S&T. Maharashtra was the top most state followed by Tamil Nadu. The country needs a balanced approach in regional distribution of its resources. Maharashtra, Tamil Nadu, Uttar Pradesh, Delhi, Karnataka, Andhra Pradesh are the leading states in Productivity of research papers, accounting together for 54% of the publications output in S&T during 2005-09. Uttaranchal, Rajasthan, Kerala, Gujarat, West Bengal, Madhya Pradesh, Punjab and Haryana together contributed 255% share in country publications output during the corresponding period. Other states, such as Bihar, Orissa, Assam, Himachal Pradesh, and J&K are considered as low productivity states and together contributed only 20% publications share during 2005-09.

- A total of 987 cities have contributed all the papers Delhi (New Delhi also included) ranked 1st among all the cities with its share of 8.92%. The other cities that have papers in the range of more than 2% were Hyderabad (3.56%), Mumbai (2.62%), Chennai (2.24%), Pune (2.15%) and Kolkata (2.03%).
- Bihar and Delhi recorded the fastest average growth in the number of papers during the period of 2006-07. Their annual growth rate increased in the range of -33.13 to 99.89. Delhi is not only among top 20 states but also came up with exponential increase in terms of papers with an average growth rate in the range of -41.39 to 74.63. The most strong÷ area of research, in terms of papers being published from Indian States÷ is of Biological Sciences÷ followed by Chemical Sciences÷ and Medical Sciences÷. The next area is of Agricultural Sciences÷ where all the states have contributed papers except Dadra & Nagar Haveli÷ and Lakshadweep.

Least Productive States: There is need of concern for the states of Jammu & Kashmir, Dadra & Nagar Haveli and Lakshadweep as the number of research papers coming from these parts of India are negligible. Regional disparities in publications productivity could be addressed through a more balanced distribution of financial and manpower resources support infrastructural.

Institutional Analysis:

Research in S&T in India is an institutional activity

India has invested heavily in terms of financial resources devoted to R&D, creation of infrastructure, institutional capacity, instrument & laboratory facilities over the years. The institutional participation in research has widened. There are a total of 5,801 institutions contributing the total papers. Also, there were 45 institutions, which published $\times 600$ papers each during 2005-09.

It clearly reveals that the numerical strength of high productivity institutions in S&T in the country is very low, but, their publications activity index indicated a rise over the years.

- The 10 top most institutions, having more than 1000 papers each, were *Indian Inst Technol, Banaras Hindu Univ, CCS Haryana Agric Univ, Andhra Univ, All India Inst Med Sci, Annamalai Univ, Christian Med Coll Hosp, Vellore, Postgrad Inst Med Educ Res, Natl Inst Technol, Punjab Agric Univ.*
- In terms of Activity Index÷of institutions for a total of five years the top most institution was *Bhabha Atom Res Ctr* followed by *Natl Chem Lab, Indian Inst Technol, Indian Inst Chem Technol, Univ Delhi, Himanchal Pradesh Univ, Christian Med Coll Hosp, Vellore, Postgrad Inst Med Educ Res, Natl Inst Technol and Indian Inst Sci .*

Collaboration Analysis:

India's collaborative research output has grown faster than its growth in total papers.

- Collaboration is the rule not the exception, during the periods of study. More than 91% of all the papers involved two or more authors and more than 50 % involved two or more institutions
- In India , the study revealed that Southern States were working more in collaboration with each other as compared to Northern States but later years are indicating a shift towards Northern Region.
- There is a distinct relationship between institutional publishing size and the amount of institutional collaboration. On average, institutional collaboration showed a strong invisible relationship with the publishing size of the institutions.
- A greater proportion of publications from smaller institutions than from larger institutions involved domestic, intra-city, inter-city collaboration. On the other hand a greater proportion of the papers from larger institutions were having international collaboration than from smaller institutions.

International Collaboration:

- At international level the data has indicated that a total of 159 countries have collaborated with an Indian authored paper. The collaborating countries are distributed around the globe.
- **United States continues to be the India's biggest collaborating partner, but publications share in collaborative research output has gradually declined. The other countries are in following order are:**

Germany, United Kingdom, Japan, France, South Korea, Canada, Australia, China, Italy, Taiwan, Switzerland, Russian Federation, Spain, Netherlands, Malaysia, Brazil, Sweden, Poland and Singapore in the same order.

Physical Sciences have been the most preferred subject area for collaborative research.

- We have also found significant differences in collaboration patterns across fields, through the analysis of Collaboration Index÷ (CI), Biological Sciences, Medical Sciences, Physical Sciences, Chemical sciences and Earth & Atmospheric Sciences including Environmental studies are the fields with the highest level of both national and international collaborations.
- Mathematics, Agricultural Sciences, Engineering, Computing & Technology are the field with the highest level of national publications.

Citation Analysis:

India's share of world papers and the relative number of citations to these papers received have both increased in recent years. India is currently ranked seventh in terms of total output of papers within the group of Asian countries (SCOPUS data 2005-09), most of India's research is cited less frequently than world average but it continues to improve.

An analysis was carried out to see the ranking of India, in terms of Citation÷ among Asian countries during 2005-09. During all these years India was among the top 10 countries occupying 3rd or 4th position throughout the period of study. The country at the top was China.

- The co-citation mappings reveal that subject categories Medicine, General & Internal, Pharmacology & pharmacy, and Biochemistry & molecular biology are among the most productive categories as they have more relations with other categories.
- India published a total of 16 highly-cited papers (total 290- 700 Citations to each paper Source: WoS) in science and technology during the period of study (2005-09).
- Two papers in the field of Particle Physics÷ stood at the top with 3981 & 3679 Citations each. Both the papers are review articles titled Review of particle physics÷ published in Physics Letters÷ & Journal of Physics G: Nuclear and Particle Physics÷ from Tata Institute of Fundamental Research, Mumbai (Bombay), with × 100 co-authors from around the world, indicating that the papers were the out- come of a metacentric study (Source: WoS).

- The other top 15 papers from different disciplines, receiving \times 200 Citations were from the field of Supra-molecular jelling agents, Orthopedic Implants, Arsenic removal from water, Human Papilloma Virus, Indian Diabetes Program, Biological Activities of *Curcumin*, Maternal & Child Health under Nutrition, Stem & Progenitor Cells, Ionic Liquids, Nuclear Transcription Factor, Boron & Nitrogen, Bioengineering Applications, Glycogen Synthase & Glutathione Disulphide and Placenta Derived Stem Cells (Source: WoS).

Coverage of Journals having Indian Research papers by Secondary Services

- The coverage of the major Global Secondary Services÷ indicates that over the years the coverage of the Indian Papers have indicated slight increase (on the basis of data captured during 2011).

Database	2005	2006	2007	2008	2009	Total Papers Covered
SCOPUS*	30336	35368	39328	43692	49965	198689
WoS	28187	31652	36919	43373	44775	184906
MEDLINE	8623	10460	7598	14750	9146	50577
CABI	6952	14834	6801	9620	10712	48919
INSPEC	2112	2272	2052	1996	387	8819
COMPENDEX	1060	2610	3632	5994	7444	20740
ISA	12275	19359	17325	12829	11453	73241

*A total of 5083, 5832, 6630, 7436 and 6958 records from the years of 2005, 2006, 2007, 2008 and 2009 have been deleted from the downloaded data of SCOPUS, as they were from other areas than S&T, Medicine or Agriculture, or were published in a Book Series, Conference Proceedings, Trade Journal or in a House Bulletin like ICMR Bulletin etc.

- Contribution made by the Indian scientists during 2005-09 as reflected in Indian Science Abstracts was almost steady throughout the period. Indian Science Abstract is a useful tool to study the scientific research productivity but it has its limitations which include the lack of coverage of Indian Scientific Papers published in foreign Journals and also that it is more of an abstracting source, the inclusion of Papers is also delayed in ISA.