Project Completion Report

Assessing Science & Technology (Including Medicine & Agriculture) Research Output : A Pilot study for "Indian National Science Indicators (INSI)" 2005-2009

Dr. Divya Srivastava
Publication & Information Division
ICMR (HQ), New Delhi

Sponsored BY

National Science and Technology Management Information System (NSTMIS)

Department of Science & Technology (DST)

Ministry of Science & Technology

Govt. of India

October 2013

Project Sponsored by:
National Science Technology Management Information System (NSTMIS)
Department of Science & Technology (DST)
Govt. of India
New Delhi

Project Investigator:
Dr Divya Srivastava
Scientist 'F'
Division of Publications & Information
Indian Council of Medical Research
New Delhi, India

Project Co-investigator:
Dr Rajni Kant
Scientist 'E'
Division of Publications & Information
Indian Council of Medical Research

Over all Guidance:
Shri R Chetal
(Chairperson Project Advisory Committee)
Former Scientist 'G', NSTMIS Division
Department of Science & Technology (DST)
New Delhi

Mrs. Namita Gupta
Scientist 'F', Member Project Advisory Committee
National Science and Technology Management Information System (NSTMIS)
Department of Science & Technology (DST)
New Delhi

and

Dr V K Srivastava
Scientist 'F' & Head
Publications & Information Division
Indian Council of Medical Research
New Delhi

Project Staff:
Sh. Arvind Singh Kushwah, Scientist B
Ms. Mona Gupta, Scientist B

Assessing Science & Technology (Including Medicine & Agriculture) Research Output : A Pilot study for "Indian National Science Indicators (INSI)" 2005-2009

Dr. Divya Srivastava
Project Investigator

Dr. Rajni Kant
Co-Investigator

Publication & Information Division
ICMR (HQ), New Delhi

Sponsored BY

National Science and Technology Management Information System (NSTMIS)

Department of Science & Technology (DST)

Ministry of Science & Technology

Govt. of India

MINISTRY OF SCIENCE & TECHNOLOGY

October 2013

Acknowledgement

We are deeply indebted to NSTMIS Division of Department of Science & Technology, Govt. of India, for providing the Funds for carrying out the work. Our heartfelt thanks are due to Head, NSTMIS Division of DST along with Shree. Rakesh Chetal and Ms. Namita Gupta (NSTMIS-DST) whose helps, stimulating suggestions and encouragement helped us in all the time of research.

We thank the Indian Council of Medical Research for giving us permission to commence this work and providing all facilities, to do the necessary research work. We extend our sincere thanks and gratitude to Secretary, DHR & Director General, ICMR Dr. VM Katoch for encouragement and support for carrying out academic activities. We would also like to put on record our gratitude to Dr. VK Srivastava, Scientist 'F' and Head, Publications & Information Division of the ICMR for successful completion of the Project and unstinted support.

We are highly indebted to the Chairperson of Local Project Advisory Committee (LPAC) and to other LPAC members for their constructive support, suggestions and guidance towards formulation, execution and the final culmination of the project. We would like to extend our heartfelt thanks to experts in the field of Scientometrics Dr. Sanjiv Singh (Delhi University South Campus), Dr. Sujit Bhattachrya, Dr. BM Gupta and Dr. KC Garg (Former Scientists at NISTADS, Delhi) for their valuable suggestions and providing the needed analytical software (s) & academic support.

We will be failing in our duties if we do not mention the organizations which provided support towards capturing and acquiring the data for development of the CD, Lalit Saini, Manager, CABI South-Asia, India, Authorities at NISCAIR, NISTADS, NML, NPL, AIIMS, DESIDOC, IIT's, ICAR Library, South Delhi Campus of Delhi University and other libraries of ICMR network and Institutes from India..

Thanks are also due to our colleagues from the ICMR Headquarters *viz.* Ms. Renu Bahadur, Sreekumar, Vikesh Kumar Sapra, Dr. KV Ratnakar (ICMR Headquarters) and Library staff for their help, support, interest and valuable hints. Last but not the least, our gratitude is due to the present and past administrative staff of the council, particularly Mrs. Daya Mallik, Former AO (Publication & Information Division) & Mrs. Rajni Dabral.

New Delhi — Dr Divya Srivastava

Date: October, 2013 — (Project Investigator)

CONTENTS

LPAC Members

Shri R. Chetal Chairperson
Former Scientist 'G'
NSTMIS Division
Ministry of Science and Technology
Department of Science and Technology
Technology Bhawan, New Mehrauli Road
New Delhi – 110 016
rchetal@nic.in

Dr. V.K. Srivastava
Scientist 'F' and Head,
Publication & Information Division
Indian Council of Medical Research
New Delhi – 110029
vijaiksri@gmail.com

Mrs. Namita Gupta
Scientist 'F'
NSTMIS Division
Ministry of Science and Technology
Department of Science and Technology
Technology Bhawan, New Mehrauli Road
New Delhi – 110 016
namita@nic.in

Dr. Shailender Kumar
Associate Professor
Dept. of Library and Information Science
University of Delhi, Delhi
shail3@yahoo.com

Dr Sujit Bhattacharya
Scientist "F"
NISTADS
(National Institute of Science Technology and Development Studies).
Dr. K.S. Krishnan Marg,
Pusa Campus,
New Delhi-110012
sujit_academic@yahoo.com

Mrs Kamini Mishra
Scientist "F"
Department of Scientific & Industrial Research
Ministry of Science & Technology
Technology Bhawan, New Mehrauli Road
New Delhi-110016.
ksm@nic.in

Dr. Divya Srivastava
Scientist F
Division of Publication & Information
Indian Council of Medical Research
New Delhi – 110 029
drdivya.srivastava@gmail.com

Dr. Rajni Kant
Scientist E
Division of Publication & Information
Indian Council of Medical Research
New Delhi – 110 029
Kantr2001@yahoo.co.in

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 ≥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 ≥ 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.

Introduction & Objectives

Scientometrics and bibliometrics are used to measure scientific activities, using statistics on scientific publications indexed in a database. They are flexible tools used to study the sociological phenomenon associated with scientific communities, to conduct scientific/strategic, technical, technological or competitive monitoring, to design and manage research programs and to evaluate research. The methods employed for evaluating research output, positioning studies and conducting foresight studies in the field of Indian S&T Research. Few scientiometric studies have been reported in the literature on Indicators for Indian S&T research prominent among them are Gupta BM.; Bhattacharya S.; Garg K. C. ; Dutt B. ; as per these studies Indian research output is highly scattered both in terms of the sub-fields of the journals as well as the publishing country of the journals. All these studies have used the Science citation index (SCI) on CD-ROM, published by the Institute for Scientific Information (now Thomson Reuters) or SCOPUS as the source of data. The SCI does not index a large number of journals published from developing countries such as Brazil, China and India. An estimate of research outputs on Indian S&T output using the SCI will be flawed. In order to have a better view of the Indian research output, it will be appropriate to use database(s) that are more representative of the overall research output.

The objective of the National Information System for Science and Technology at DST is to develop useful indicators of activity and a framework to tie them together into a coherent picture of science and technology in India. Bibliometric indicators of science and technology provide an important contribution to the understanding of the productivity of science and technology, as measured by the production of scientific publications, and of knowledge flows within the science and technology system, as measured by co-authorships in scientific publications. Bibliometric indicators can shed light on science and technology productivity and knowledge flow at the international, national, stat, sub-regional, and inter or intra-institutional levels thus constituting a critical component of the information system on science and technology for India. In order to facilitate the use of bibliometric information for policy and decision-making a series of Projects has been supported by NSTMIS to introduce the databases and to discuss uses of it.

As we know that, one of the primary goals of scientometrics and bibliometrics applied to public policy is to serve as an information tool for decision making. It is within such a context that the present study has been done. Given the significant growth in the S & T research infrastructure and research investments in the country, India needs to monitor and measure its performance on regular basis. This requires building suitable indicators of research performance, designed to understand the dynamics of research at institutional, categories, geographical and subject level. Some indicators are required for depicting how Indian research is performing vis-à-vis a select other similarly placed countries and against countries from the developed world. Several studies made in the past have looked at indicators of research in the field of science & Technology from India. These studies did highlight the status of Indian research in terms of research papers during different periods. Some of these studies developed indicators on institutional productivity, scattering across Indian and foreign journals, quality of research, and nature of collaboration, etc. With the changing paradigm in research, there is a need for more specific indicators. The present study analyses 5 years of comprehensive S

& T research papers from India in particular *vis a vis* global research. Study has also been done on the yearly growth of papers from 2005- 2009 and the growth of journals at global level.

The objective is to provide public policy makers with a guide to the use of bibliometric tools currently available. There are many applications of bibliometrics, including the development and evaluation of science and technology programs and policies, the management of private and public research, or technological monitoring and strategic decision making. This project deals with bibliometric indicators and methods within specific applications on the basis of data compiled from major secondary services available in the field of study.

The literature has pointed that that in the present situation a lot of papers gets missed out and visibility and impact of Indian research efforts gets affected adversely. There are studies depicting that the total Indian share in world scientific output appearing in a scholarly journal covered by the Science Citation Index (SCI) between 1981 and 1995 has declined by 32%. The number of papers published in 1980, 1985, 1990, 1995, 2000, 2005 was 14,983, 11,222, 10,103, 11,084, 12,127 and 25,102 respectively. This clearly indicates that number of research papers published by Indian scientists is around 10,000-25,102+ during the last two decades. To test this hypothesis we have downloaded the papers having 'India' in its address field and appeared in a journal covered by SCI for the period of 2005-2009. There were total 1,74,403 papers indexed in SCI being published by the over 40 CSIR affiliated labs, 31 ICMR Institutes, Institutes belonging to DST, ICAR and the rest were from the university/ colleges sectors.

Most of the institutions publish their papers in non SCI journals (Satyanarayana[63]), 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, the present study would provide a consolidated and comprehensive sound database on amount of work/research done in the field in India and will facilitate a quick access to various Indicators.

The term secondary services apply to current bibliographies, list of indexes and abstracts which are regularly published either in hard copy or as machine- readable database (say on CDROM or online through the net). Examples of secondary services are Physics Abstracts (hard copy), INSPEC (machine-readable), MEDLINE, SCOPUS, Science Citation Index, CABI and Indian Science Abstracts (ISA), etc. These services, both traditional abstracting and indexing services and citation indexes are now used heavily for researches and investigations on output or productivity studies, science of science, science policy, etc. But usefulness of almost all of the secondary services as source of data is frustrating. Whether hard copy or machine-readable form, the sources do not supply complete data about the Indian contribution. Our experiences with a number of these services have made us realize that unless the data is extracted from all the available global services and complemented with the total research papers from all the Indian journals, bibliometric studies will always remain crippled and severely partial.

The Science Citation Index(as also Social Science Citation Index(SSCI)) and Arts & Humanities Citation Index(A&HCI) published by the Thomson Reuters (Earlier by Institute for Scientific Information, Philadelphia, USA) or any other Global service *viz* MEDLINE, INSPEC, and Scopus are very much restricted in the selection policy of coverage of journals. Even Indian Science Abstract (Only abstracting service for Indian journals) covers only about 650 journals (Verma[75]) . Where as in one of the study (Kushwah[41]), it has been reported that there are approximately 2000+ Indian journals in the field of Science Technology and Medicine.

It is clear that in the present situation a lot of papers get missed out and visibility and impact of Indian research efforts gets affected adversely. 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, institutional and geographical productivity as well as subject wise productivity depicting the trend of research papers. The present study on *Indian National Science Indicators* provides statistical data on national research performance measures in the sciences, Technology and Medicine.

In view of the importance of S & T research, it becomes important to map out the research activities being carried out by researchers in India by Indian Scientist. Since research publications are one of the major outputs of any research activity and which can be quantified also may reveal the trend of work being carried out in this area, the research papers appearing in a journal have been taken as the unit of study. For this purpose we need a searchable consolidated database, but there is no exclusive comprehensive Global database on Indian efforts also in the field of Science & Technology also, there is no available single source. Whatever literature is being generated by Indian Scientists is dispersed in various documents, thus making any efforts of mapping research efforts difficult. With this backdrop a comprehensive database have been developed for Bibliographical Details of all the research Papers published in any scholarly journal around the world.

The present study would provide a consolidated and comprehensive sound database on amount of work/research done in the field in India and will facilitate a quick access to various Indicators. Scientometrics can be defined as the measurement of scientific and technical research activity. Bibliometrics is a branch of scientometrics that focuses principally on the quantitative study of scientific publications for statistical purposes. Bibliometric methods serve three main functions, i.e. description, evaluation, and scientific and technological monitoring. As a descriptive tool, bibliometrics provides an account of publishing activities at the level of countries, provinces, cities or institutions, and is used for comparative analyses of productivity. The data can then be used to assess the performance of research units, as a complement to standard evaluation procedures. Bibliometric data are also used as a benchmark for the monitoring of science and technology, since longitudinal studies of scientific output help identify areas of research that are developing or regressing.

Evaluation procedures can be applied to all three levels of analysis, *i.e.* at the micro level (researchers), the meso level (research programs) and the macro level (provincial and national research systems). Callon[17] et al. described three major categories of issues associated with research evaluation. The first category is related to evaluations of the volume of scientific output. The second category deals with the relevance of research in terms of its impact on the development of knowledge or on society and the economy. Evaluations of relevance are aimed at assessing the choice of research topics and of grantees as well as their ripple effects on the dynamics of research. The third category deals with the efficiency of research management. Bibliometric evaluation procedures are directly linked to the first two categories. Whereas output indicators are used to evaluate scientific output, indicators linked to co-author analysis and citation analysis is used to evaluate relevance.

Using bibliometrics in evaluating the efficiency of research management requires that research topics be identified specifically so as to "detect possible synergies or pinpoint unwanted duplication. Bibliometric techniques can be used to set up lists of actors and research topics, providing administrators with an overview of the available resources, and allowing for their use in restructuring an organisation on the basis of the structure of research. The productivity of a single researcher can be measured within the framework of an evaluation. This is mostly used in conjunction with other evaluation methods, since bibliometric tools are not considered a valid method of measuring the productivity of individual researchers. The other two levels (meso and macro) are by far the most often used. At the meso level, bibliometric indicators describe the scientific production of institutions and research groups. They can also be linked to grant programs for program evaluation purposes. At the macro level, bibliometric indicators are used to measure national output by country, province or city. National output is analyzed as a means of comparing research systems and determining the links between the various institutions of a given national system.

Bibliometric monitoring of research

Bibliometric monitoring makes it possible to establish a quantitative profile of the state of research and therefore of national performance. Public policy makers need to be constantly informed about overall research activities at the national level, and about a country's relative position on the world scene, for a given research activity. Descriptive indicators provide such a monitoring at various levels of data aggregation. Bibliometric monitoring is usually carried out at a fairly high level of aggregation such as national scientific output by discipline or by institutional sector. However, bibliometric monitoring can also be used for administrative monitoring, in which case it deals mostly with the activities of universities and research centers.

The problems which administrators of research institutions have to overcome are different from those of public policy makers. Administrators need to access detailed information about the research activities for which they are responsible. Bibliometric monitoring helps them understand and evaluate research activities taking place within research units. Administrators use bibliometrics for guidance about the future of research, on the basis of existing research in a given field.

Strategic positioning is one of the major applications of bibliometric indicators. This is done by identifying, through the use of databases, the people who are active in a field, the topics on which they are working, and the networks within which they operate. This information is used to identify emerging niches, those that have reached maturity as well as those in decline, along with the actors and partners who are responsible for research output. Research managers use data on the relationships between researchers and the links between research topics to understand their position within the network and to evaluate it in terms of what is going on in a given field of research.

With national science indicators, one can:

- Make strategic budget decisions - Which research areas within the nation are showing an increase or decrease in publication output and impact?
- How does the overall performance of one region -- and the performance of specific research fields within those areas -- compare with others?
- Identify strengths, weaknesses, and opportunities.
- Discover areas of specialization, and use country and field baselines to see how other countries' research performance compares.
- Track other nations' progress - -Gather the competitive intelligence information one need for accurate benchmarking against peer countries.

Specific objectives of the Project:

The objectives of the present study are to analyze Indian Papers as reflected in INSI database:

- To analyses the growth of literature.
- India's publications growth rate.
- Identify sub-fields of Indian S&T research in which the research efforts are concentrated.
- Identify research gaps & areas of intense activity in the field.
- Identify Journals- core & others wherein R & D literature on Indian S&T research is published.
- Institutional Analysis.
- Authorship Analysis & co-authorship index (CAI).
- Citation Analysis.

These indicators are of special significance to planners and policy makers in measuring progress in research and in formulation of research policy for long-term planning and implementation in the country. To compare actual and relative performance, the data has been compared: national and regional performance against the average for each discipline. The data has been Visualized by using specific 'Visualization Softwares' & creating tables, charts and figures. Based on unique and authoritative publication (INSI Database) and citation statistics from SCOPUS & Thomson Scientific, *Indian National Science Indicators* may provide valuable analytical data for policymakers and research analysts, offices of science and technology, ministries of research and education, councils of rectors, and non-governmental organizations.

About the Indicators

New communication technologies have resulted not only in new tools that are useful for epidemiology but also in a wealth explosion in the developed world. These tools should be used to their capability to integrate the developing world into the rest of the world and its affairs. The increasing availability of computer technology and the World Wide Web have enhanced communication capabilities. The transfer of these capabilities from developed to developing countries has positive impacts on the ability of people within regions of developing countries to communicate with international agencies. These communication technologies, when implemented, are also useful for communication within countries

Bibliometric indicators

In order to make rational decisions, public policy makers need to have a firm understanding of scientific and technological activities. Bibliometric indicators provide the only overall picture of the scientific output of a country. In a research paper dealing with science and technology indicators, Godin described the present status of bibliometrics:

> *There may have been a time when the fact that bibliometric indicators were standardized limited their usefulness, but this is no longer the case. Furthermore, they are not expensive to produce. They do*

have their limits, notably because they normally include only the natural sciences, engineering, and the biomedical sciences. There is also an obvious linguistic bias that largely limits the coverage of scientific output to publications in English. Finally, it must be remembered that publishing represents only one of the activities of researchers. In spite of such limits, bibliometric indicators are one of the principal tools for measuring research output, while providing a very good tool — contrary to popular belief — for research conducted by other types of actors. For this reason, they deserve a place in scientific and technological directories.[10]

Descriptive indicators

Bibliometric indicators can be subdivided into two major categories: descriptive indicators and relational indicators having an analytical function. Listings of papers and citations, listings of patents and the citations they contain are examples of the most current descriptive indicators. They measure the volume and impact of research at various levels. When they are used over prolonged periods of time, they provide a means of identifying trends. Enumeration methods are based on calculations of the number of scientific publications that can be attributed to one 'actor' in a given area. This may be an author, an institution, a sector of activity covering several institutions (universities, public laboratories, industries) or even a geographic area (city, state, country). A research area can be aggregated at the level of one scientific discipline or of one sub-discipline, one technology or even one specific technological niche. Descriptive indicators can be applied to publications and patents depending on whether the analysis deals with scientific output or with technological output.

Relational indicators

Co-author analysis is the most frequent relational indicator. It helps identify links and interactions between the actors of national and international systems of science and technology. Such interactions constitute the flow of knowledge. The methods known as co-word analysis and co-citation analysis are also relational indicators.[12] they provide a picture of scientific activity based on the content of publications. Such indicators help monitor changes in science and technology and identify emerging research topics and the relevant contributors. Co-citation analysis and co-word analysis are rarely used for policy purposes, unlike descriptive indicators and co-author analysis which are currently used in the description and evaluation of research.

Analysis of output

A listing of a country's scientific publications is an indicator that can be used for the detailed analysis of scientific output. Depending on the objectives of a given study, this indicator is used to measure the relative weight of a country, the output of researchers, or the dynamics of a scientific field or an institutional sector. The output of one country can then be compared to that of other countries in a competitive or comparable situation. Comparisons between countries can also be based on disciplines.

In an effort to measure aspects of national output, a number of countries publish statistics on scientific publications by discipline. A specialization index has been developed to identify, for a given country, those disciplines that are over-represented or under-represented in terms of world averages for each sector. This index is the ratio of the percentage of a country's publications in a given discipline to the percentage of publications in that discipline at the world level. If the result is greater than 1.0, the index shows that the country in question produces more than its share of the publications in that discipline compared to the rest of the world. The same type of calculations can be applied to provinces, cities or sectors.

Flow analysis

Flow indicators emphasis the relationships between researchers, institutions and research fields. As a result, they are sometimes called relational indicators. Science and technology are the result of exchanges of knowledge and collaborative work among researchers. It is therefore necessary to establish indicators to identify these exchange networks. Flow analysis provides an important measure of the integration of researchers and of the scope of a national network of collaboration; both types of information help identify the effectiveness of public intervention and its impact.

The study was designed specifically to determine the flow patterns in the national system. By breaking down the information contained in the addresses, it is easy to gather the data needed for flow analysis. The study provides information about the flow of international knowledge, the flow of knowledge within and between states or cities, as well as the flow of knowledge between institutional sectors.

Co-authorship is the preferred indicator used to describe collaboration and co-operation in all areas of research. Such collaborative efforts, or flow, lead to publications within the formal network of scientific journals. Co-author analysis is based on the principle that, when two or more researchers jointly sign a paper, intellectual and/or social links can be assumed to exist between them. Such links are measured by coauthor analysis. Flow analysis makes use of any and all information present in the addresses of authors. Linking such information to the discipline associated with the corresponding paper provides a detailed picture of the many aspects of scientific exchanges. Co-author analysis thus helps identify the principal partners of research activities while providing a detailed picture of the formal network of collaboration within which exchanges take place.

International flow patterns

Exchanges between countries are undoubtedly the most well-known form of knowledge flow. To obtain a profile of a country's scientific collaboration with other countries for a given year, the first step is to list all the publications in which the country in question is mentioned in the "address" field. The next step is to compile all the co-authorships with other countries displayed in the "address" field. The countries are identified on the basis of the institutional affiliation of the authors.

Impact measurements

The Citation Analysis is an index used to measure the probable impact of research findings published in a scientific journal. This is related to individual papers, included in the analysis. The Journal Citation Reports, published each year by ISI, define the impact factor of a journal as the ratio between the citations and the published papers. The higher the prestige of a journal, the higher the impact factor and the greater the probability that an article published in the journal will be cited. As applied to papers, the impact factor indicates the number of times an article in a scientific journal will probably be cited, on the average, during a given period of time.

Data and Methodology

Publications brought out by scientists broadly indicate the output of science and technology. These outputs are used to understand growing Indian capacities and potential in different fields of science and technology. A review of these provides significant insight into the national R&D capabilities, emerging priorities, performance and future trajectories of scientific institutions in the country. The present assessment of Indian science is based on the publication data extracted for the years 2005-2009. Five years data have been used to avoid year-to-year fluctuations in the publication output of individual institutions. The objectives of the study are many-folds: overall contribution of Indian scientists towards the body of S&T Knowledge during the year of the study (2005-2009), assessing the contribution towards different disciplines of science and technology, contribution of scientific agencies to mainstream scientific literature in different disciplines of science and technology during 2005-2009; identifying most prolific institutions and their contribution, and studying the impact of the research output using citations.

To carry out this project, efforts were made to collect information on research publications in the field of science & technology including agricultural sciences from Indian researchers published during 2005-2009 The data sources (see table below) have been searched using the search string:- **(India IN Address field) AND (2005-2009 IN year of publication) AND (Article IN Publication Type)** for research papers in Web of Science (WOS), MEDLINE, CABI including Tropical Diseases Bulletin (TDB) & Global Health, SCOPUS, INSPEC, COMPENDEX and Indian Science Abstracts (ISA), Indian institutes active in the field over a period of study. Some of the left out journals were physically consulted (total 1820 journals; list of journals available in Appendix on CD), which were not covered by any of these services but were important as identified by the peer group of the field. Indian research papers are highly scattered both in field of research papers and patents in terms of the sub-fields of the journals as well as the publishing country of the journals, subject category, etc. The data from hard copies were collected on pre-designed formatted input sheets. The fields were decided in consultation with subject specialist of the area as well as experts from Information Science. Each record is provided with suitable keywords and Institutional affiliation of the author (wherever available). Once the basic data for Indian research papers, were captured from the digital sources, it was converted into searchable database format through a specifically developed conversion program for the purpose. All the research papers were captured from individual secondary services & journals.

Data Cleaning & Removal of Duplicate Records:

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 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.

Year	WoS	Scopus*	COMPENDEX	MEDLINE	INSPEC	CABI	ISA
2005	281870	30336	1060	8623	2112	6952	12275
2006	31652	35368	2610	10460	2272	14834	19359
2007	36919	39328	3632	7598	2052	6801	17325
2008	43373	43692	5994	14750	1996	9620	12829
2009	44775	49965	7444	9146	387	10712	11453
Total	**184906**	**198689**	**20740**	**50577**	**8819**	**48919**	**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.

It may be noted that the total output in a broad disciplines may exceed the actual output as a journal / papers can be classified into more than one discipline by the global services. Analyses have also been done to compute time trend analyses and journal analysis where Indian papers have appeared, for the data from different global secondary services e.g. WoS, Scopus, MEDLINE, CABI, INSPEC and COMPENDE individually. An analysis has also been carried out in detail for ISA, to find out comparative coverage of subject areas, prolific institutions, publishing countries of journals with Indian Papers during the period of study and trend of papers appearing from different geographical locations at national level.

A thorough check-up and corrections were done to standardize the names of journals, institutions, categorization of papers into "Broad Subject Areas" defined by NSTMIS and replacing the individual 'data element' as per the standard sequence of the 'data fields' . We have followed the classification of 'Major Broad Areas' of WoS, SCOPUS and SPRU.

Assigning subject areas to publications:

Frequently policy experts want information about the size or impact of R&D activity in broad subject areas or disciplines, fields or sub-fields. This raises the questions of how to assign papers to different areas. There are two general approaches. The first and most time consuming approach is to assign individual papers to one or more broad areas. In other words by examining the content of each paper, the keywords in the title or exploring citations to the paper by other papers one determines which science area(s) the paper addresses. This approach is costly in terms of time and computational resources. For a data set of this study size, it isn't practical to manually examine each publication's content and it is computationally too expensive to use techniques such as co-word analysis of title words or citation clustering.

The second approach classifies papers based on the journal in which they appear. This approach is less precise but has proven to be acceptable and is affordable. It is used at international level *e.g.* national indicators by NSF science indicators being given for each of eight science fields based on a fixed journal set developed at CHI Research, Inc.

ISI classifies SCI papers into 21 fields of science. The Elsevier's SCOPUS has classified all the papers into 27 subject areas including management, social sciences, geography and some other soft sciences. Only 21 subject areas belong to the field of the study of present research study. Each journal in the SCI & SCOPUS is assigned to one or more sub-fields by using a mixture of techniques: keyword analysis, journal to journal citation analysis and user feedback. The assignment of journals to sub-fields is an on-going process and journal assignments can change with time as the research focus of the journal changes. Although it is not a perfect classification scheme it has the advantage of being standardized over a long period of time and inexpensive. Furthermore, since journals are assigned to one or more sub-fields, one can develop at least a minimal set of indicators to explore the R&D activity in interdisciplinary and multidisciplinary science areas.

In the present study, for the analyses, we have aggregated the sub-fields provided by SCOPUS & SCI, into eight scientific disciplines (as per the classification provided by DST): Agricultural Sciences, Biological Sciences, Chemical Sciences, Earth & Atmospheric Sciences, Engineering & Technology, Medical Sciences, Physical Sciences, Multidisciplinary and Others. The papers having linkages with more than 'One' broad subject area have been assigned the group of 'Multidisciplinary Sciences' and the papers dealing with an area which is 'NOT' clearly defined subject or are from 'Science Policy' or other related issues have been grouped under 'Others'. All the broad areas were grouped according to 'Broad Area' finalized by NSTMIS (DST).This classification scheme provides enough flexibility to develop indicators at three levels of detail. These were the most difficult tasks.

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. The software has two versions: User Version is having facilities for search, (simple and advanced), summarization, saving (in desired format) and printing. The Full Version (Admin CD) is having additional facilities, such as data editing, data updates, deletion or addition of records, data entry and saving mode. The 5 years database is common to both the versions. Once the data was converted into a CD with the software, a formal validation, editing and corrections were also carried out to make sure that errors are removed completely. Computer inputs were also validated and checked and many test run (s) were carried out. INSI 2013 is a compilation of Bibliographical details of Research Papers appearing during 2005-2009 in a journal from India. Searchable fields for data base are as follows:

- Title (Title)
- Author (Author)
- Address (Author Affiliation)
- City
- State
- Journal (Only Journal Abbreviation)
- Broad Subject Area (Defined by NSTMIS)
- Source (Full detail-Journal, Year, Volume, Page)
- Place of Publication (Country)
- Year
- Major Discipline
- Minor Discipline
- Citation (where ever available from the database)

Finally, the aggregated data was analyzed to generate need based reports on the indicators, detailed above, for the national productivity as well as subject wise productivity depicting the trend of research papers over the years. A number of measures have been developed , analysis and mapping has been done on the basis of data available on 'Indian National Science Indicators' - INSI 2012, for various indices of the scientometric study for indicators as needed for S&T research, depicting India's status for 2005-2009. We have used 5 years of publications data on India and top 20 'categories' for developing indicators for Indian S&T output. Larger time coverage of data has been used to ensure accurate and reliable results. For journal analysis, the original data captured from WOS, SCOPUS, CABI, INSPEC, MEDLINE and ISA were used to assess the trend of coverage of Indian papers, published in a journal, individually for each secondary service from the scope of the study and in comparison to each other. Various visualization techniques and Text mining techniques have been used (Where-ever needed) to cull out the hidden information embedded in the data.

For comparison of 'Publications' of Indian papers in journals, at 'Global Level' the data have been captured from SCOPUS and analysis has been done for computing Total Output (2005-09), Expected Outcome in 2018, Rank in 2009, Expected Rank in 2018 and Difference in Rank from 2009 for some select countries of Asiatic Region, Eastern Europe, Latin America, Middle East, Northern America, Pacific Region, and countries from Western Europe. For conclusive results suitable statistical techniques were also used. For comparing the productivity of countries, 'Increment Percentage' has been carried out. As we know, how much percentage a given relative number has increased from the number of reference. The percentage increase is the way to express a change in percentage of a number with respect to the reference number. The simplest way to calculate percentage increase is to divide the difference between relative number and reference number by the reference number and then multiplying the answer by 100 will give the percentage increase. Percentage Increase can be mathematically derived from the formula given below:

$$\text{Percentage Increase} = \frac{\text{Relative Difference}}{\text{Reference Number}} * 100$$

Where the Percentage Increase is an increase of relative quantity in percentage from the number of reference. Thus analyzed data have been presented in the report as independent chapters.

Limitations of Different Databases

A study based on a sampling of S&T periodicals surveyed in 2001 has shown that SCI provides excellent coverage for the United States and the United Kingdom, good coverage for France, Germany and under-coverage for publications from Japan, the Soviet Union, South East Asian countries including India as well as other countries except China. Moreover, in terms of disciplines, the coverage was best for research in medicine, biomedical research and the physical sciences such as chemistry, physics and mathematics. On the other hand, SCI provided less good coverage for engineering and technology in general, as well as for the earth sciences. The same reservations are expressed by many other Indian studies.

The types of documents that are compiled also represent an important limit for the ISI databases. In spite of its systematic coverage of periodicals, ISI does not compile documents that are distributed outside existing dissemination channels. Such documents, known as grey literature, include theses, internal reports, research notes, patents and communications that have not been published. Monographs are not surveyed in spite of the fact that they represent a significant part of the scholarly output in the humanities and social sciences. Certain reservations should therefore apply whenever bibliographical data from the ISI databases are used for evaluation purposes. The smaller the analytical unit, the higher the risk that the choice of data will affect the evaluation results. The SCI shows significant bias in terms of coverage by country, publications in foreign languages (other than English), as well as coverage of publications in the applied sciences. In spite of these shortcomings, SCI remains a valid bibliographical source. Such considerations raise the issue of the inclusion of Indian papers in some of the major global secondary services & databases

- Scopus is the international multidisciplinary database indexing 18000 peer reviewed journals (including 1800 open access journals), besides more than 500 international seminar/conference proceedings, 400 trade publications and 300 book series. While downloading, all types of items covered in the database are were captured, which needed a lot of efforts and data cleaning to cull out only those papers which could have been included in the study as per the 'Objectives & Scope' of the study.

- The coverage of Indian Journals is quite exhaustive (total 290 journals). But, SCOPUS data has to be used with utmost caution, as this covers a lot of 'In-house bulletins, Newsletters, Book series, Conference proceedings . Apart from this, the database includes other than S&T subjects also *e.g.* Arts & Humanities, Social sciences, Geography, Languages, and Publications related to leisure & tourism, Commerce, Management etc. The database does not follow any standardized pattern for naming of the journals, place of publication or the institutions, which is the strongest point of SCI database.

The Scopus database classifies each item covered under 21 subject categories of S&T and four broad subject categories, such as physical sciences, engineering sciences, life sciences and health sciences. The physical sciences include subjects such as physics, chemistry, mathematics, earth & planetary sciences and environmental sciences. Life sciences subjects such as agricultural & biological sciences, biochemistry, genetics & molecular biology, pharmacology, toxicology and pharmaceutics, immunology & microbiology and neurosciences. Engineering sciences include subjects such as engineering, materials science, computer science, chemical engineering and energy. Health sciences include subjects such as medicine, veterinary science, public health, dentistry and nursing. But, for the present study, the broad subject areas have been defined on the basis of classification provided by NSTMIS according to their own scheme *e.g.* Agricultural Sciences, Biological Sciences, Chemical Sciences, Earth & Atmospheric Sciences, Engineering & Technological Sciences, Mathematical Sciences, Medicine, Multidisciplinary and Physics.

Indian Science Abstracts (ISA) is a semi-monthly abstracting service which has been reporting scientific work done in India since 1965. It is a leading abstracting service in India covering entire spectrum of Science and Technology including Intellectual Property Rights, Management and Library & Information Science. The abstracts in ISA are broadly classified according to Universal Decimal Classification (UDC) scheme. The documents are grouped under 26 broad subject categories. The keyword index terms are free text terms rather than standard terms.

ISA Does not provide option for data to be captured in any other format than only in bibliographic format (text format). For any bibliometric analysis of the data, there should be option for downloading the data, saving the data in other than text format. More-over the formatting of data elements is not proper or uniform *e.g.* Rendering of the 'Journal Name' does not have a standard format, where ever ISA provide Journals Abbreviation, does not follow any international standard format for abbreviation. Place of publication of the Journal is not provided with the data. Does not have any standard Correspondence Address of the authors. Institutions name don't have a standard format. The rendering of the same institution has been entered in different ways (e.g. AIIMS, New Delhi; A.I.I.M.S., New Delhi; All India Inst of Med Sci, New Delhi; All India Institute of Medical Sciences, New Delhi). Same is true for Geographical Locations. The rendering of 'Year' is not in proper format, also there are lots of typing mistakes in the data.

CAB Abstracts is an applied life sciences bibliographic database, which is international in scope. It contains 6 million records, with coverage from 1973 to present day, adding 300,000 abstracts per year. Subject coverage includes agriculture, environment, animal sciences, veterinary sciences, applied sciences, economics, food science, microbiology, parasitology, and plant sciences and nutrition. CABI's global health resources provide public health information dating back to 1910. global health indexes biomedical sources and beyond, including the medical aspects of entomology, parasitological and mycology, human nutrition, tropical diseases, communicable and non-communicable diseases, environmental and public health, and veterinary public health and zoo noses. Indexed publications are from 150 countries in 50 languages, including English abstracts for most papers. Literature coverage includes journals, proceedings, books, and a large collection of serials. Other non-journal publications are also indexed.

Database systems is complex, difficult, and time-consuming to search. Extensive conversion time in moving from a file-based system to a database system is required to come to a conclusive results. The data base does not provide option for data to be captured in any other format than only in bibliographical text format. For any bibliometric analysis of the data, there should be option for downloading the data & saving the searched results in other than text format. The formatting of data elements is not proper or uniform. There are lots of typing mistake in data. Rendering of the 'Journal Name' does not have a standard format, where ever CABI provide Journals Abbreviation, does not have any international standard format for abbreviation (e.g. Zoo's Print is given as Zoos Print, Zoo Print, and Zoos- Print). Institutions name don't have a standard format. The rendering of the same institution has been entered in different ways (e.g. IIT, Indian Institute of Technology, I.I.T.). Same is true for Geographical Locations. The rendering of 'Year' is not in proper format (e.g. 2004 is given as 2004, 2003-2004, 2004 June). To standardize the whole data is the time consuming. In its present make-up, CABI cannot be considered as a comprehensive repository for bibliometric analysis.

Country based analysis:

Originally country names were not standardized because they were not crucial to the database users, scientists searching for literature. Thus natural variety and errors meant that fairly sophisticated searching was needed to count, for example all UK entries (publisher or the papers- i.e. from England, Scotland, Wales, Northern Ireland, UK, or Britain but not New England, New South Wales etc.). Country names are now standardized and the techniques for producing reliable national counts are well known. However, since institutional names are not standardized, counting institutional publications are problematic. We have tried to overcome this through different steps. The first step was to unify variations of each institutional name recorded in the database (INSI) to a standard name, and then assign each standard name to an institutional sector. This problem involved the manipulation of hundreds of megabytes of original bibliographic text data, the development of techniques to construct a thesaurus of variant and standard institutional names and the design of software to use the thesaurus to produce a unified data set.

Institutional Affiliation:

Another class of difficulties is conceptual. First, the relationship between addresses and institutions is not entirely straightforward. The technique assumes that addresses indicate the institutional affiliation of authors. This may not be true. For example, the address of a researcher may be a university but the institutional affiliation may be something else. Sometimes, independent institutes may be located on the same campuses.

Second, institutions change, but time series data assume they remain the same. Some universities in the India have had three names in the last 10 years. Government laboratories have been consolidated. Companies merge, split and acquire.

Third, an institution may not always be clearly assigned to one sector. Fortunately, this is an infrequent problem. Indicators developed at the categories level assume that institutions can be assigned to one of the following categories : Academic Institutions, Institutions of Higher Learning, Research & Development Institutions, Universities, Private Institutions. In India, new institutions seem to be appearing that get funding from several sources - governmental, industrial and charity for example. These institutions transcend the categories boundaries as traditionally defined. Fortunately, few exist at the moment.

The most pervasive problem in institutional and categories assignment is determining which institutions belong to the health sector. Clinical researchers often have dual university-hospital affiliations; there are two streams of funding and medical schools can be departments of universities or hospitals. Separating the two is not just a problem of bibliometric method, clinicians are not clear about which stream of money paid for what themselves. We resolved the dilemma with the following rules which are based on the principle that we do not second guess the author of the paper:

1. As we unified to the institutional not the departmental level, medical schools as departments were unified to their institution - hospital or university.

2. If an author lists hospital and university addresses on one line as one address, which occurs infrequently the paper was assigned to the first affiliation.

3. If an author lists hospital and university affiliations as two separate addresses on two lines, the paper is counted as collaborative between the hospital and university.

The conceptual difficulties of unification, namely complex and changing institutional structures and multiple sector affiliations, have several consequences for multi-national indicator development. First, the process will only be possible where addresses reflect institutional affiliation to a reasonable degree. Second, national experts must oversee unification. Only local knowledge brought to bear on institutional complexity will produce sound data. Third, no single sector classification will suit all institution. At this point the best solution would seem to be two levels of sector classification: a more detailed level designed to meet national policy interest and an internationally negotiated higher level aggregation designed for international indicator use.

Publication Analysis

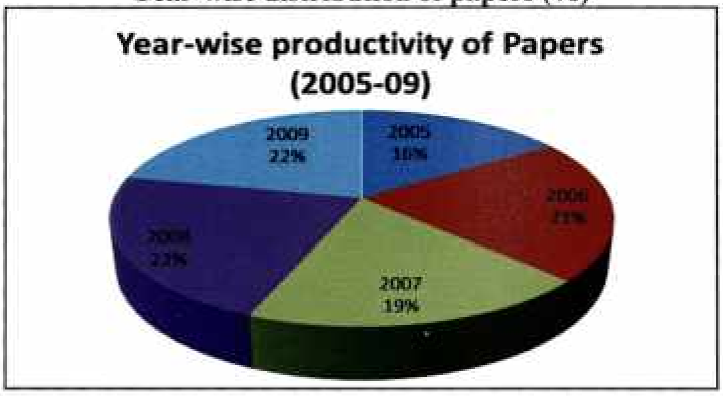
The research performance analysis is based on the publication data from Web of Science (WoS) Science Citation Index-expanded (SCI-E), Scopus, MEDLINE, INSPEC, CABI, COMPENDEX and ISA databases. These parallel sources complement each other and present an in-depth view of India's research performance as reflected through research publications. Scopus, CABI and ISA includes more local journals than SCI-E, MEDLINE, COMPENDEX & INSPEC and thus provides a different view of Indian scientific activity than that from SCIE, MEDLINE, COMPENDEX and INSPEC which reflects more closely the global visibility of Indian research. The overlap between the databases has been estimated to be 58.2% and thus these contributions complement each other.

Two crucial indicators employed in measuring research performance are the publication and citation indicators, although the assessment is not limited to the above two. Publications in the peer reviewed journals and further parameters based on publications and the impact of the publications based on the citation score of the journals are the derived indicators for the current presentation.

The number of publications from India as indexed in the INSI, applies to measure the productivity at national, institutional, city and state level. The perceived quality of publications as measured through the Impact Factor (the ratio between the total citations received in the current year for the papers published in the previous two years and total papers published in the previous two years) and the following databases have been used to present the data contained in this study.

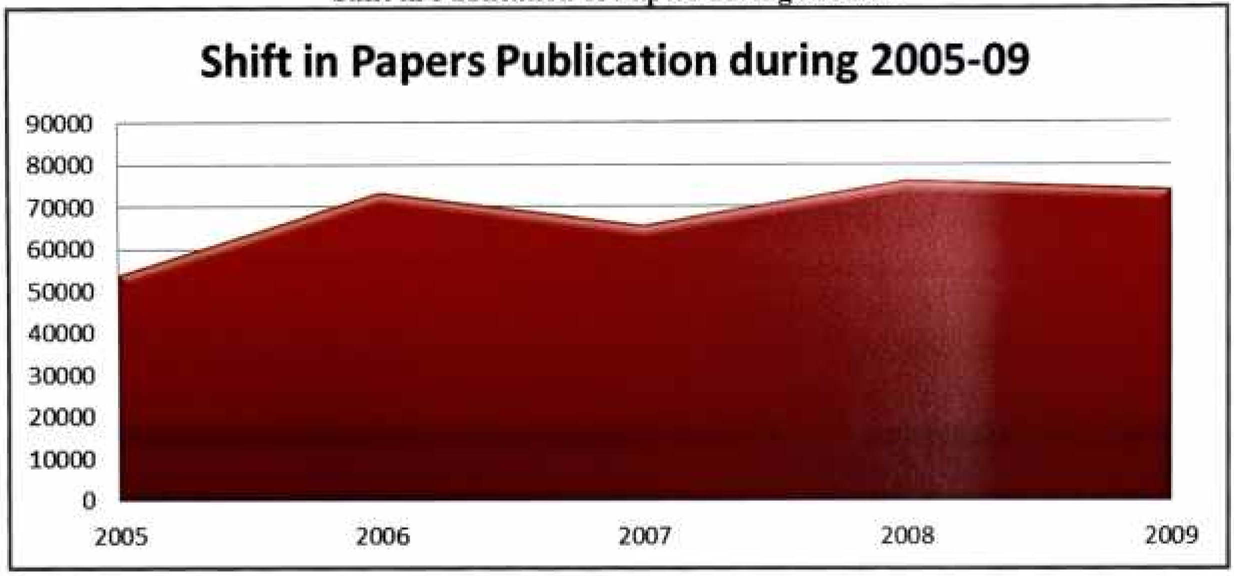
During 2005-2009, Indian scientists published 3,43,599 different type of papers. All of these appeared in a total of 9,618 journals published from different Indian and foreign publishers There were 'Proceedings Papers' which constituted about 14% of the total output. 'Reviews and Letters' each constitute about 3% of the total output. Remaining 6% of the output is scattered in Meeting, Abstracts, Editorials, Bibliographies, News items, and Book reviews.

Year-wise distribution of papers (%)



In the period of 2005 - 2009, the Indian S & T output as reflected in INSI database, is skewed, none the less, during 2005-2009 a significant growth was observed. Particularly in the years 2008 & 2009, there is remarkable increase of 25% in scientific publications than the previous years. The trend analysis of research output indicated an exponential growth of papers from 15.72% (2005) to 21.58% (2009).

Shift in Publication of Papers during 2005-09



Growth of Indian S&T Output:

The publications data in INSI had achieved annual average growth of 8.51 per cent in S&T during 2005-2009. India published 54,041 papers in the field of the study during 2005, which rose to 74,158 in 2009.

Year	Total Papers
2005	54041
2006	73412
2007	65806
2008	76182
2009	74158
Total	**3,43,599**

Global Trend: The pace of country growth in research publications is accelerating. Despite clocking faster publications growth rate in the later periods, India's world share did not show any significant change with time. Its world share marginally improved from 1.68 per cent to 1.77 per cent (as seen from SCI database) and from 2.03 per cent to 2.08 per cent (as seen from SCIE database) during 1993 to 2003 (Gupta *et-al.* 2008). In the last few years, debates and discussions are initiated about the scientific output of India in comparison with China and South Korea. According to a study by Buchandiran (2011), the scientific output of US, Canada and UK in the last couple of years remain constant while there is a significant increase for China. We have carried out a preliminary study for the total papers indexed in SCOPUS for the years of 2005-09 for some countries from Asiatic Region, Eastern Europe, Latin America, Middle East, Northern America, Pacific Region, and countries from

Western Europe. Not-withstanding, the coverage of a specific country's journals has influence on the publication profile of a country and such influence is reflected in databases. The coverage of Chinese and South Korean journals is on increase, while the number of Indian journals is not increasing in the same proportion in the last five years. The Indian journal papers also are not increasing with the same pace while the Chinese and South Korean papers continue to increase. In a preliminary analysis based on the data captured from SCOPUS, the 'expected rank' of china for 2018 is on the I[st] place whereas in terms of 'Total Papers' during 2005-09 USA is at the top and China is on the II[nd] position. India stood

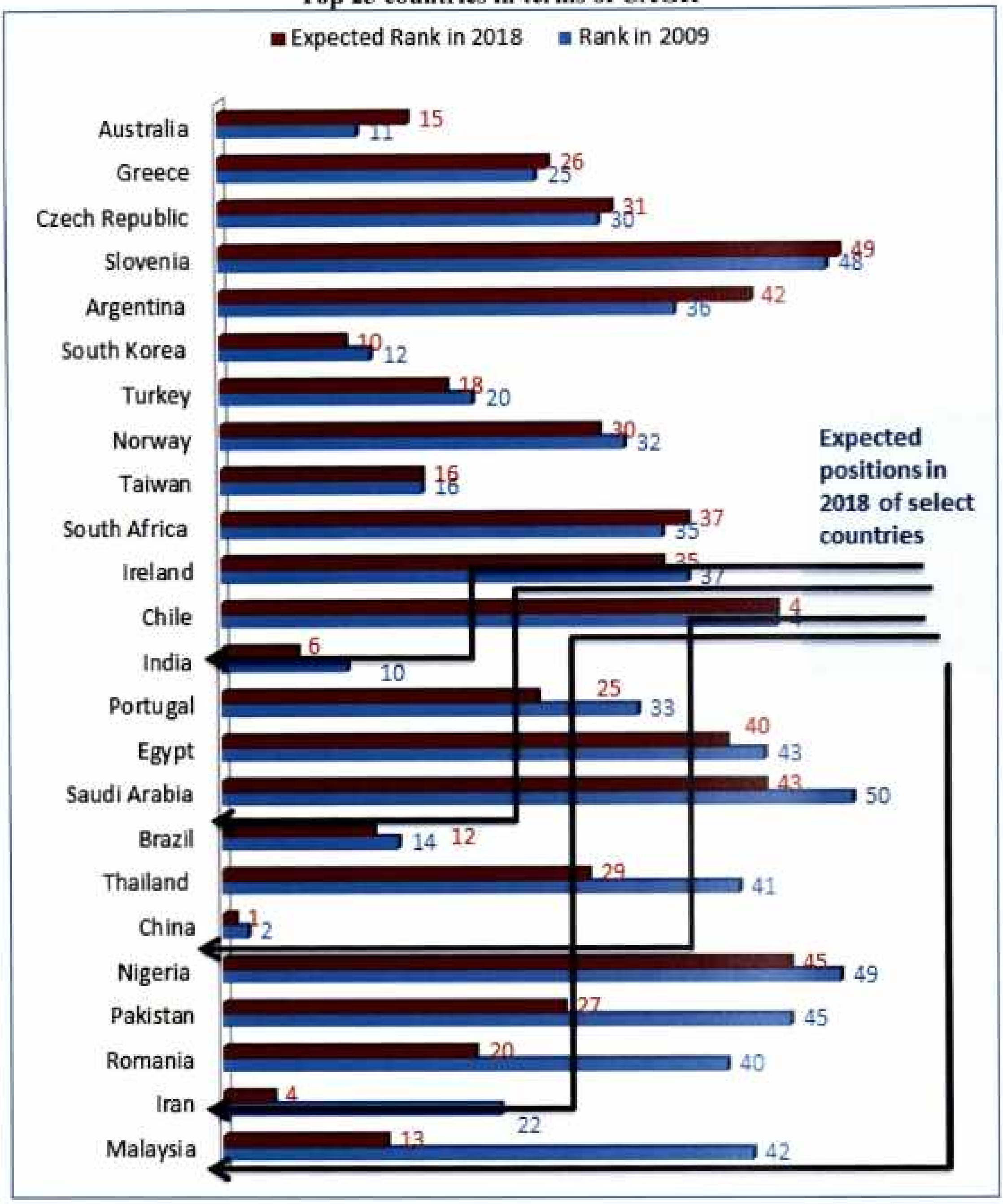
Total Papers published by a Country during the period of 2005-09 (sorted on expected outcome in 2018)

Country	Region	2005	2006	2007	2008	2009	Total Output (2005-09)	CAGR (2005-09)	Expected Outcome in 2018	Rank in 2009	Expected Rank in 2018	Diff. of Rank
China	Asiatic Region	162,658	189,867	214,232	249,973	290,745	1,107,475	12.32	1385288	2	1	1
United States	Northern America	441,250	458,999	469,433	480,305	487,704	2,337,691	2.02	693796	1	2	-1
United Kingdom	Western Europe	117,413	124,884	130,899	132,939	136,638	642,773	3.08	201051	3	3	0
Iran	Middle East	7,767	10,974	14,614	18,850	22,960	75,165	24.21	187133	22	4	18
Germany	Western Europe	108,551	111,268	115,215	119,445	123,881	578,360	2.68	185084	5	5	0
India	Asiatic Region	35,419	41,200	45,958	51,128	56,923	230,628	9.95	168925	10	6	4
France	Western Europe	76,979	80,609	83,782	88,593	91,977	421,940	3.62	138784	6	7	-1
Japan	Asiatic Region	116,790	118,617	115,931	115,465	115,886	582,689	-0.16	131100	4	8	-4
Canada	Northern America	64,121	67,423	72,203	75,136	77,674	356,557	3.91	123496	7	9	-2
South Korea	Asiatic Region	36,084	41,308	45,913	49,336	50,990	223,631	7.16	122057	12	10	2
Spain	Western Europe	46,664	51,621	55,393	59,017	63,055	275,750	6.21	120712	9	11	-2
Brazil	Latin America	25,425	32,525	36,134	40,994	44,169	179,247	11.68	112030	14	12	2
Malaysia	Asiatic Region	3,109	4,112	4,873	7,392	10,573	30,059	27.74	111549	42	13	29
Italy	Western Europe	58,877	62,936	67,767	70,525	73,440	333,545	4.52	110746	8	14	-6
Australia	Pacific Region	40,141	44,565	47,773	51,585	54,737	238,801	6.40	109905	11	15	-4
Taiwan	Asiatic Region	24,585	27,485	30,818	33,665	35,453	152,006	7.60	83912	16	16	0
Netherlands	Western Europe	33,636	35,452	36,981	38,914	41,673	186,656	4.38	69948	13	17	-4
Turkey	Middle East	20,124	22,408	24,530	25,274	28,661	120,997	7.33	63117	20	18	2
Switzerland	Western Europe	24,067	25,853	27,382	28,408	29,582	135,292	4.21	48729	17	19	-2
Romania	Eastern Europe	4,131	4,380	6,022	7,789	9,888	32,210	19.07	40893	40	20	20
Poland	Eastern Europe	22,689	24,513	23,952	25,735	26,003	122,892	2.76	40575	18	21	-3
Russian Federation	Eastern Europe	36,802	32,622	33,770	34,475	35,066	172,735	-0.96	38786	15	22	-7
Belgium	Western Europe	19,285	19,900	21,454	22,806	23,445	106,890	3.98	37188	21	23	-2
Sweden	Western Europe	22,984	23,413	24,497	24,519	25,679	121,092	2.24	37059	19	24	-5
Portugal	Western Europe	7,571	9,374	9,868	11,692	12,550	51,055	10.64	33699	33	25	8
Greece	Western Europe	11,497	13,450	14,296	15,240	15,904	70,387	6.70	30631	25	26	-1
Pakistan	Asiatic Region	2,749	3,397	4,080	4,926	5,861	21,013	16.35	29661	45	27	18
Singapore	Asiatic Region	10,305	11,123	11,405	12,532	12,962	58,327	4.69	29363	31	28	3
Thailand	Asiatic Region	4,570	5,673	6,403	7,591	7,963	32,200	11.75	27813	41	29	12
Norway	Western Europe	9,357	10,221	11,293	11,818	13,345	56,034	7.36	27333	32	30	2
Czech Republic	Eastern Europe	9,645	10,983	11,859	12,997	13,438	58,922	6.86	26834	30	31	-1
Austria	Western Europe	12,963	13,409	14,582	15,531	16,106	72,591	4.44	26754	24	32	-8
Denmark	Western Europe	12,157	12,742	13,467	14,163	15,394	67,923	4.83	25271	26	33	-7
Mexico	Latin America	10,808	11,948	12,339	13,569	13,801	62,465	5.01	24334	29	34	-5
Ireland	Western Europe	6,563	7,044	7,889	8,664	9,542	39,702	7.77	23781	37	35	2
Hong Kong	Asiatic Region	11,740	12,598	12,938	13,190	13,755	64,221	3.22	21794	27	36	-9
South Africa	Southern Africa	7,114	7,969	8,454	9,318	10,279	43,134	7.64	21389	35	37	-2
Finland	Western Europe	11,631	12,362	12,989	13,346	13,877	64,205	3.59	19903	28	38	-10
Israel	Middle East	14,019	14,869	15,220	15,573	15,412	75,093	1.91	18731	23	39	-16
Egypt	Middle East	4,596	5,059	5,654	6,368	7,902	29,579	11.45	18490	43	40	3
New Zealand	Pacific Region	7,945	8,396	8,945	9,659	9,851	44,796	4.39	17299	34	41	-7
Argentina	Latin America	6,688	7,302	7,795	8,713	9,432	39,930	7.12	16565	36	42	-6
Saudi Arabia	Middle East	2,340	2,533	2,783	3,134	4,059	14,849	11.65	15124	50	43	7
Chile	Latin America	3,907	4,778	5,302	5,935	6,253	26,175	9.86	14229	44	44	0
Nigeria	Central Africa	2,066	3,005	3,484	3,577	4,308	16,440	15.83	13584	49	45	4
Hungary	Eastern Europe	7,137	7,302	7,524	7,869	7,813	37,645	1.83	10870	38	46	-8
Croatia	Eastern Europe	3,475	3,452	3,933	4,132	4,732	19,724	6.37	9918	46	47	-1
Ukraine	Eastern Europe	6,936	6,241	6,550	6,881	6,567	33,175	-1.09	8090	39	48	-9
Slovenia	Eastern Europe	2,998	3,141	3,596	3,986	4,212	17,933	7.04	7178	48	49	-1
Slovakia	Eastern Europe	3,147	3,450	3,575	4,160	3,988	18,320	4.85	6937	47	50	-3

Source: SCOPUS – data as was extracted (without editing) December, 2012.

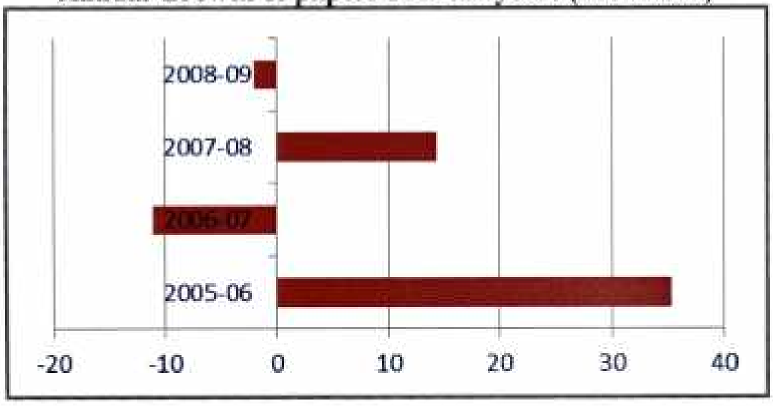
at the 10[th] position, which is expected to rise to 6[th] position by 2018. The other country indicating a phenomenal rise in the position is Iran (22[nd] position rising to 4[th] position).

Top 25 countries in terms of CAGR



Annual Growth Rate of Indian Papers (Source database –INSI) : 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.

Annual Growth of papers over the years (2005-2009)



Publications Output by Subject:

The Department of Science and Technology Government of India (DST) has a broad classification of science and technology. It has recognized eight broad S&T fields viz., agricultural sciences, biological sciences, chemical sciences, earth & atmospheric sciences, engineering and technology, medical sciences, mathematics and physical sciences. The INSI papers were relocated and fitted in the eight DST recognized broad subjects. However, the "multidisciplinary sciences" cannot be placed in any of the DST eight categories and were grouped separately along with 'Other' where all those papers are grouped which do not fall into any of the areas including 'multidisciplinary'. These papers are dealing with S&T subjects but not related to any fields of S&T directly or indirectly *eg.* science policy studies.

Some of the papers were grouped under more than one 'Broad Subject Area' by the indexing services; those classifications have been maintained as such, because of this overlapping, (2.27% - 2005, 3.59% - 2006, 3.80% - 2007, 4.69% - 2008 and 5.20% - 2009) year-wise distribution of total papers being published in different subject areas are different from those of the 'year wise publications' of India.

Chemical Sciences , Medical Sciences , Biological sciences and Engineering & Technology have been the leading areas of research in India and have shown consistent rising trend in publications output. Medical Sciences however, was an exception, since it showed a small dip in 2007. 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.

Total Papers in the Broad Subject Areas (2005-2009)

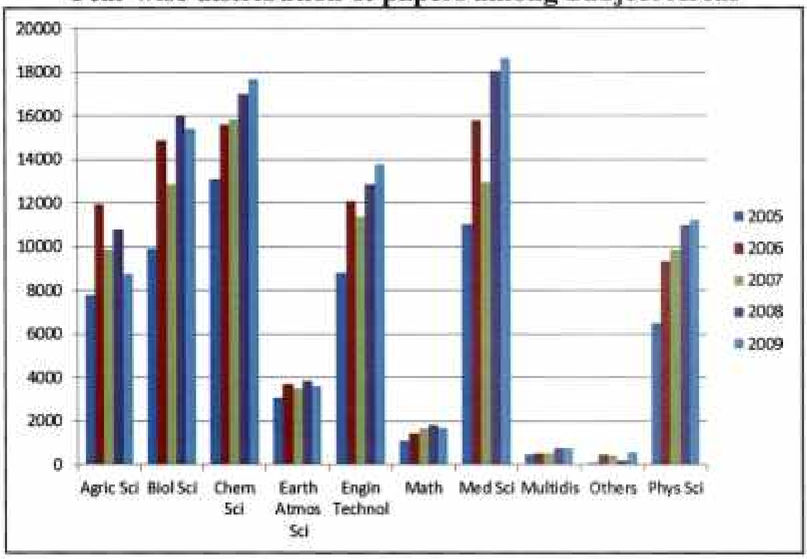
Broad Subject Area	2005	2006	2007	2008	2009	Total*
Agricultural Sciences	7796	11958	9872	10796	8735	49157
Biological Sciences	9895	14889	12840	15975	15392	68991
Chemical Sciences	13103	15603	15822	16982	17686	79196

Earth & Atmospheric Sciences	3063	3678	3526	3845	3622	17734
Engineering & Technology	8780	12081	11377	12854	13744	58836
Mathematics	1090	1440	1679	1828	1699	7736
Medical Sciences	11038	15764	12938	18073	18628	76441
Physical Sciences	6512	9311	9867	10967	11189	47846
Multidisciplinary	457	521	541	780	760	3059
Others	92	486	410	195	564	1747

(3.92% of the papers are covered in more than one area)*

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.

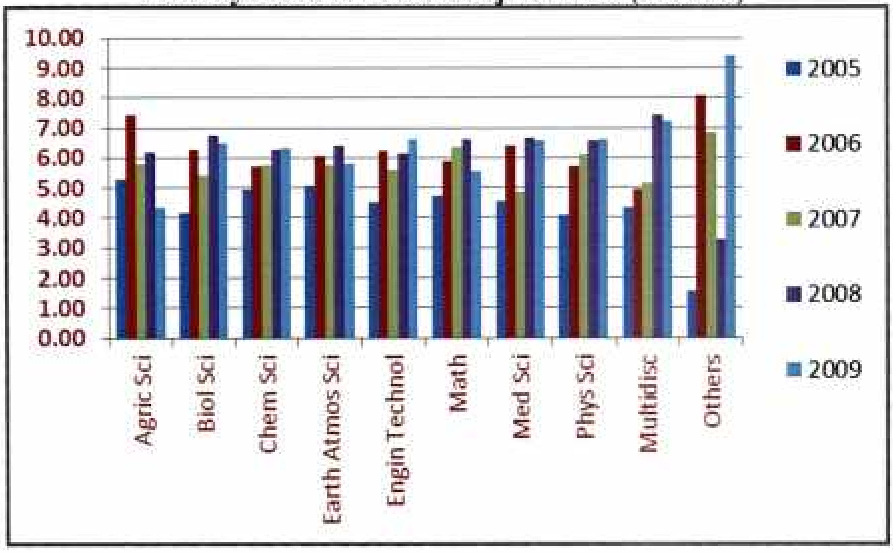
Year wise distribution of papers among Subject Areas



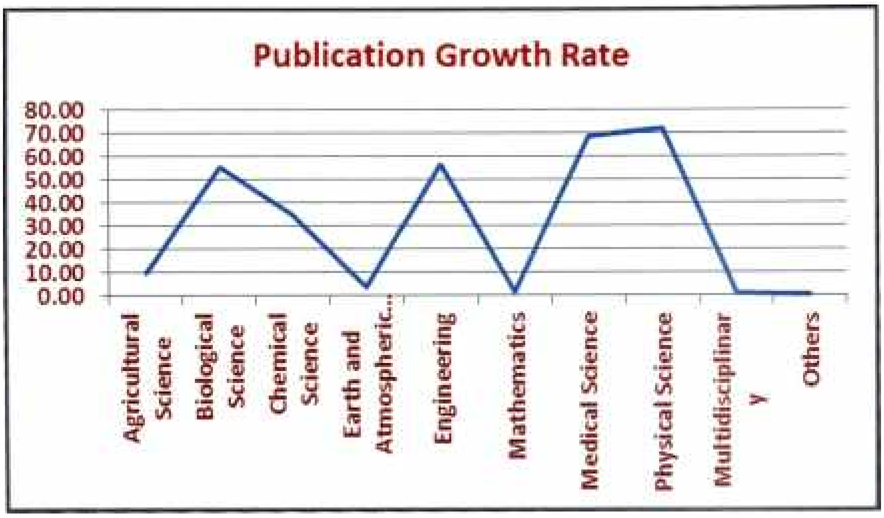
Engineering & Technology, Agricultural sciences and Biological Sciences have been the medium productive areas of research in Indian science. Mathematics, Physical sciences and Earth & Atmospheric Sciences were the least productive areas.

The 'Activity Index' (AI) was also examined for all the 'Broad Subject Area' for 5 years as well as year-wise. AI was first proposed by Caplan D[18] (1998) and later has been elaborated by Schubert & Braun[64]. It characterizes the relative research efforts in 'different categories' being examined.

Activity Index of Broad Subject Areas (2005-09)



Since the government had been providing substantial support to universities and R&D agencies for research in biological sciences, environmental sciences & computer science, their low share in the country's output is a matter of concern. The decline in the publications share of Physical Sciences and Engineering & Technology in the national output may be attributed to the inadequate coverage of journals in the major global secondary services *e.g.* Web of Science or INSPEC. The national share in earth and atmospheric sciences remained stagnant. This discipline needs greater attention in view of the challenges thrown by Tsunami, greenhouse effect and other environmental changes taking place the world over. The decline and slow growth of publications in biology, medicine and mathematics in spite of well-established departments and faculties (comparable to physics and chemistry) in large number of universities & medical colleges is a matter of concern. There is an urgent need to improve course contents and focus in research in both the fields. For example, changes in curriculum from traditional to modern biology, and from traditional mathematics to computational and applied mathematics may attract more research funds, and make this research more relevant to Indian biotechnology and computer industry and may help the students engaged in research in these fields in getting employment in India.



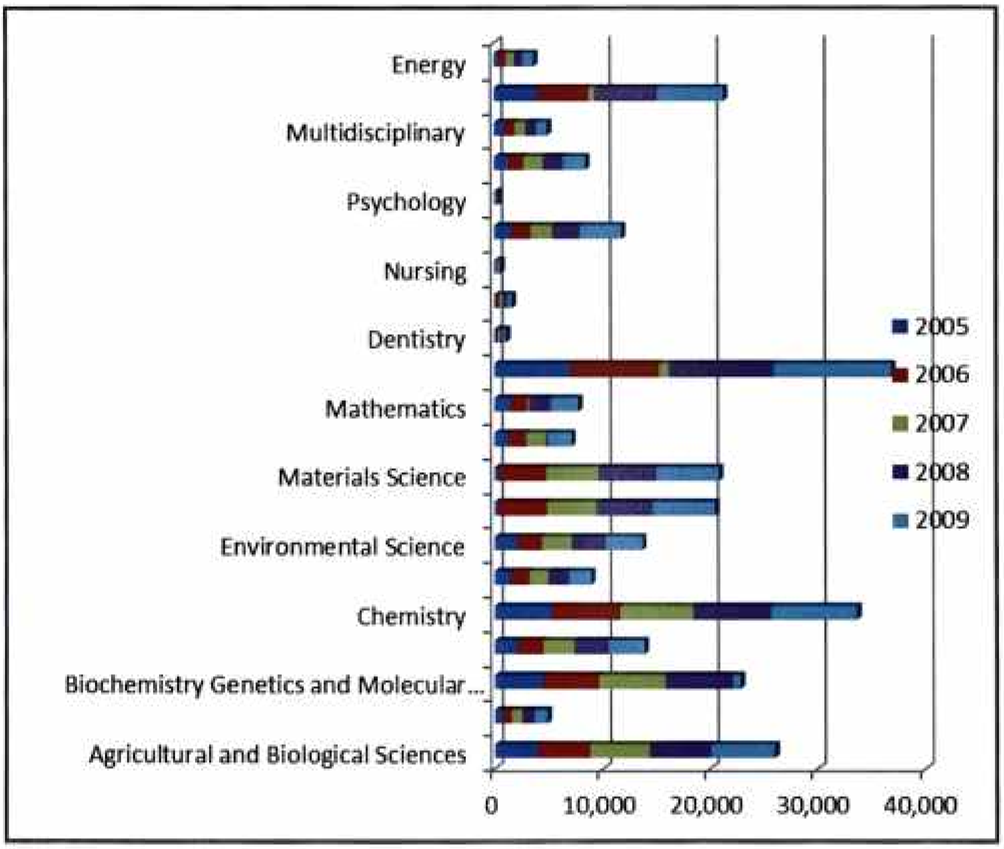
Over a period of 5 years, the publication growth was fastest in physical sciences (71.82) followed by medical sciences (68.76) and engineering & technology (56.53). In contrast, the country witnessed slower growth in biological sciences (55.55), chemical sciences (34.97). Mathematics and earth & atmospheric sciences also witnessed slower growth rate. Mathematics and computer science, though, witnessed high growth rate but its national share is still very small (1.3 per cent and 1.8 per cent) during 2005-2009. The papers have been further analyzed on the basis of 21'major disciplines' as classified by the Scopus and WoS for the period of 2005-09. Here the number may increase from the actual number of papers, as the same paper may be appearing in more than one major discipline.

All 21 Subject Areas (2005-09 Source- INSI):

Subject Analysis	2005	2006	2007	2008	2009
Agricultural and Biological Sciences	4077	4803	5439	5758	5933
Biochemistry, Genetics and Molecular Biology	4526	5124	6158	6299	723
Chemical Engineering	2094	2444	2865	3094	3369
Chemistry	5283	6325	6775	7316	7955
Computer Science	1259	1712	1802	195	2213
Dentistry	138	202	213	258	257
Earth and Planetary Sciences	1475	1743	1745	1965	2063
Energy	416	683	760	790	1049
Engineering	334	4548	4586	5187	5828
Environmental Science	2101	2331	2727	3087	3418
Immunology and Microbiology	1281	1437	1814	1931	2044
Materials Science	366	4474	4774	5377	5846

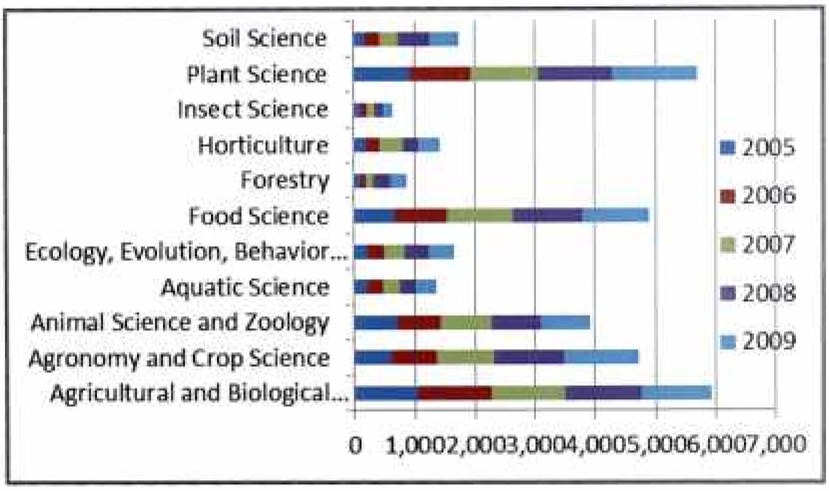
Mathematics	1482	1527	184	2046	2586
Medicine	7076	8187	893	9793	10946
Multidisciplinary	926	964	1049	971	1038
Neuroscience	177	289	314	398	437
Nursing	63	85	121	122	178
Pharmacology, Toxicology and Pharmaceutics	1498	1865	2044	2606	3742
Physics and Astronomy	4015	4805	528	5789	6141
Psychology	48	66	91	81	106
Veterinary	732	797	989	1176	1233

- Among the 21 major disciplines 'Medicine' has the maximum contribution followed by Chemistry, Agricultural and Biological Sciences, Biochemistry, Genetics and Molecular Biology, Physics & Astronomy, Materials Science, Engineering, Chemical Engineering, Environmental Science, Pharmacology and Toxicology & Pharmaceutics in the same decreasing order of contribution for the whole period of study.



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

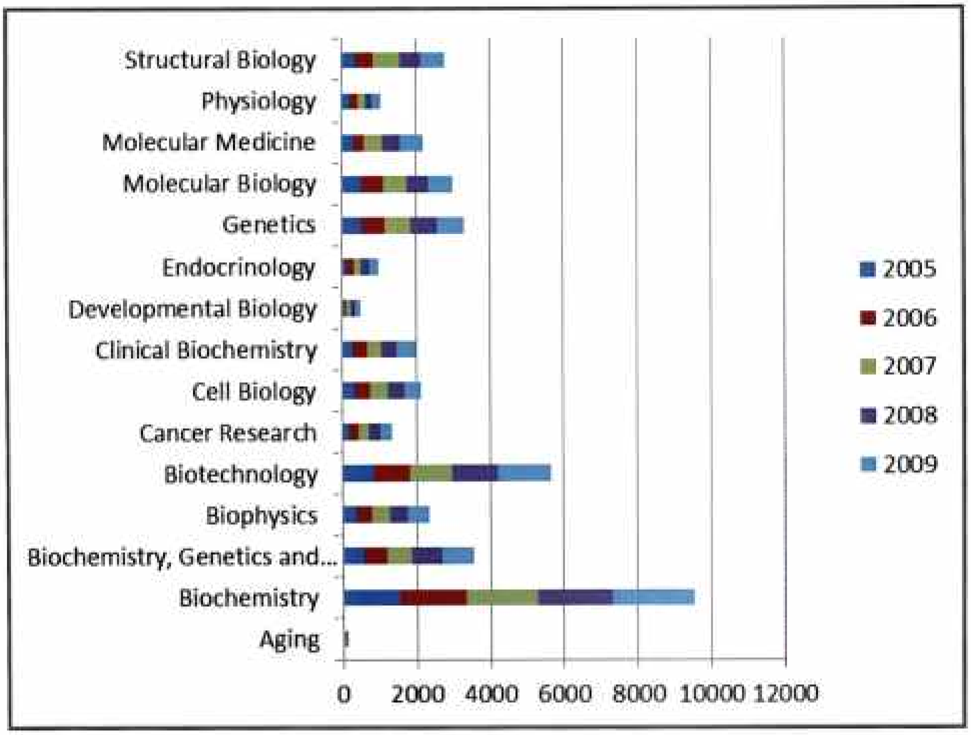
Agricultural and Biological Sciences:



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.

Biochemistry, Molecular Biology & Genetics:

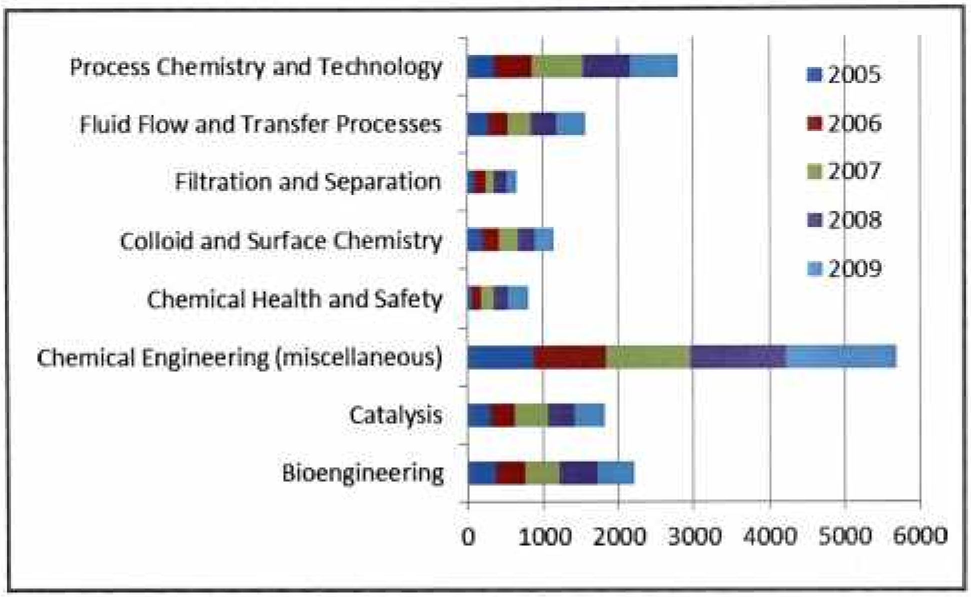
Subject Analysis	2005	2006	2007	2008	2009
Aging	17	21	21	30	46
Biochemistry	1,559	1,783	1,948	2,032	2,216
Biochemistry, Genetics and Molecular Biology (miscellaneous)	567	634	662	820	872
Biophysics	383	395	503	478	569
Biotechnology	856	976	1,136	1,235	1,458
Cancer Research	192	244	275	304	331
Cell Biology	346	405	497	426	472
Clinical Biochemistry	312	356	395	427	502
Developmental Biology	75	65	99	136	142
Endocrinology	140	188	178	231	241
Genetics	550	619	684	722	738
Molecular Biology	541	599	602	584	685
Molecular Medicine	330	285	462	500	621
Physiology	214	213	223	177	224
Structural Biology	359	481	748	545	669



In the category of Biochemistry, Molecular Biology & Genetics, maximum papers appeared in the field of Biochemistry followed by Biotechnology, Genetics, Molecular Biology and Structural Biology.

Chemical Engineering:

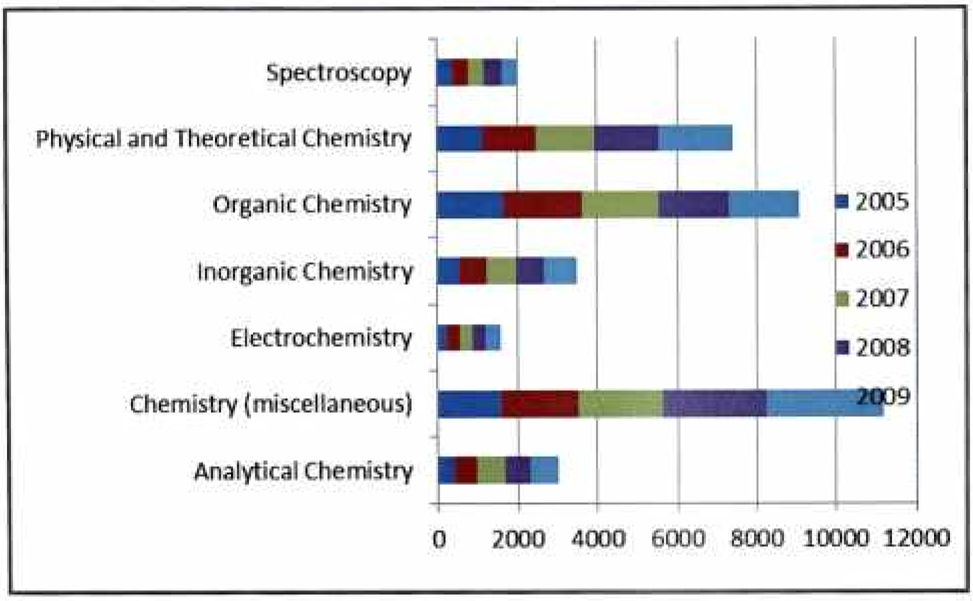
Subject Analysis	2005	2006	2007	2008	2009
Bioengineering	355	399	449	514	492
Catalysis	289	324	438	360	402
Chemical Engineering (miscellaneous)	869	962	1,116	1,269	1,470
Chemical Health and Safety	60	125	161	178	272
Colloid and Surface Chemistry	193	221	246	230	245
Filtration and Separation	99	138	115	159	138
Fluid Flow and Transfer Processes	272	256	304	348	389
Process Chemistry and Technology	341	516	668	627	653



In the category of Chemical Engineering maximum papers were in the miscellaneous field of Chemical Engineering, followed by process chemistry & technology, bioengineering, studies related to catalysis and fluid flow & transfer processes.

Chemistry:

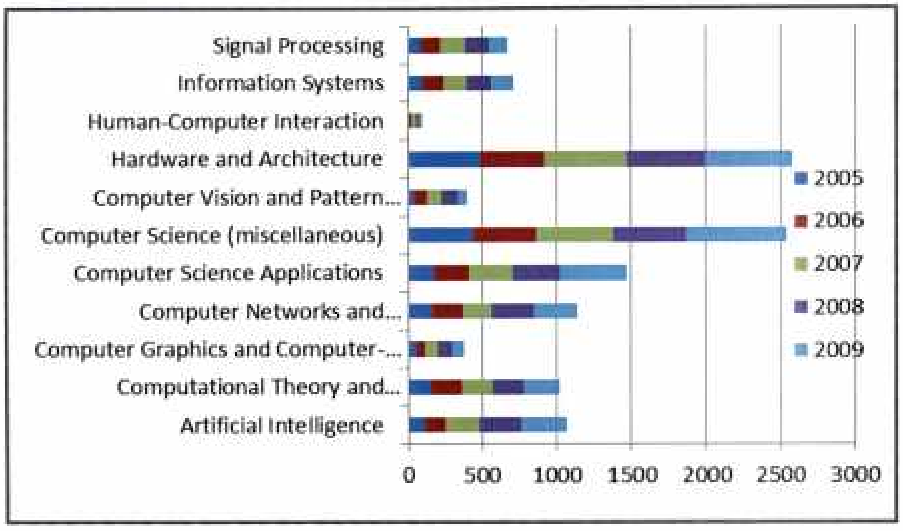
Subject Analysis	2005	2006	2007	2008	2009
Analytical Chemistry	422	539	700	666	682
Chemistry (miscellaneous)	1,582	1,945	2,104	2,613	2,959
Electrochemistry	227	305	328	333	382
Inorganic Chemistry	545	667	736	707	840
Organic Chemistry	1,651	1,969	1,926	1,783	1,757
Physical and Theoretical Chemistry	1,127	1,332	1,498	1,588	1,878
Spectroscopy	373	392	406	430	406



In the category of Chemistry again maximum papers were published in the miscellaneous areas of chemistry followed by organic chemistry, physical & theoretical chemistry, inorganic chemistry and analytical chemistry.

Computer Science:

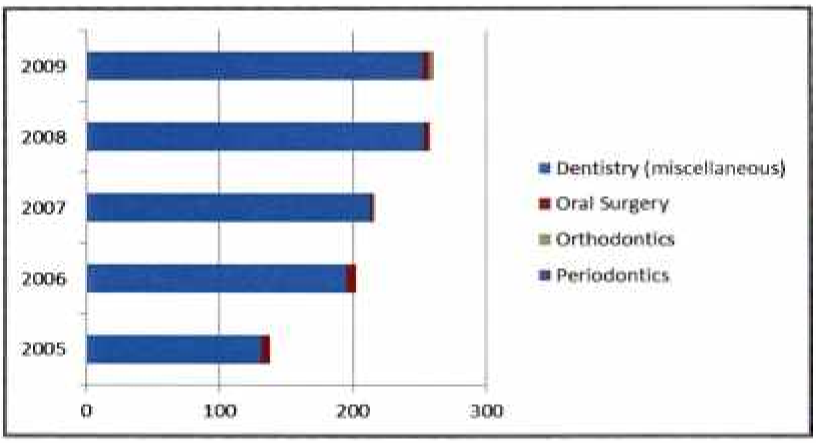
Subject Analysis	**2005**	**2006**	**2007**	**2008**	**2009**
Artificial Intelligence	111	137	231	272	313
Computational Theory and Mathematics	154	203	209	204	243
Computer Graphics and Computer-Aided Design	56	58	86	93	83
Computer Networks and Communications	161	200	195	283	294
Computer Science Applications	171	236	292	320	449
Computer Science (miscellaneous)	433	428	513	496	665
Computer Vision and Pattern Recognition	41	84	95	110	63
Hardware and Architecture	485	432	550	530	575
Human-Computer Interaction	9	15	28	19	21
Information Systems	94	141	155	165	151
Signal Processing	85	132	165	157	131
Software	160	397	224	309	324



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.

Dentistry:

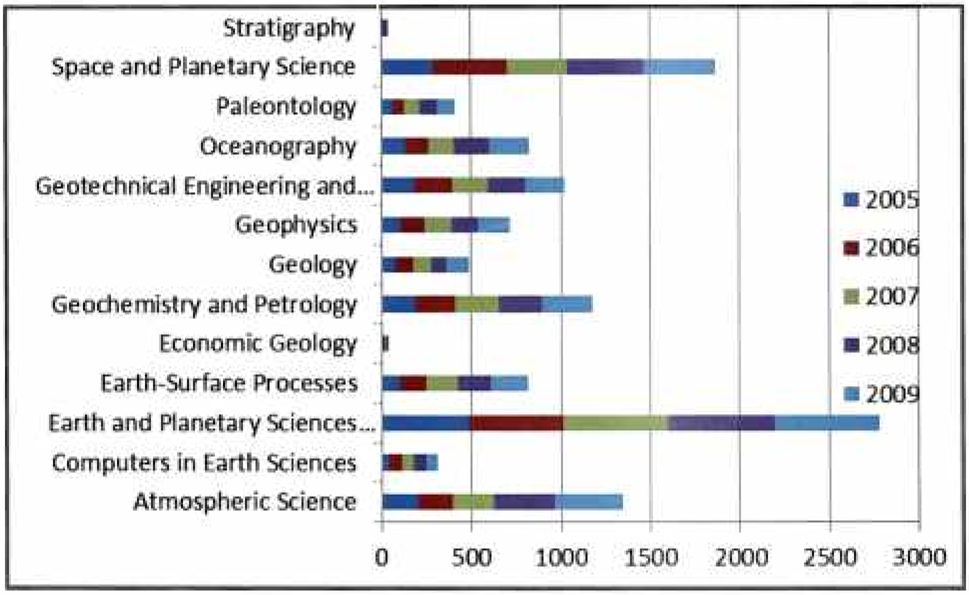
Subject Analysis	2005	2006	2007	2008	2009
Dentistry (miscellaneous)	132	195	213	253	252
Oral Surgery	6	7	1	4	5
Orthodontics	-	-	1	1	2
Periodontics	-	-	1	-	1



The field of Dentistry is one of the least explored areas of research and needs attention of policy makers and academics.

Earth & Planetary Sciences:

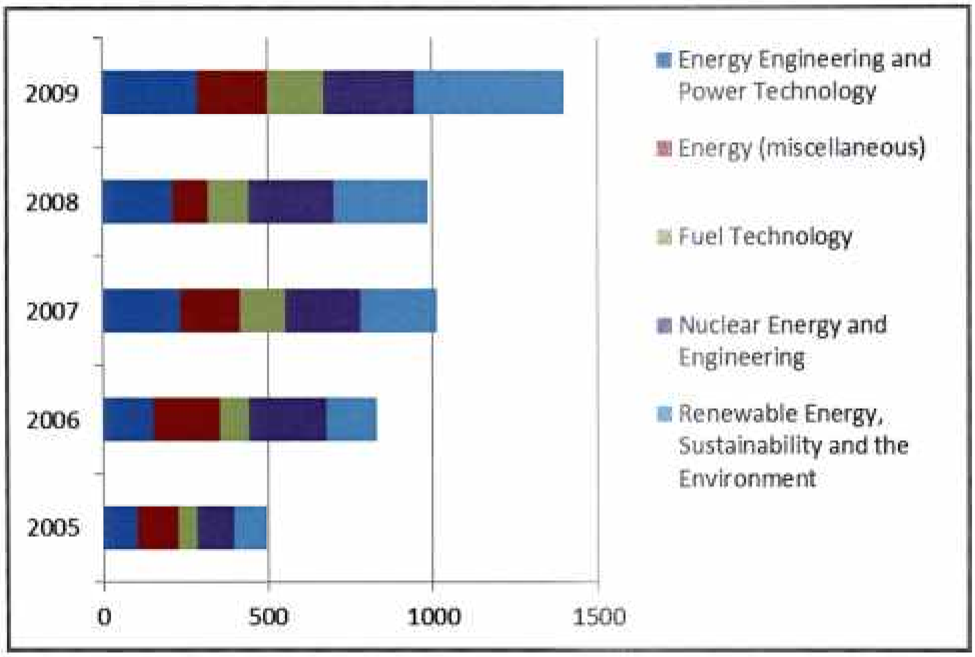
Subject Analysis	2005	2006	2007	2008	2009
Atmospheric Science	199	194	226	343	382
Computers in Earth Sciences	41	69	67	70	61
Earth and Planetary Sciences (miscellaneous)	490	524	585	594	590
Earth-Surface Processes	103	143	175	186	210
Economic Geology	5	10	6	9	8
Geochemistry and Petrology	186	219	244	245	282
Geology	77	99	98	85	127
Geophysics	104	135	147	153	176
Geotechnical Engineering and Engineering Geology	183	214	194	210	217
Oceanography	131	125	148	195	223
Paleontology	58	67	83	98	101
Space and Planetary Science	288	409	340	423	408
Stratigraphy	11	3	6	8	2



In the category of Earth & Planetary Sciences, maximum papers appeared in the area of space and planetary sciences, apart from miscellaneous papers. The other areas were geochemistry & petrology, Geotechnical Engineering & Engineering Geology, Oceanography and earth & surface processes.

Energy:

Subject Analysis	2005	2006	2007	2008	2009
Energy Engineering and Power Technology	104	154	235	213	288
Energy (miscellaneous)	124	199	180	107	211
Fuel Technology	56	91	140	121	175
Nuclear Energy and Engineering	111	234	224	259	274
Renewable Energy, Sustainability and the Environment	102	153	231	286	448

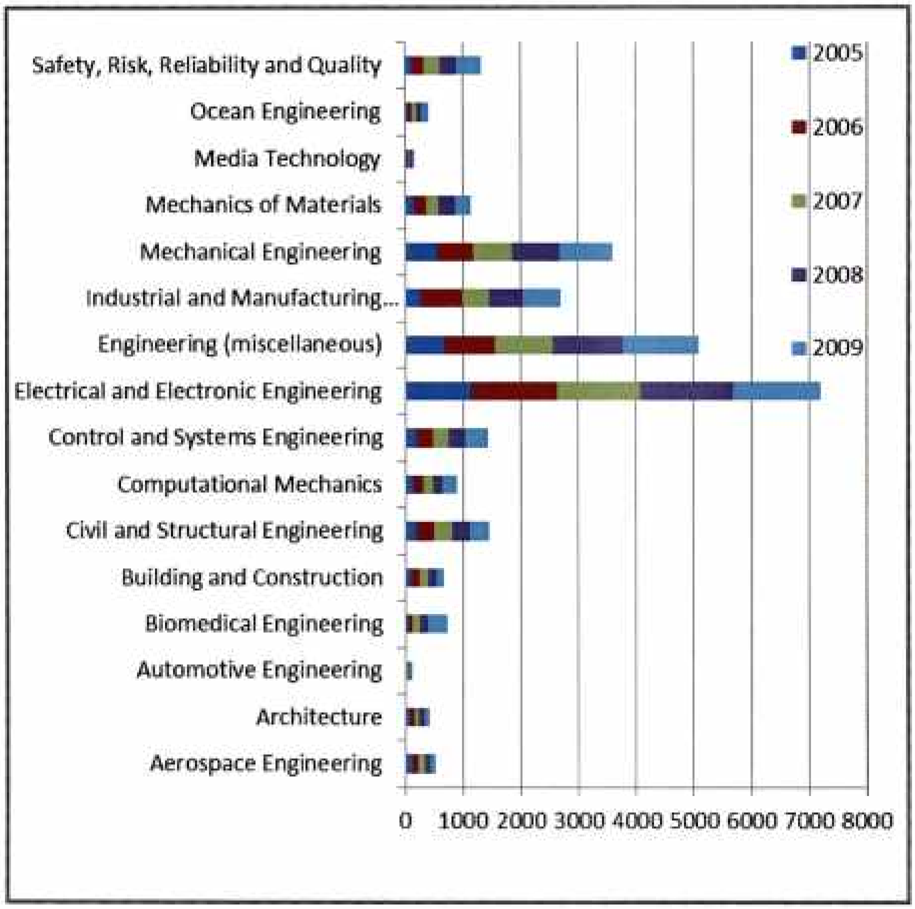


The next category of papers in the field of 'Energy' have maximum entries in the area of Renewable Energy, Sustainability and the Environment followed by Energy Engineering and Power Technology and Nuclear Energy & Engineering.

Engineering:

Subject Analysis	2005	2006	2007	2008	2009
Aerospace Engineering	109	112	104	99	94
Architecture	69	87	69	95	90
Automotive Engineering	15	5	28	24	43
Biomedical Engineering	59	54	124	142	334
Building and Construction	97	147	143	156	124

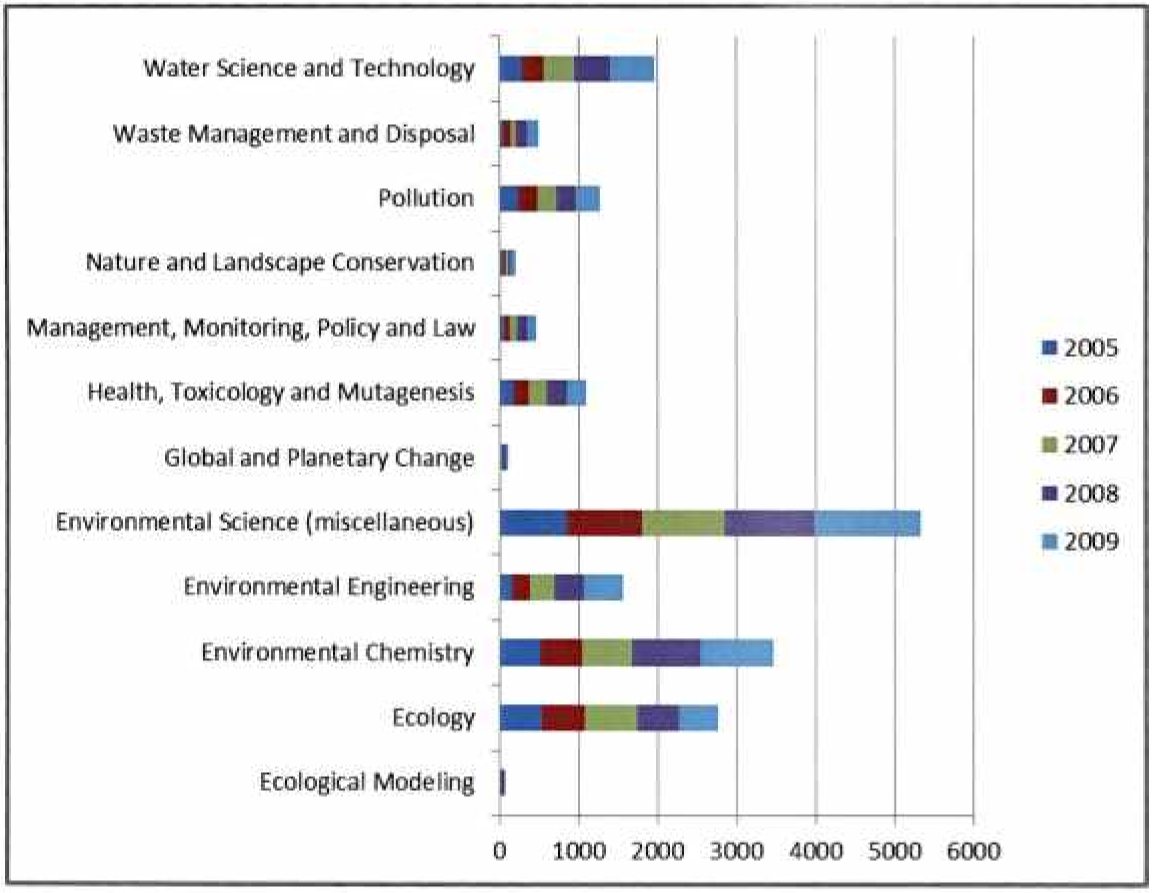
Civil and Structural Engineering	203	287	320	300	331
Computational Mechanics	128	169	168	179	232
Control and Systems Engineering	199	262	275	295	402
Electrical and Electronic Engineering	1,130	1,495	1,445	1,613	1,514
Engineering (miscellaneous)	679	877	995	1,221	1,301
Industrial and Manufacturing Engineering	292	691	473	566	670
Mechanical Engineering	557	614	674	831	911
Mechanics of Materials	156	203	220	276	289
Media Technology	31	23	26	29	45
Ocean Engineering	55	59	88	85	123
Safety, Risk, Reliability and Quality	118	211	257	301	433



In the field of Engineering the top most area was of Electrical and Electronic Engineering followed by miscellaneous papers from Engineering field, mechanical engineering, industrial & manufacturing *etc*.

Environmental Sciences:

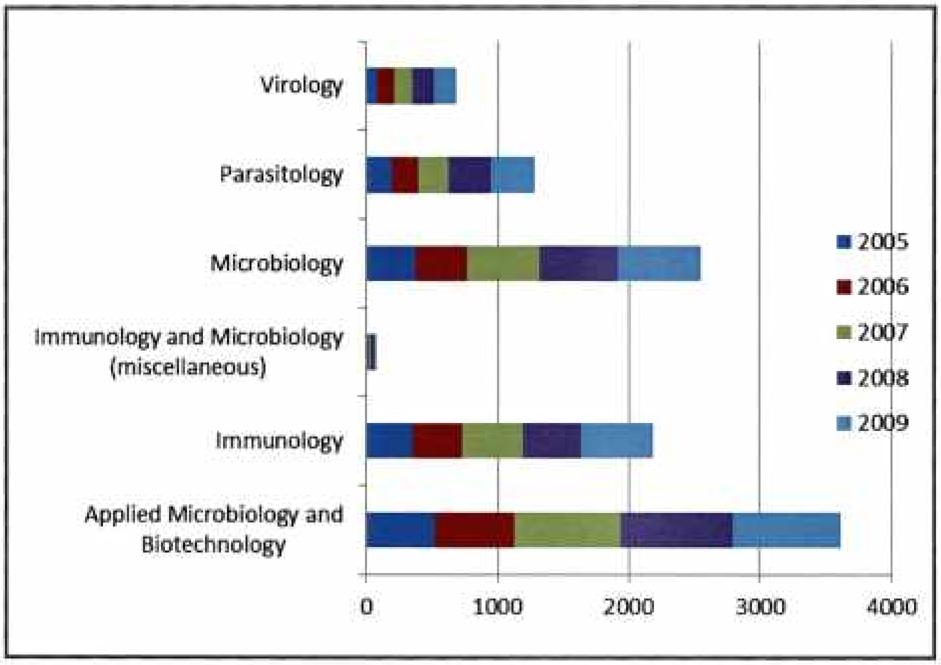
Subject Analysis	2005	2006	2007	2008	2009
Ecological Modeling	21	15	10	10	11
Ecology	525	555	651	546	490
Environmental Chemistry	506	543	629	861	921
Environmental Engineering	154	227	304	382	492
Environmental Science (miscellaneous)	857	951	1,038	1,138	1,347
Global and Planetary Change	8	11	16	39	36
Health, Toxicology and Mutagenesis	169	190	230	265	245
Management, Monitoring, Policy and Law	56	75	84	128	120
Nature and Landscape Conservation	40	32	35	38	57
Pollution	240	243	243	232	306
Waste Management and Disposal	52	83	76	142	137
Water Science and Technology	290	278	384	454	552



In the category of Environmental Sciences, miscellaneous papers have the biggest share followed by papers in the area of environmental chemistry, ecology, water science & technology, environmental engineering. Some other very important areas of pollution, waste management & disposal, health toxicology & mutagenesis also needs utmost attention of researchers as well as policy makers so that more research should be carried out in these areas as presently (as reflected by published papers) the situation is not satisfactory.

Immunology & Microbiology:

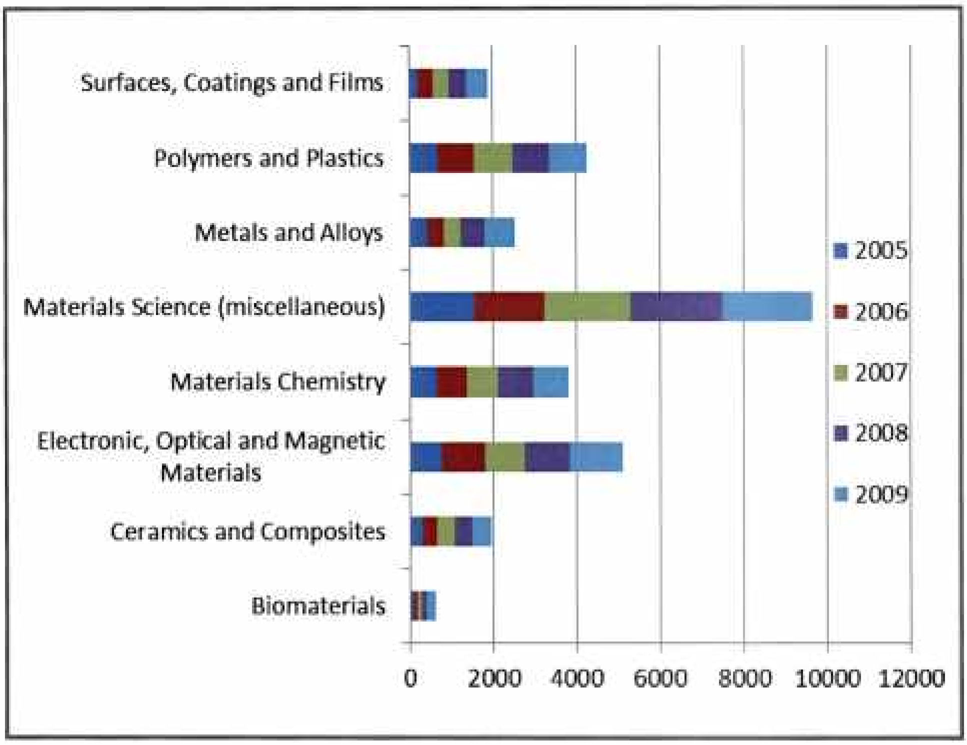
Subject Analysis	2005	2006	2007	2008	2009
Applied Microbiology and Biotechnology	522	600	807	864	825
Immunology	345	379	468	442	549
Immunology and Microbiology (miscellaneous)	6	6	20	20	19
Microbiology	371	390	557	597	634
Parasitology	194	197	230	324	335
Virology	80	133	135	159	170



As the category of Immunology & Microbiology, is very important from the perspective of health care of the population, which is reflected from the top most papers in the area of Applied Microbiology and Biotechnology followed by Immunology and Microbiology (miscellaneous), Microbiology, Parasitology and Virology.

Material Science:

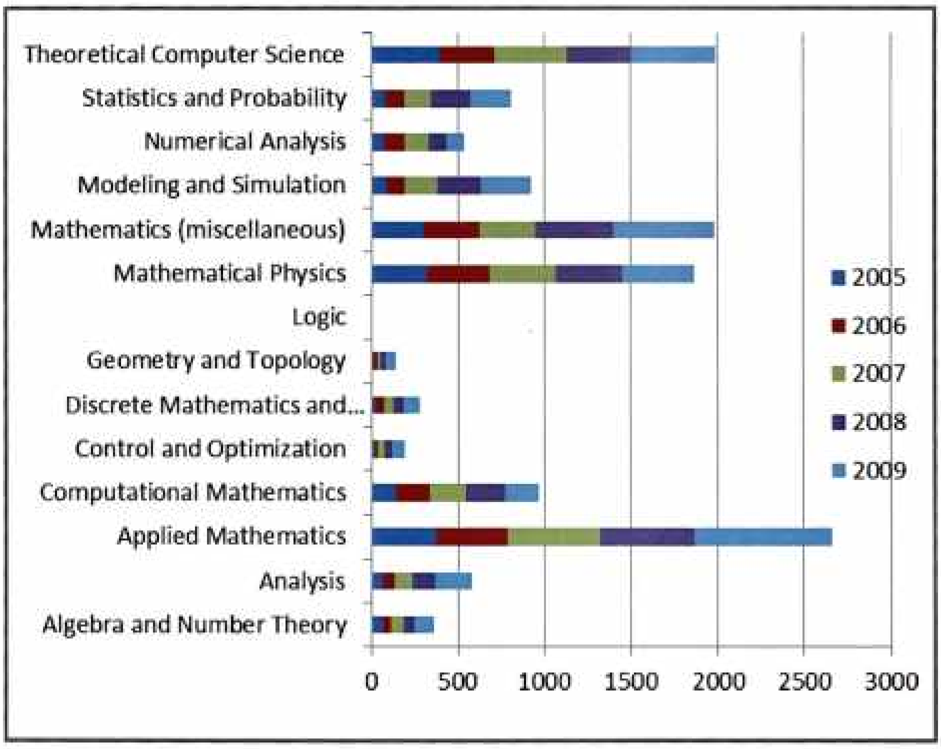
Subject Analysis	2005	2006	2007	2008	2009
Biomaterials	80	101	90	117	205
Ceramics and Composites	298	336	412	443	453
Electronic, Optical and Magnetic Materials	760	1,015	958	1,092	1,283
Materials Chemistry	617	748	742	840	862
Materials Science (miscellaneous)	1,560	1,674	2,049	2,201	2,173
Metals and Alloys	414	385	421	581	707
Polymers and Plastics	662	896	916	860	930
Surfaces, Coatings and Films	214	349	362	442	515



Material Science is one of the most prolific subject fields for Indian researchers. 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.

Mathematics:

Subject Analysis	2005	2006	2007	2008	2009
Algebra and Number Theory	64	47	71	69	107
Analysis	63	70	100	133	214
Applied Mathematics	373	408	541	543	797
Computational Mathematics	140	195	211	222	202
Control and Optimization	22	14	38	43	72
Discrete Mathematics and Combinatorics	24	49	52	61	96
Geometry and Topology	12	21	18	30	59
Logic	1	-	-	2	2
Mathematical Physics	324	356	381	390	414
Mathematics (miscellaneous)	304	319	325	451	580
Modeling and Simulation	90	101	188	248	294
Numerical Analysis	73	116	143	99	104
Statistics and Probability	83	110	149	227	240
Theoretical Computer Science	397	316	416	376	485

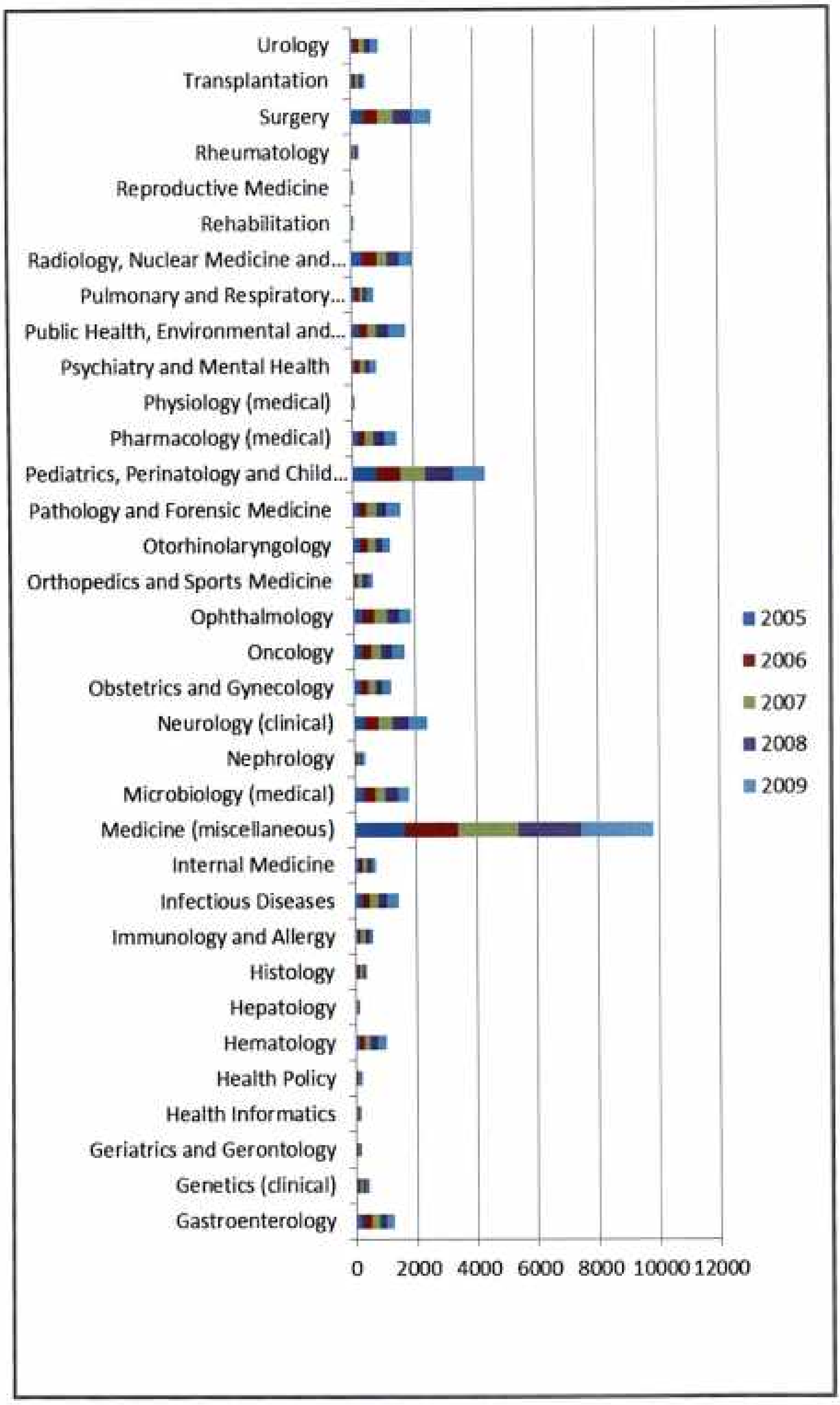


The subject field of Mathematics is one of the least active field from research point of view and research papers, because of the 'nature' of the subject. None the less Indian researchers have published papers in this field also. The top most area was Applied Mathematics followed by papers of miscellaneous in nature, Theoretical Computer Science, mathematical physics, computational mathematics, modeling & simulation.

Medicine:

Subject Analysis	2005	2006	2007	2008	2009
Anatomy	96	120	129	153	160
Anesthesiology and Pain Medicine	263	280	267	343	348
Biochemistry (medical)	17	22	30	69	82
Cardiology and Cardiovascular Medicine	305	313	329	364	376
Complementary and Alternative Medicine	26	44	71	127	173
Critical Care and Intensive Care Medicine	62	48	60	63	71
Dermatology	354	397	379	464	515
Drug Guides	1	-	2	1	-
Embryology	12	17	12	13	18
Emergency Medicine	51	42	51	51	69
Endocrinology, Diabetes and Metabolism	50	87	117	110	131
Epidemiology	26	29	31	30	41
Family Practice	-	-	-	1	-
Gastroenterology	204	261	248	280	240
Genetics (clinical)	45	78	79	108	89
Geriatrics and Gerontology	31	31	42	35	34
Health Informatics	12	17	27	34	57
Health Policy	26	27	42	39	63
Hematology	138	131	191	248	274
Hepatology	7	20	18	34	33
Histology	57	73	92	76	49
Immunology and Allergy	70	97	124	141	119
Infectious Diseases	230	218	277	292	374
Internal Medicine	108	129	144	129	138
Medicine (miscellaneous)	1,614	1,740	2,006	2,067	2,351
Microbiology (medical)	296	356	329	420	379
Nephrology	53	45	66	58	101
Neurology (clinical)	339	416	474	547	606
Obstetrics and Gynecology	219	217	268	212	268

Oncology	249	298	325	343	444
Ophthalmology	315	348	435	392	364
Orthopedics and Sports Medicine	55	66	169	181	167
Otorhinolaryngology	220	253	242	244	247
Pathology and Forensic Medicine	208	226	316	335	465
Pediatrics, Perinatology and Child Health	754	779	839	928	1,042
Pharmacology (medical)	182	232	268	355	416
Physiology (medical)	15	10	15	8	13
Psychiatry and Mental Health	104	174	161	155	215
Public Health, Environmental and Occupational Health	246	254	298	390	587
Pulmonary and Respiratory Medicine	117	132	139	139	207
Radiology, Nuclear Medicine and Imaging	321	515	338	376	419
Rehabilitation	14	14	16	12	16
Reproductive Medicine	13	18	10	21	39
Rheumatology	13	29	64	77	71
Surgery	411	446	526	611	637
Transplantation	84	80	95	107	98
Urology	79	190	182	221	235

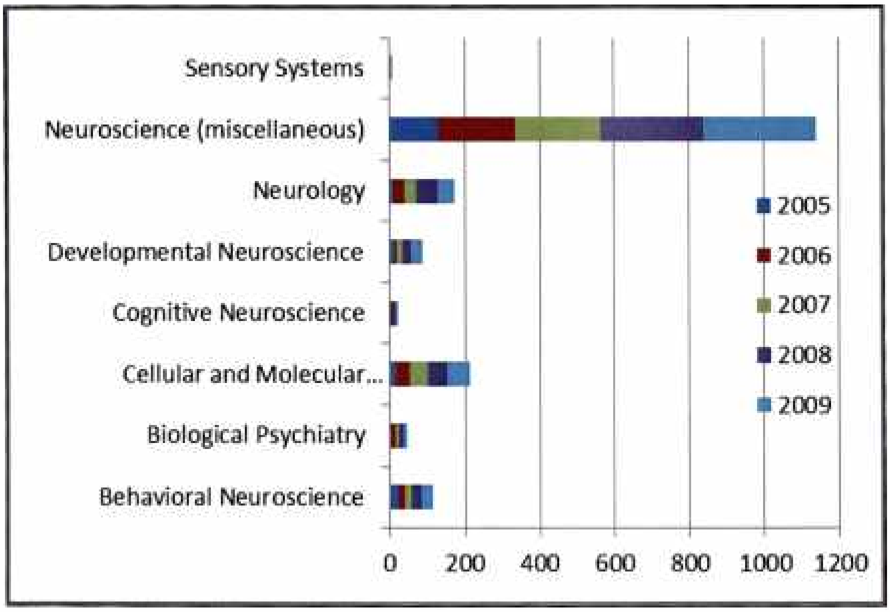


Urology
Transplantation
Surgery
Rheumatology
Reproductive Medicine
Rehabilitation
Radiology, Nuclear Medicine and...
Pulmonary and Respiratory...
Public Health, Environmental and...
Psychiatry and Mental Health
Physiology (medical)
Pharmacology (medical)
Pediatrics, Perinatology and Child...
Pathology and Forensic Medicine
Otorhinolaryngology
Orthopedics and Sports Medicine
Ophthalmology
Oncology
Obstetrics and Gynecology
Neurology (clinical)
Nephrology
Microbiology (medical)
Medicine (miscellaneous)
Internal Medicine
Infectious Diseases
Immunology and Allergy
Histology
Hepatology
Hematology
Health Policy
Health Informatics
Geriatrics and Gerontology
Genetics (clinical)
Gastroenterology
0 2000 4000 6000 8000 10000 12000
2005
2006
2007
2008
2009

Medicine is one the most active field from the research point of view and papers being published from India. The SCOPUS also has grouped many (47) major subject disciplines under 'Medicine'. The top most ten areas are of Miscellaneous papers in the field of medicine followed by Pediatrics or Perinatology & Child Health, Surgery, Neurology (clinical), Dermatology, Radiology, Nuclear Medicine and Imaging, Ophthalmology, Microbiology (medical), Public Health, Environmental & Occupational Health and Cardiology, Cardiovascular Medicine and Oncology.

Neurosciences:

Subject Analysis	2005	2006	2007	2008	2009
Behavioral Neuroscience	24	15	19	26	32
Biological Psychiatry	4	11	7	15	11
Cellular and Molecular Neuroscience	15	40	46	50	62
Cognitive Neuroscience	1	4	2	8	8
Developmental Neuroscience	12	8	14	25	28
Neurology	10	31	31	55	46
Neuroscience (miscellaneous)	130	204	228	274	303
Sensory Systems	1	3	1	1	1

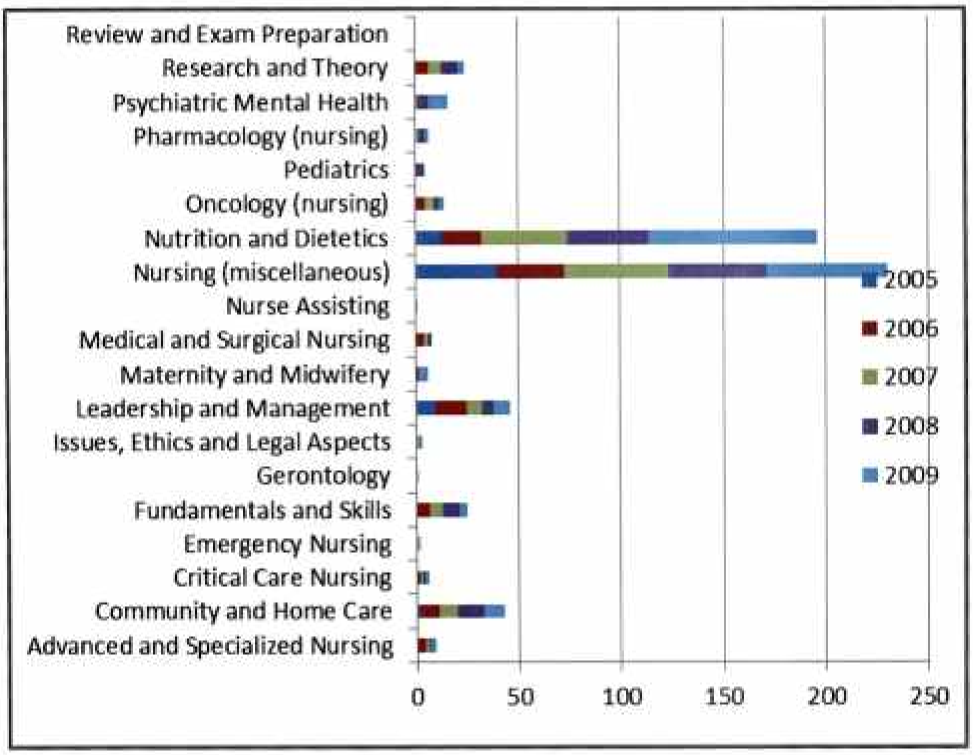


The field of Neurosciences is one of the less explored areas for Indian researchers as indicated by the total papers in this category. The top most area was of the group of miscellaneous papers in

Neurosciences followed by Cellular and Molecular Neuroscience, Neurology, Behavioral Neuroscience, Developmental Neuroscience, Biological Psychiatry, Cognitive Neuroscience and the last one is of papers from Sensory Systems.

Nursing:

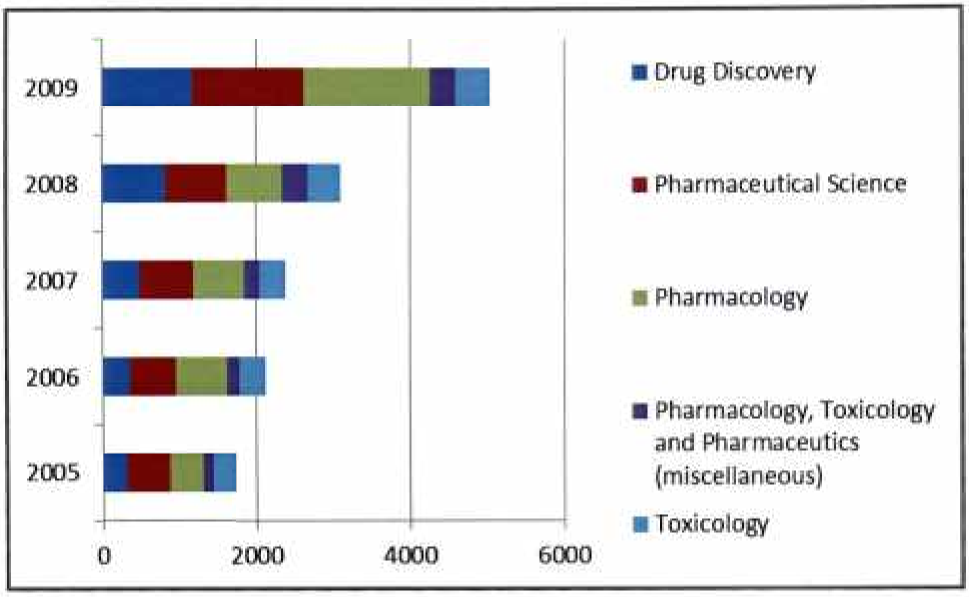
Subject Analysis	**2005**	**2006**	**2007**	**2008**	**2009**
Advanced and Specialized Nursing	-	4	2	1	2
Community and Home Care	2	9	9	13	10
Critical Care Nursing	-	2	1	1	2
Emergency Nursing	-	-	2	-	-
Fundamentals and Skills	-	7	6	8	4
Gerontology	-	-	1	-	-
Issues, Ethics and Legal Aspects	-	-	2	-	1
Leadership and Management	10	15	7	6	8
Maternity and Midwifery	-	1	-	1	4
Medical and Surgical Nursing	-	4	2	2	-
Nurse Assisting	-	-	1	-	-
Nursing (miscellaneous)	40	33	50	48	59
Nutrition and Dietetics	13	19	42	40	82
Oncology (nursing)	-	5	4	3	2
Pediatrics	-	1	-	3	1
Pharmacology (nursing)	-	-	2	3	2
Psychiatric Mental Health	-	-	1	6	9
Research and Theory	-	7	6	8	3
Review and Exam Preparation	-	-	-	-	-



Like 'Neurosciences' the subjects dealing with different issues under 'Nursing' has also did not attracted many researchers. This is also one of the least active areas of study. How- ever there are some papers in the decreasing order in 'Nursing'; miscellaneous papers followed by Nutrition & Dietetics, Community & Home Care, Leadership and Management, Fundamentals & Skills, Research & Theory, Psychiatric Mental Health and some papers related to nursing care of Cancer Patients.

Pharmacology, Toxicology & Pharmaceutics:

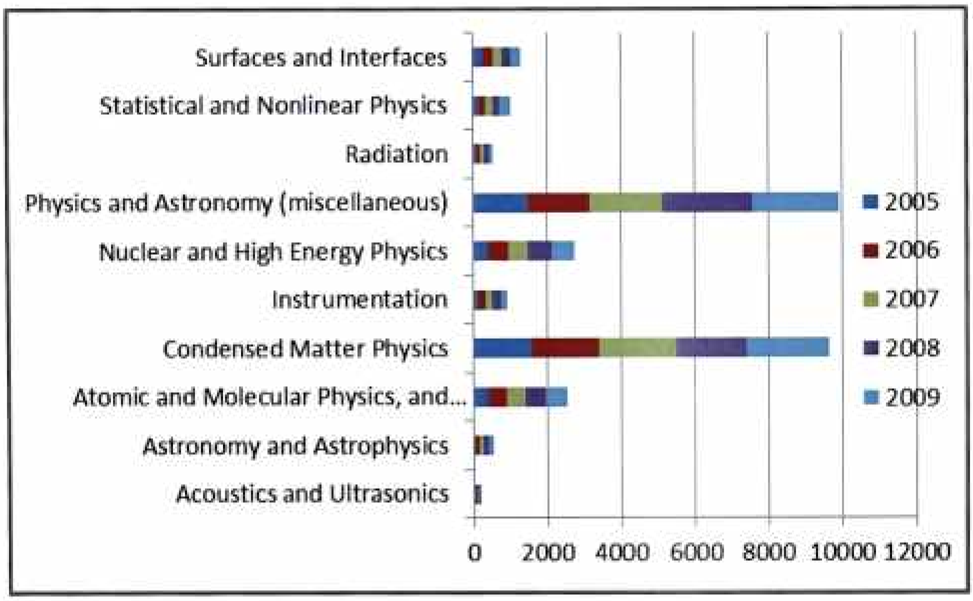
Subject Analysis	2005	2006	2007	2008	2009
Drug Discovery	308	364	497	832	1,172
Pharmaceutical Science	568	594	693	781	1,447
Pharmacology	428	660	665	740	1,638
Pharmacology, Toxicology and Pharmaceutics (miscellaneous)	137	173	187	319	341
Toxicology	285	347	346	435	444



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.

Physics & Astronomy:

Subject Analysis	2005	2006	2007	2008	2009
Acoustics and Ultrasonics	37	42	41	30	40
Astronomy and Astrophysics	64	103	107	108	138
Atomic and Molecular Physics, and Optics	396	478	515	550	619
Condensed Matter Physics	1,569	1,825	2,077	1,912	2,259
Instrumentation	120	212	175	221	172
Nuclear and High Energy Physics	409	548	528	629	627
Physics and Astronomy (miscellaneous)	1,478	1,687	1,949	2,444	2,353
Radiation	86	111	90	141	121
Statistical and Nonlinear Physics	161	155	214	194	292
Surfaces and Interfaces	250	295	228	262	276

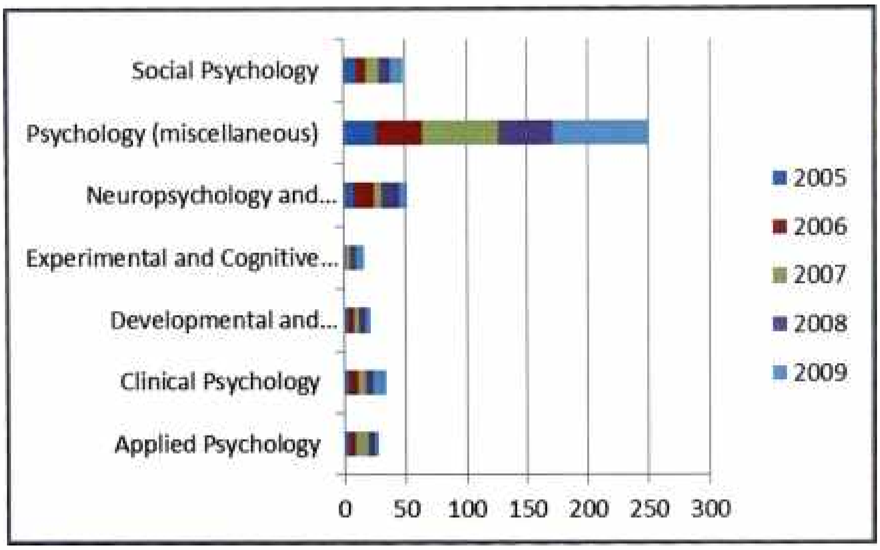


Physical Sciences is not a very strong research field of Indian Researchers, but still there are papers in all the major sub-disciplines of this subject field from India. The top most area is of miscellaneous papers from Physics and Astronomy followed by Condensed Matter Physics, Nuclear and High Energy Physics, Atomic and Molecular Physics, and Optics, Surfaces and Interfaces, Statistical and Nonlinear Physics, Instrumentation, Radiation, Astronomy and Astrophysics, Acoustics and Ultrasonics in the same decreasing order.

Psychology:

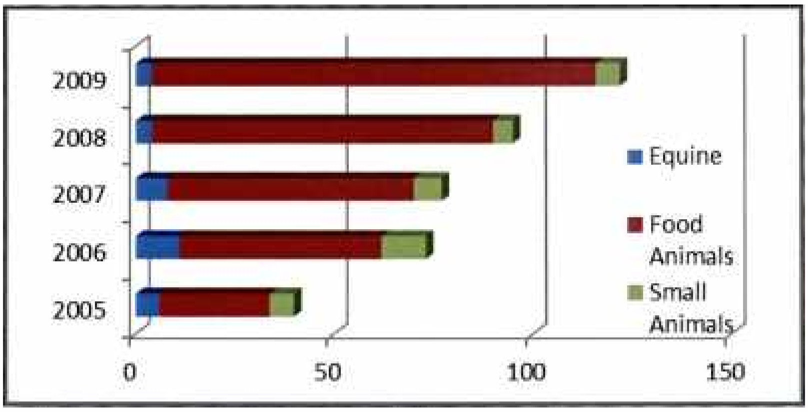
Subject Analysis	2005	2006	2007	2008	2009
Applied Psychology	4	5	10	6	3
Clinical Psychology	4	7	6	6	11
Developmental and Educational Psychology	4	4	4	5	4
Experimental and Cognitive Psychology	1	1	3	5	6
Neuropsychology and Physiological Psychology	8	16	7	14	7
Psychology (miscellaneous)	27	37	62	45	79
Social Psychology	10	8	11	9	11

The next two broad subject areas of 'Psychology' and 'Veterinary Sciences' are also low activity area for Indian Researchers. The policy makers need to look into the matter to support more research activity in the field of 'Psychology' because of increasing 'stress' conditions and growing life expectancy of Indian population.



Veterinary Science:

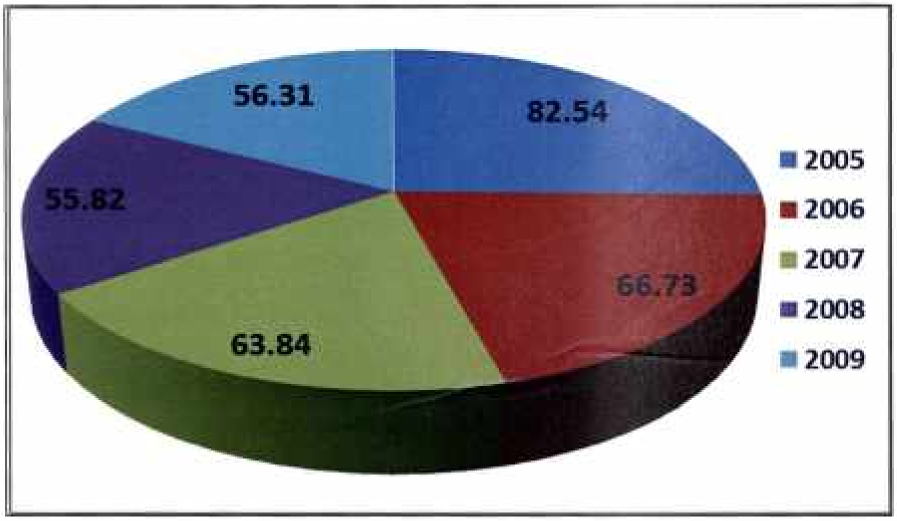
Subject Analysis	2005	2006	2007	2008	2009
Equine	6	11	8	4	4
Food Animals	28	51	62	86	112
Small Animals	6	11	7	5	6
Veterinary (miscellaneous)	704	744	926	1,089	1,119



Journal Analysis

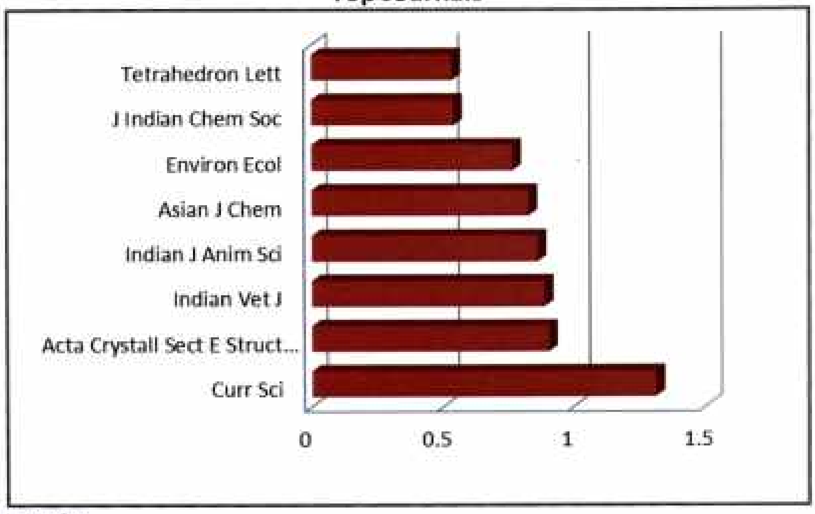
There were total 9618 journals publishing a total of 3,43,599 (Master Journal list available in Appendix on CD) papers during the whole study period (2005-09). The first 50% papers (around 1,71,770) appeared in a total of 382 journals with an average of approximately 449.65 papers per journal. The rest of the papers were distributed among a total of 9,236 with an average of 18.61 papers per journal. In a study, Buchandiran (2011) have reported that the prestigious high impact scientific journals, publish more papers of international authorship. However, the journals that have moderate or less impact publish more national papers. This is true for the journals published in the Asian and Latin American countries. Among the Chinese, South Korean and Indian journals, only two Chinese and two Indian journal have the impact factor of more than 1. The impact factor values of 145 Chinese, South Korean and Indian journals (covered in ISI) is much less and can be deemed as national rather than international because of their low visibility and less international reception.

Percentage of total Journals of Indian papers in 2005-09 (INSI)



The minimum percentage of Journal was 55.82 during 2008, whereas maximum percentage was 82.54 during 2005. During the rest of the years it was 66.73 (2006), 63.84 (2007) and 56.31 during the year of 2009.

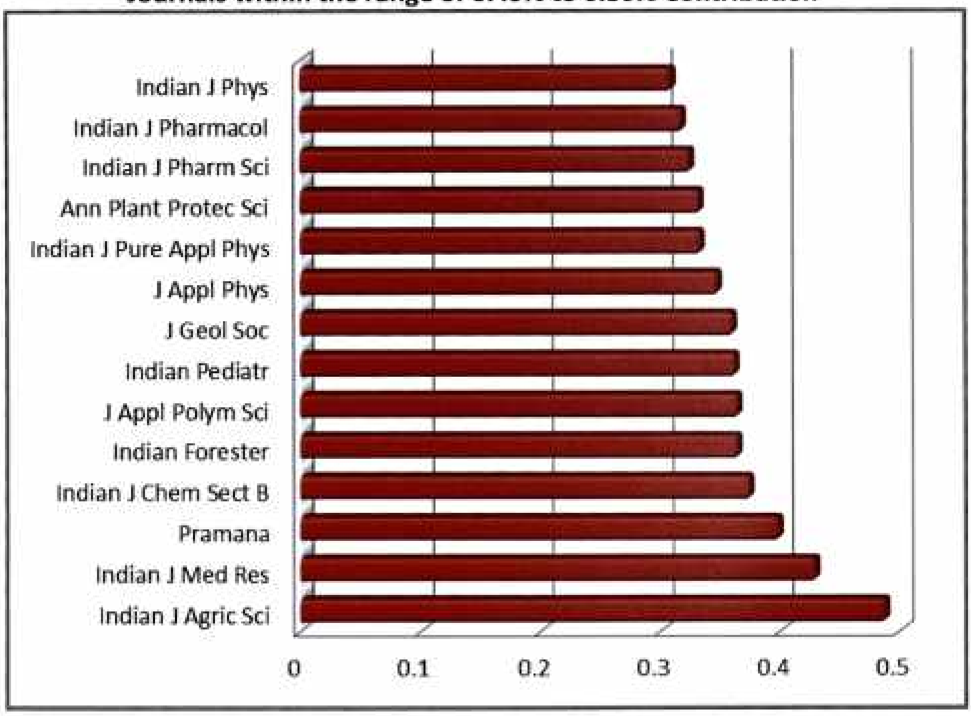
Top Journals



Most Prolific Journals:

The top most journal having 4455 Papers was *Curr Sci* (1.31%) followed by *Acta Crystall Sect E* (0.90% - 3067 Papers), *Indian Vet J* (0.89% - 3013 papers), *Indian J Anim Sci* (0.86% - 2927 Papers), *Asian J Chem Sci* (0.83% - 2807 Papers), *Environ Ecol* (0.76% - 2599 Papers), *J Indian Chem Soc* (0.54% - 1837 Papers) and *Tetrahedron Lett* (0.53% -1813 Papers).

Journals within the range of 0.49% to 0.30% Contribution



The next group is of, having papers between the range of 0.30% to 0.49% *Indian J Agric Sci* stood at the top position (0.49% - 1660 papers). The other journals in this category were *Indian J Med Res, Pramana, Indian J Chem Sect B, Indian Forester, J Appl Polym Sci, Indian Pediatr, J Geol Soc, J Appl Phys, Indian J Pure Appl Phys, Ann Plant Protect Sci, Indian J Pharm Sci, Indian J Pharmacol* and *Indian J Phys.*

Journals with their subject Category having share of >0.15%

Journal	**Subject Area**
Curr Sci	*Mutltdisciplinary*
Acta Crystall Sect E	*Chemical Science*
Indian Vet J	*Agricultural Science*
Indian J Anim Sci	*Agricultural Science*
Asian J Chem	*Chemical Science*
Earth and Environ Sci Ecol	*Earth and Environmental Science*
J Indian Chem Soc	*Chemical Science*
Tetrahedron Lett	*Chemical Science*
Indian J Agric Sci	*Agricultural Science*
Indian J Med Sci Res	*Medical Science*
Pramana	*Physical Science*
Indian J Chem Sect B	*Chemical Science*
Indian Forester	*Biological Science*
J Appl Polym Sci	*Chemical Science*
Indian Pediatr	*Medical Science*
J GeolSoc	*Earth and Environmental Science*
J Appl Phys Sci	*Physical Science*
Indian J Pure Appl Phys	*Physical Science*
Ann Plant Protec Sci	*Biological Science*
Indian J Pharm Sci	*Medical Science*
Indian J Pharmacol	*Medical Science*
Acta Cienc Indica Math	*Mathematics*
Res Crop	*Agricultural Science*
Indian J Heterocyclic Chem	*Chemical Science*
J Econ Taxon Bot	*Biological Science*
Indian J Exp Biol	*Biological Science*
Pollut Res	*Earth and Environmental Science*
Bull Mater Sci	*Engineering & Technology*
Karnataka J Agric Sci	*Agricultural Science*
J SciInd Res	*Multidisciplinary*
Bioorg Med Sci Chem Lett	*Chemical Science*
J Hazard Mater	*Earth and Environmental Science*
Indian J Chem Sect A	*Chemical Science*
Indian J Hort	*Agricultural Science*
Adv Pl Sci	*Biological Science*
Spectrochim Acta A	*Chemical Science*
J Food Sci Tech Mysore	*Biological Science*
Tetrahedron	*Chemical Science*
Bioresour Technol	*Biological Science*
Pl Archs	*Biological Science*
J Alloy Compd	*Chemical Science*
Indian J Med Microbiol	*Medical Science*
PhysSci Rev B	*Physical Science*
Indain J Pediatr	*Medical Science*
Synth Commun	*Engineering &Technology*
J PhysChem B	*Physical Science*
Zoos Print J	*Biological Science*
ApplPhysSci Lett	*Physical Science*
PhysSci Rev Lett	*Physical Science*
J Agromed	*Medical Science*
Medical Sci J Armed Forces India	*Medical Science*
Indian J Biotech	*Biological Science*
Ecol Conserv	*Earth and Environmental Science*
Pestology	*Earth and*

	Atmospheric Science
AgricScienceSci Dig	Agricultural Science
Indian J Otolaryngol Head Neck Surg	Medical Science
Indain J Dermatol Venorol Leprol	Medical Science
J Soil Crops	Agricultural Science
Pl Arch	Biological Science
Ultra Sci	Physical Science
Polyhedron	Chemical Science
J Phys Sci D	Physical Science
Mater Lett	Engineering & Technology
Antiseptic	Medical Science
J Earth Environ Sci	Biological Science
J Indian Med Sci Assoc	Medical Science
Pharmacol Online	Medical Science
Indian J Chem Tech	Chemical Science
Indian J Tradl Knowl	Biological Science
PhysSci Rev C	Physical Science
Ann Plant Physiol	Biological Science
Crop Res	Agricultural Science
IndEnginChem Res	Engineering & Technology
J Mater Sci	Engineering & Technology
Indian J Field Vet	Agricultural Science
J Gastroentorol Hepatol	Medical Science

J ChemPhysSci	Chemical Science
Indian J For	Biological Science
E J Chem	Chemical Science
J EcolSci	Biological Science
Mater Sci Engin A	Engineering & Technology
Biosci Biotech Res Asia	Biological Science
Int J ChemSci	Chemical Science
Legume Res	Agricultural Science
J Nanosci Nanotech	Physical Science
J ChemSci	Chemical Science
Neurol India	Medical Science
Indian J Agron	Agricultural Science
Trans Indian Inst Metal	Chemical Science
Eur J Medical Science Chem	Medical Science
Indian J Opthalmol	Medical Science
Mater Chem Physical Science	Mutltdis
Physical Science Lett B	Physical Science
Life Sci J	Biological Science
J Assoc Physical Science India	Medical Science
Def Sci J	Multidisciplinary
Afr J Biotech	Biological Science
Earth and Environmental Science Monit Assess	Earth and Environmental Science
Indian J Engin Mater Sci	Engin & Technol

There are total 100 Journals with a percentage share of more than 0.15%. The average paper in this category was 9.19 paper /journal.

The journal contributing the largest number of papers is ranked as number one, next is ranked two and so on. There are total 150 core journals covered in first zone having total 1,16,907 papers The top 60 journals of first core are as follows:

Ranked list of Core journals 2005-09 (all the subject areas)

Curr Sci	Asian J Chem	Indian J Agric Sci
Acta Crystall Sect E	Environ Ecol	Indian J Med Res
Indian Vet J	J Indian Chem Soc	Pramana
Indian J Anim Sci	Tetrahedron Lett	Indian J Chem Sect B

Indian Forester
J Appl Polym Sci
Indian Pediatr
J Geol Soc
J Appl Phys
Indian J Pure Appl Phys
Ann Plant Prot Sci
Indian J Pharm Sci
Indian J Pharmacol
Indian J Phys
Acta Cienc Indica Math
Res Crop
Indian J Heterocy Chem
J Econ Taxon Bot
Indian J Exp Biol
Pollut Res
Bull Mater Sci

Karnataka J Agric Sci
J Sci Ind Res
Bioorg Med Chem Lett
J Hazard Mater
Indian J Chem Sect A
Indian J Hort
Adv Pl Sci
Spectrochim Acta A
J Food Sci Tech Mysore
Tetrahedron
Bioresour Technol
Pl Archs
J Alloy Compd
Indian J Med Microbiol
Phys Rev B
Indain J Pediatr
Synth Commun

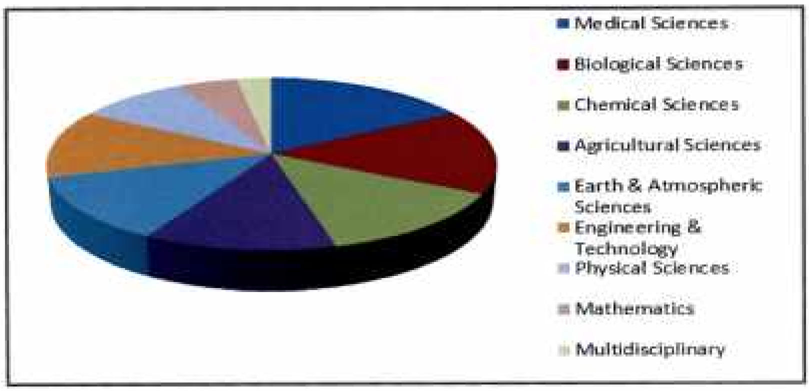
J Phys Chem B
Zoos Print J
Appl Phys Lett
Phys Rev Lett
J Agromed
Med J Armed Forces India
Indian J Biotech
Ecol Environ Conserv
Pestology
Agric Sci Dig
Indian J Otolaryngol Head Neck Surg
Indain J Dermatol Venorol Leprol
J Soil Crops
Pl Arch

In 2nd zone there is a total of 1750 Journal with 170668 papers. Top 10 journals from this category are as follows:

Mon Not R Astron Soc
Indian J Weed Sci
Vet Pract
Uttar Pradesh J Zool
Indian Med Gaz
Appl Math Comput
J Vet Parasitol
Indian J Microbiol
J Appl Zool Res
Pestic Res J

Subject Area & Journal Analyses- Top Most Journals:

These top journals belong to all the broad subject areas, as defined by NSTMIS (DST) In this 'category' maximum journals were from the area of **Medicine (24), Biological Science (23) and Chemical Science (19) followed by Agricultural Science, Earth and Atmospheric Science, Engineering & Technology (18 each), Physical Science (13),** and for **Mathematics** there were only **6 journals** in the **top most** category while in the category of Multidisciplinary Sciences, there was 5 journals only.



The top most ten journals for all the subject categories (individually in decreasing order of contribution) are:

Agricultural Sciences : *Indian Vet J, Indian J Anim Sci, Indian J Agric Sci, Res Crop, Karnataka J Agric Sci, Indian J Hortcult, Agric Sci Dig, J Soil Crops, Crop Res, Indian J Field Vet.*

Biological Sciences: *Indian Forester, Ann Plant Protect Sci, J Econ Taxon Bot, Indian J Exp Biol, Adv Pl Sci, J Food Sci Tech Mysore, Bioresour Technol, Pl Archs, Zoos Print J, Indian J BioTech*

Chemical Sciences: *ACTA Crystall Sect E, Asian J Chem, J Indian Chem Soc, Tetrahedron Lett, Indian J Chem Sect B, J Appl PolymSci, Indian J Heterocyclic Chem, Bioorg Med Chem Lett, Indian J Chem Sect A, SpectrochimActa A*

Earth & Atmospheric Sciences : *Environ Ecol, J GeolSoc, Pollut Res, J Hazard Mater, Ecol Environ Conserv, Pestology, Environ Monit Assess, J Ecotoxic Environ Monit, Nature Environ Pollut Tech, J Earth Syst Sci.*

Engineering & Technology: *Bull Mater Sci, Synth Commun, Mater Lett, Ind Engin Chem Res, J Mater Sci, Mater Sci Engin A, Indian J Engin Mater Sci, J Struct Eng ASCE, Chem Engin J, Colloid Surf A Physicochem Engin.*

Mathematics: *Acta Cienc Indica Math, Appl Math Comput, J Phys A Math Gen, Bull Calcutta Math Soc, J Discrete Math Sci Cryptograph, J Indian Acad Math, Proc Indian Acad Sci Math Sci,*

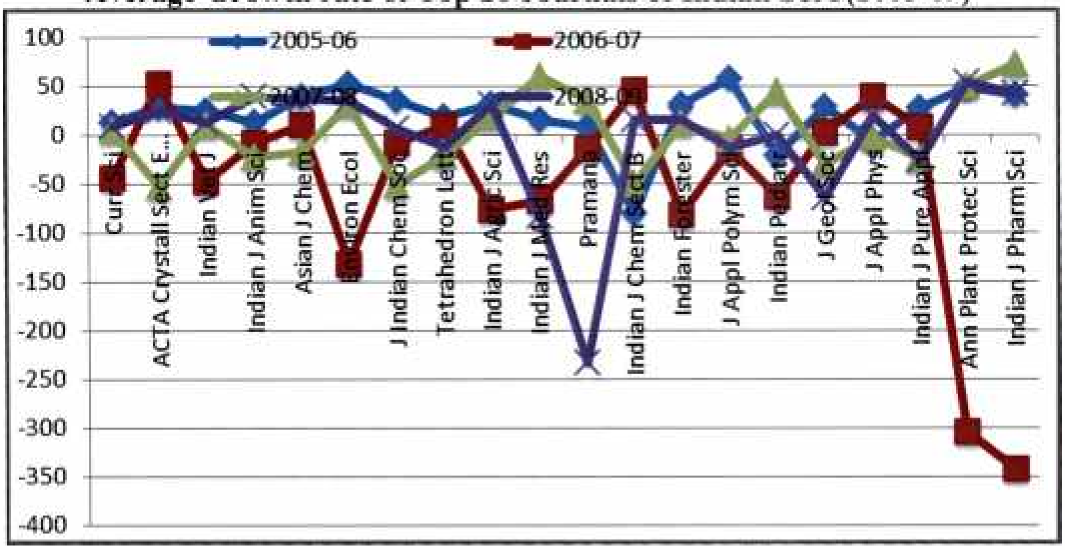
Medical Sciences: *Indian J Med Res, Indian Pediatr, Indian J Pharm Sci, Indian J Pharmacol, Indian J Med Microbiol, Indain J Pediatr, J Agromed, Med J Armed Forces India, Indian J Otolaryngol Head Neck Surg, Indain J Dermatol Venorol Leprol.*

Physical Sciences : *Pramana, J Appl Phys, Indian J Pure Appl Phys, Indian J Phys, Phys Rev B, J Phys Chem B, Appl Phys Lett, Phys Rev Lett, Ultra SciPhysSci, J Phys D Appl Phys*

Multidisciplinary Sciences: *Curr Sci, J Sci Ind Res, Mater Chem Phys, Def Sci J.*

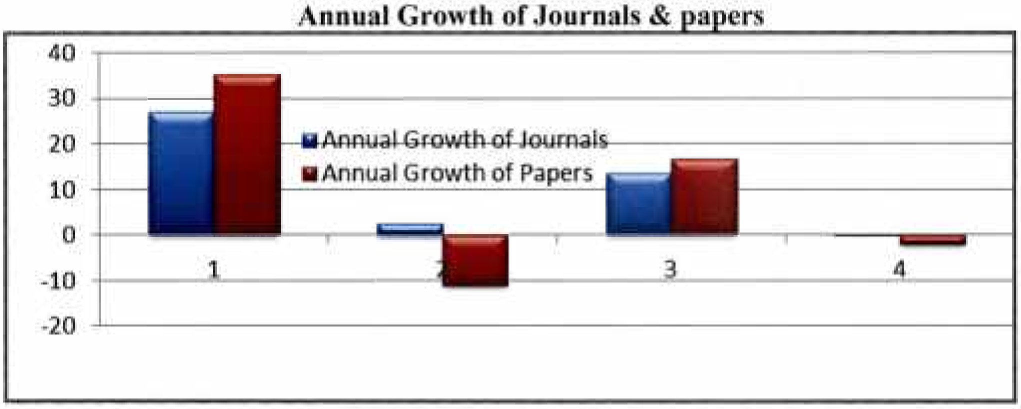
Annual Growth rate of Inclusion of Indian Papers in Journals:

Average Growth rate of Top 20 Journals of Indian S&T(2005-09)



For computing annual growth rate of journals, only top 20 Journals having maximum papers indexed in INSI were considered. During the period of 2007-08 the annual growth of journals was at the peak. While during 2006-07 the annual growth rate was minimum.

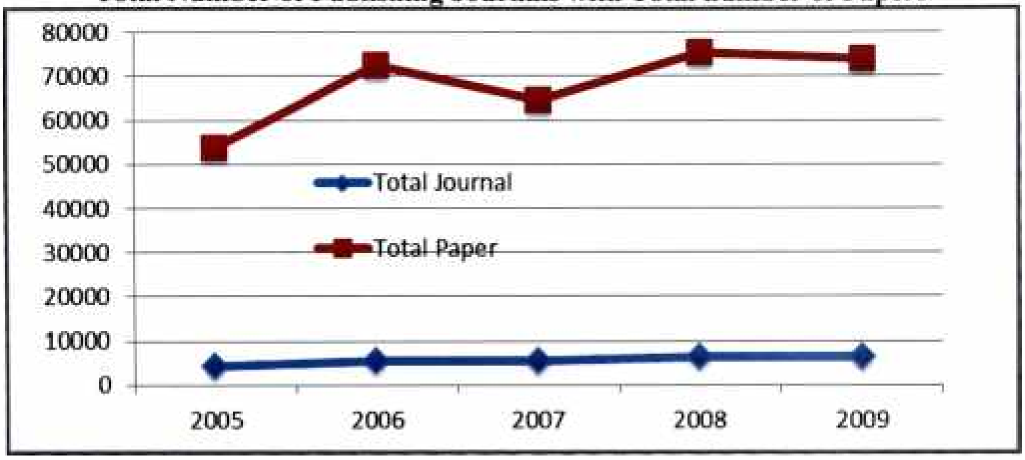
Annual Growth of Journals & papers



During the period of study annual growth of Journals and coverage of Indian Papers was at its maximum in 2005-06 & 2007-08. During 2006-07 and 2008-09 the annual growth rate of Journals having Indian Papers was minimum.

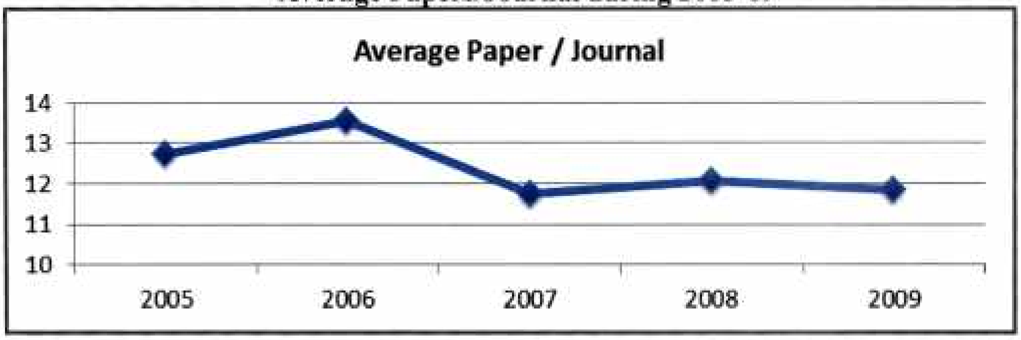
Average growth Rate

Total Number of Publishing Journals with Total number of Papers



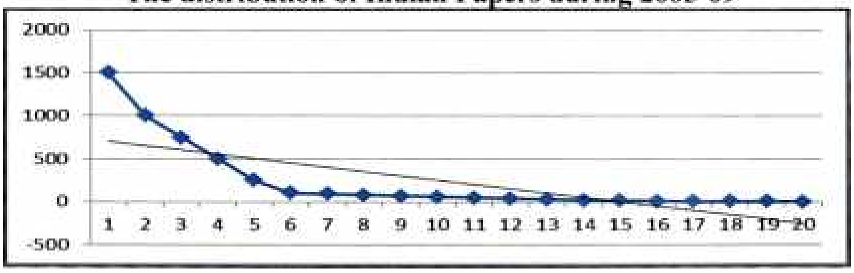
The total 3,43,599 papers appeared in 9,618 Journals. During 2008 number of journals was maximum (6156) along with maximum number of papers also.

Average Papers/Journal during 2005-09



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.

The distribution of Indian Papers during 2005-09



Bradford's law of scattering

Research has been made in Library and Information Science (LIS) about how the literature is scattered, for example, how the articles about a particular subject is scattered in scientific journals. One can also use the opposite expression: how articles on a given subject are concentrated in journals. Generally, how documents are scattered (or concentrated) in different sources. Scattering has mostly been considered in relation to what is known as Bradford's law. It is, however, possible to approach this phenomenon from other points of view.

'Bradford's law of scattering' first formulated by Bradford (1934, 1948) and coined so by Vickery (1948) is a particular bibliometric law. The law states that documents on a given 'subject' is distributed (scattered) according to a certain mathematical function so that a growth in papers on a subject requires a growth in the number of journals/information sources. The numbers of the groups of journals to produce nearly equal numbers of articles is roughly in proportion to 1: n: n2 …, where n is called the Bradford multiplier. (Bradford believed n to be constant in the different zones (n1=n2=n). However Results reported by Rao (1998) indicates, that Bradford's assumption was wrong: Bradford multipliers vary from zone to zone). Explained in words, Bradford's law states that a small core of, for example, journals have as many papers on a given subject as a much larger number of journals, n, which again has as many papers on the subject as n2 journals.

It is sometimes claimed that Bradford's law is not only about quantitative issues but also about qualitative issues: That the most productive journals on a subject are also the best journals (and thus the journals that should be selected by users). This claim is problematic given that different epistemologies are at play in disciplines and that the dominant view in one place and time need not be the best or the winning one. Journals which at a time represent a minority view and thus are regarded 'less quality' in relation to a Bradford distribution may later represent a majority view. Experimental methods, for example, dominates in social psychology, but journals with a more macro-sociological orientation may be seen as being of an even quality (or perhaps higher quality) even if they publish much less papers.

Now the question comes 'How should different patterns in scattering be understood and explained'? Authors make decisions about where to publish their papers. They may choose to publish them in many different places (scattered) or to publish them in a few journals (concentrated). There may be individual variation in this form of publishing behavior. However, general patterns in scattering may reflect underlying norms, cultures and constraints. Some fields are more interdisciplinary, some cultures are more open, and some fields have a high degree of consensus about which journals are the most important and so on. In some field are national traditions important, in other not.

The most scattered subjects may be the subjects that are broad and have a high probability of being researched in many different contexts. The least scattered subjects may be the subjects that require very special equipment that only exists in a few laboratories. In this way may the scattering of subjects reflect the social organization of knowledge?

In every subject there are some journals which are frequently referred by the researchers because of the close relation between the subject of the journals and the areas of research work. These highly cited journals are listed as core journals of the specific subject. The core journals are considered as 'central set of journals, which most clearly reflects the conceptual essence of the research being reported in the discipline'.

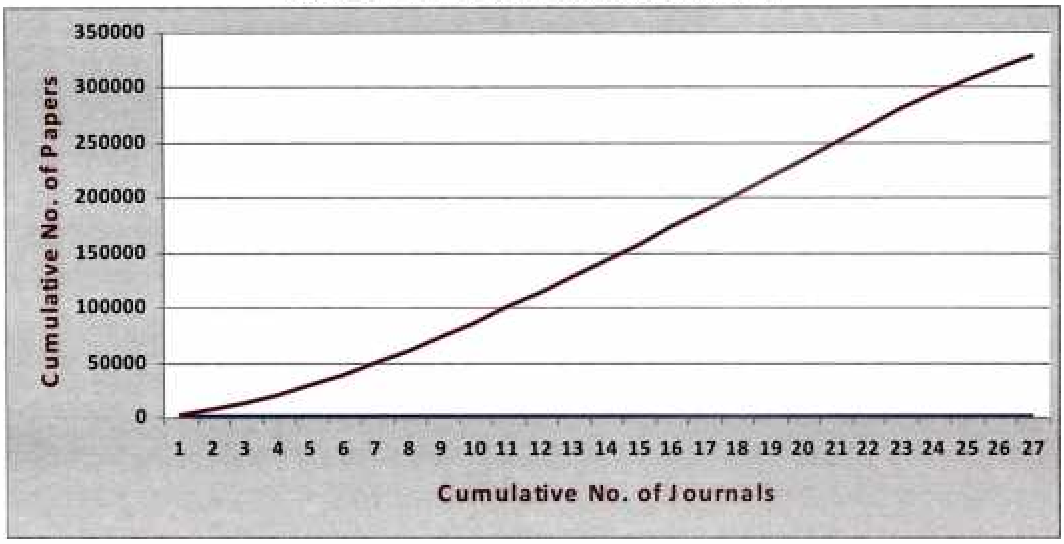
The core journals always contain a higher concentration of papers in a particular discipline. There is a relation in the number of journals in the nuclear or most productive zone, to the number of journals in successively less productive zones containing equal numbers of papers. Core journals ranking studies are usually made to help in the selection of journals and in assessing the importance of one or more journals in a particular subject field.

The data for 2005-09 (as defined by Bradford)

	2005		2006		2007		2008		2009	
	Total Papers	Total Journals	Total Papers	Total Journals	Total Papers	Total Journals	Total Papers	Total Journals	Total Papers	Total Journals
zone 1	13572	69	18393	72	15980	72	18574	79	18608	75
zone 2	27009	718	36608	840	31988	840	38443	1035	37016	1043
zone 3	13460	3423	18411	4439	17838	4439	19165	5129	18534	5116
Total	54041	4210	73412	5351	65806	5351	76182	6243	74158	6234
% of articles per journal	12.83		13.72		12.3		12.2		11.9	
$1 : n : n^2$	1:3.88: 57.88		1: 4.75: 113.38		1: 4.92: 105.67		1: 4.87: 132.13		1: 5.72: 163.94	

We tried to explore the pattern of distribution of papers in journals and identify 'Core Journals' for Indian S & T Papers, through 'Bradford's Law of Scattering.

Bradford Curve of Publishing Journals



The Core Journals in the first zone of Bradford Curve have been identified, which is as followed:

Journal
Curr Sci
Acta Crystall Sect E Struct Rep Online
Indian Vet J
Indian J Anim Sci
Asian J Chem
Environ Ecol
J Indian Chem Soc
Tetrahedron Lett
Indian J Agric Sci
Indian J Med Res

Pramana
Indian J Chem Sect B
Indian Forester
J Appl Polym Sci
Indian Pediatr
J Geol Soc
J Appl Phys
Indian J Pure Appl Phys
Ann Plant Protec Sci
Indian J Pharm Sci
Indian J Pharmacol

Indian J Phys
Acta Cienc Indica Math
Res Crop
Indian J Heterocyclic Chem
J Econ Taxon Bot
Indian J Exp Biol
Pollut Res
Bull Mater Sci
Karnataka J Agric Sci
J Sci Ind Res
Bioorg Med Chem Lett
J Hazard Mater
Indian J Chem Sect A
Indian J Hort
Adv Pl Sci
Spectrochim Acta A Mol Biomol Spectrosc
J Food Sci Tech Mysore
Tetrahedron
Bioresour Technol
Pl Archs
J Alloy Compd
Indian J Med Microbiol
Phys Rev B
Indain J Pediatr
Synth Commun
J Phys Chem B
Zoos Print J
Appl Phys Lett
Phys Rev Lett
J Agromed
Med J Armed Forces India
Indian J BioTech
Ecol Environ Conserv
Pestology
Agric Sci Dig
Indian J Otolaryngol Head Neck Surg
Indain J Dermatol Venorol Leprol
J Soil Crops
Pl Arch
Ultra Sci Phys Sci

Polyhedron
J Phys D Appl Phys
Mater Lett
Antiseptic
J Environ Biol
J Indian Med Assoc
Pharmacol Online
Indian J Tradl Knowl
Indian J Chem Tech
Phys Rev C
Ann Plant Physiol
Crop Res
Ind Engin Chem Res
J Mater Sci
Indian J Field Vet
J Gastroentorol Hepatol
J Chem Phys
Indian J Forestry
E J Chem
J Ecobiol
Mater Sci Engin A
Biosci Biotech Res Asia
Int J Chem Sci
Legume Res
J Nanosci Nanotech
J Chem Sci
Neurol India
Indian J Agron
Trans Indian Inst Metal
Eur J Med Chem
Indian J Opthalmol
Mater Chem Phys
Phys Lett B
Life Sci J
J Assoc Phys India
Def Sci J
Afr J Biotech
Environ Monit Assess
Indian J Engin Mater Sci

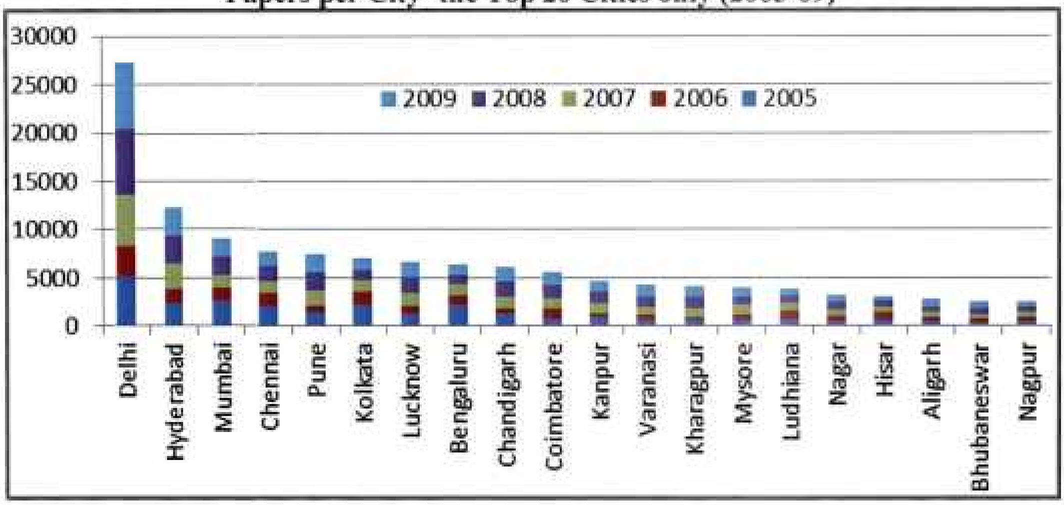
It is suggested that all the national libraries of India in the field of Science & Technology including Medical Sciences & Agricultural Sciences should have these journals in their collection as they cover approximately 50% of the total research papers.

Geographical Analysis

Commitment of Cities towards Research Papers

A total of 987 cities have contributed all the 3,43,599 papers in the field of S & T, including medicine & agriculture. Delhi (New Delhi also included) ranked 1st among all the cities with its share of 8.92% on the basis of papers during the period of 2005-2009. 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%) in decreasing order of contribution The overall share for the period (2005-2009) of top 20 cities ranged from 0.73% to 8.92%.

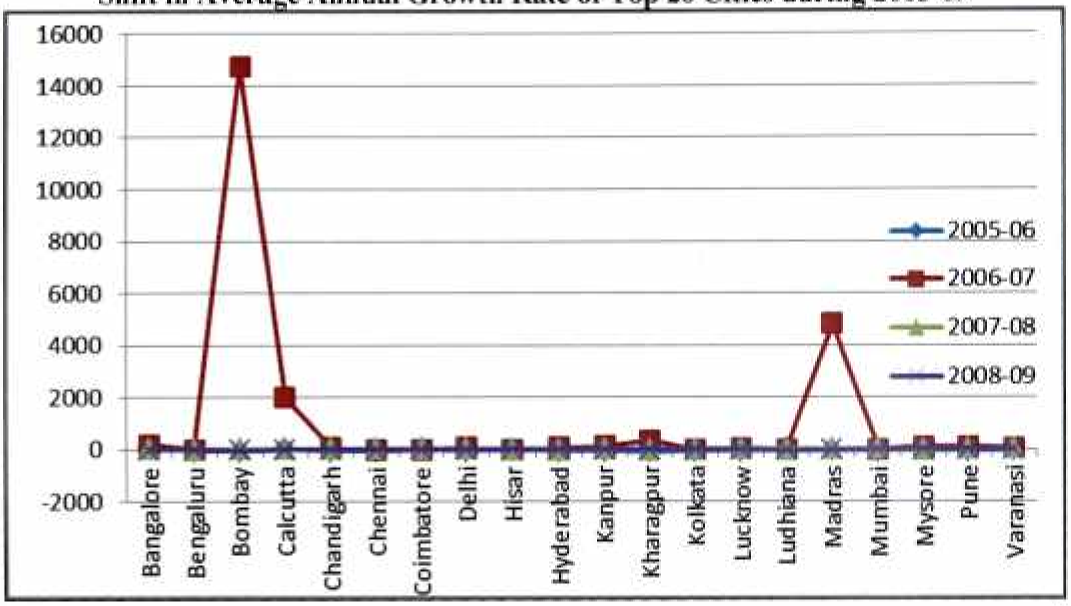
Papers per City- the Top 20 Cities only (2005-09)



The Annual Growth Rate:

The annual growth rate of cities in top 20 is from -7.82 to 7.52 during successive years. Kharagpur and Kanpur were the top most growing cities. Their annual growth rate increased from -66.69 to 34.312 Mysore was at 16th position but its growth rate was highest during five years.

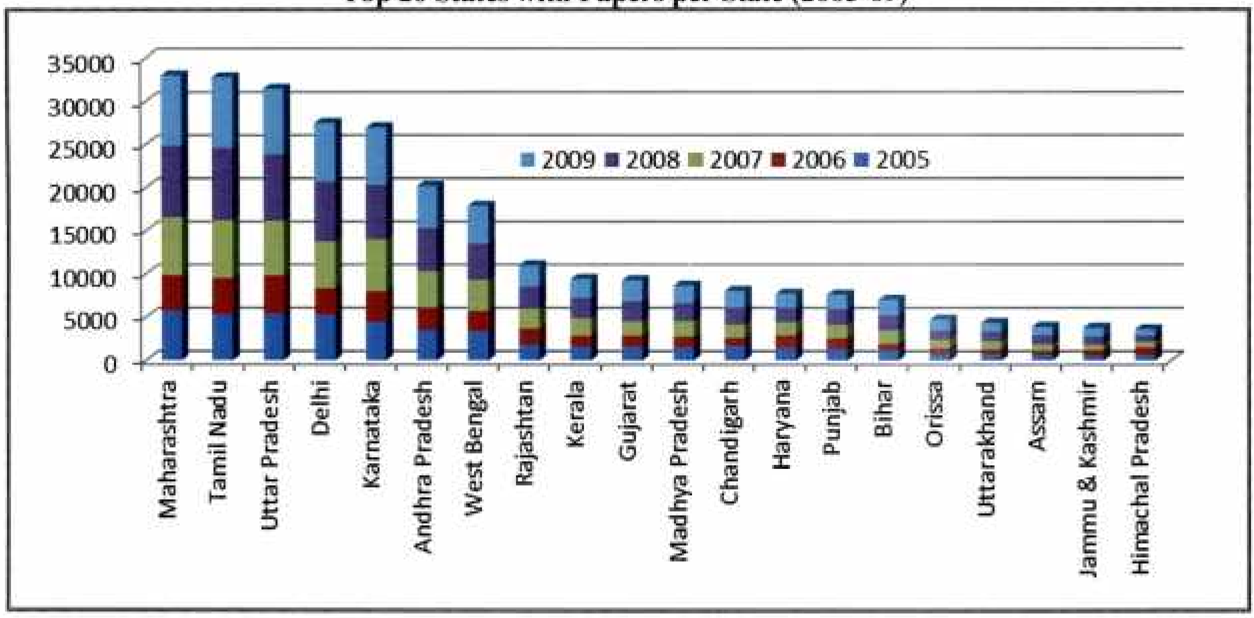
Shift in Average Annual Growth Rate of Top 20 Cities during 2005-09



Contribution of States towards Indian Papers:

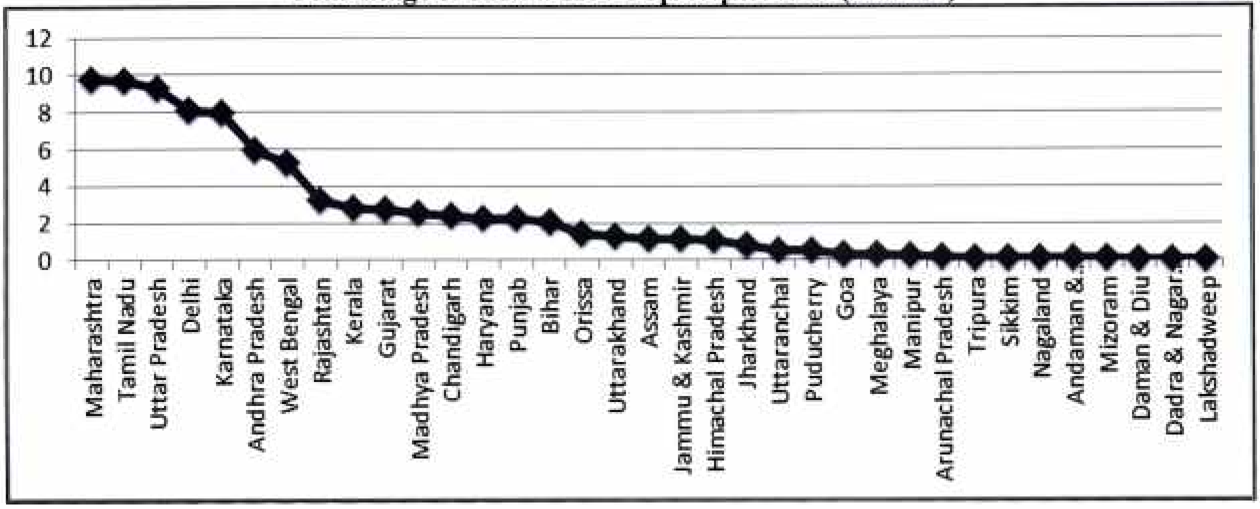
There are total 34 states contributing a total of 3,43,599 Papers in INSI database. Maharashtra is the only state which has maintained its top position (9.72% total contributions), throughout the period of the study (2005-09) with an exception in the year of 2008 and 2009, when it's position slide down to 2nd place. Tamil Nadu was at the 2nd position among top 20 during 2005-09. Uttar Pradesh also was having more or less number of papers as that of Maharashtra during 2005-09.

Top 20 States with Papers per State (2005-09)



There is need of concern for the states of Jammu & Kashmir, Dadra & Nagar Haveli and Lakshadweep as the number of research papers appearing from these parts of India are negligible.

Percentage of Indian S&T Papers per State (2005-09)



Annual Growth Rate:

The papers from India have grown significantly (7.92% to 9.01%) during the five year period (2005-09). Some of the states that have shown rapid growth in their publications are Uttar Pradesh, Maharashtra, Delhi and Tamil Nadu. The number of papers from top states are in the range of 0.97 (Himanchal Pradesh) to 9.01% (Uttar Pradesh). The total percentage for 5 years was in the range of 0.0005 (Lakshadweep) to 9.01 % (Uttar Pradesh).

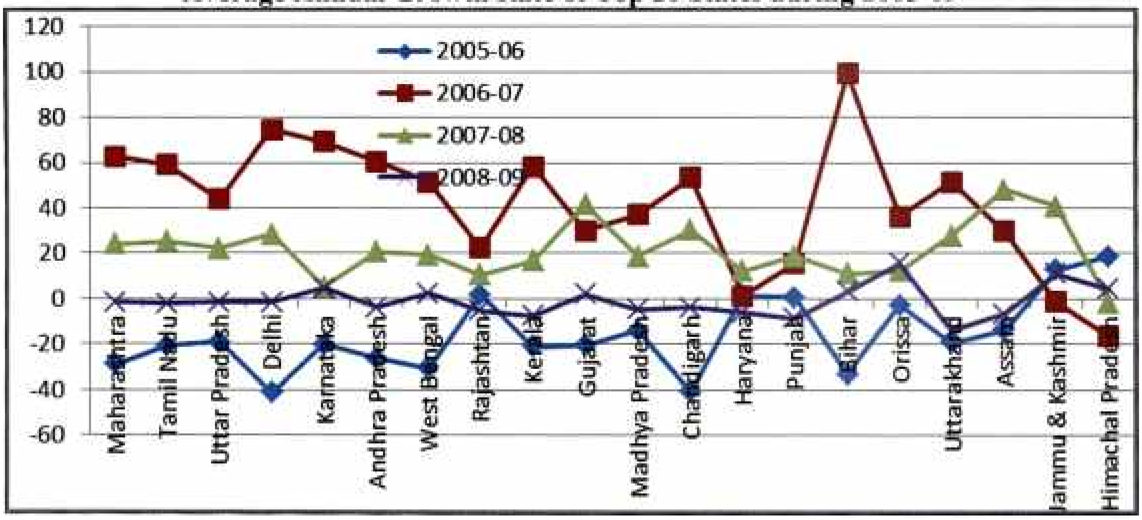
Annual Growth Rate of Papers from Indian States

State	2005-06	2006-07	2007-08	2008-09
Maharashtra	-28.85	62.7	24.1	-1.6
Tamil Nadu	-20.87	59.1	25.3	-2.2
Uttar Pradesh	-19.08	43.7	22	-1.7
Delhi	-41.39	74.6	28.2	-1.6
Karnataka	-20.06	69.2	5.18	4.64
Andhra Pradesh	-26.32	60.5	20.8	-3.7
West Bengal	-30.65	51.4	19.2	2.4
Rajashtan	1.73	22.3	10.6	-5.2
Kerala	-20.97	58.2	16.7	-7.6
Gujarat	-20.44	30.1	41.7	2.13
Madhya Pradesh	-13.92	36.9	18.6	-4.8
Chandigarh	-40.79	53.4	30.3	-3.8
Haryana	1.44	1.35	12.2	-6.2
Punjab	0.61	15.6	18.8	-8.6
Bihar	-33.13	99.2	11.1	3.13
Orissa	-2.74	36.1	12.3	15.7
Uttarakhand	-19.35	51.4	27.8	-14
Assam	-13.74	29.9	48	-6.8

Jammu & Kashmir	12.76	-1.4	40.6	11
Himachal Pradesh	18.79	-17	-1.4	4.41
Jharkhand	-21.62	57.5	12.9	-15
Uttaranchal	-2.07	-18	5.14	-40
Puducherry	-26.2	35.1	29.6	-2.1
Goa	-20.81	35.3	39.8	-9.2
Meghalaya	-21.39	33.5	-4.7	7.96
Manipur	27.98	-17	0.56	-21
Arunachal Pradesh	21.52	11	55.3	-23
Tripura	4.88	34.9	48.3	22
Sikkim	116	-11	27.1	8.2
Nagaland	1.96	-27	10.5	40.5
Andaman &	48.72	-33	-7.7	25
Mizoram	40	25	51.4	37.7
Daman & Diu	20	-33	-25	33.3
Dadra & Nagar	-50	0	-100	
Lakshadweep			0.1	0.09

The average growth rate of the top 20 states is from -41.39 to 99.89 during 2005-09. 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.

Average Annual Growth Rate of Top 20 States during 2005-09



Subject wise Contribution of States:

The data was analyzed to compute the total number of papers being published from different states of India, in the broad subject area (as defined by NSTMIS) also**. Here, this may be mentioned that the**

total number of papers may exceed the actual number, as the same paper may get classified in more than one subject area.

- The data have indicated that 'Maharashtra' have contributed maximum papers covering all the areas of study, but maximum papers were in the field of **Chemical Sciences** followed by **Medical and Physical Sciences.**

- From the table (below) it is clear that '**Mathematics**' is the least explored area in terms of research papers being published from all the states together.

- Next area which has a gap is the area of '**Earth & Atmospheric Sciences'**. The union territories of India namely, 'Lakshadweep' and 'Dadra & Nagar Haveli' have published papers only in two area *i.e.* Biological Sciences & Medical Sciences. Being a coastal area, the state may be encouraged to carry out more studies in the field of 'Earth & Atmospheric Sciences & Physical Sciences' also.

- 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 area 'Agricultural Sciences' where all the states have contributed papers except 'Dadra & Nagar Haveli' and Lakshadweep.

State wise contribution of papers in subject areas

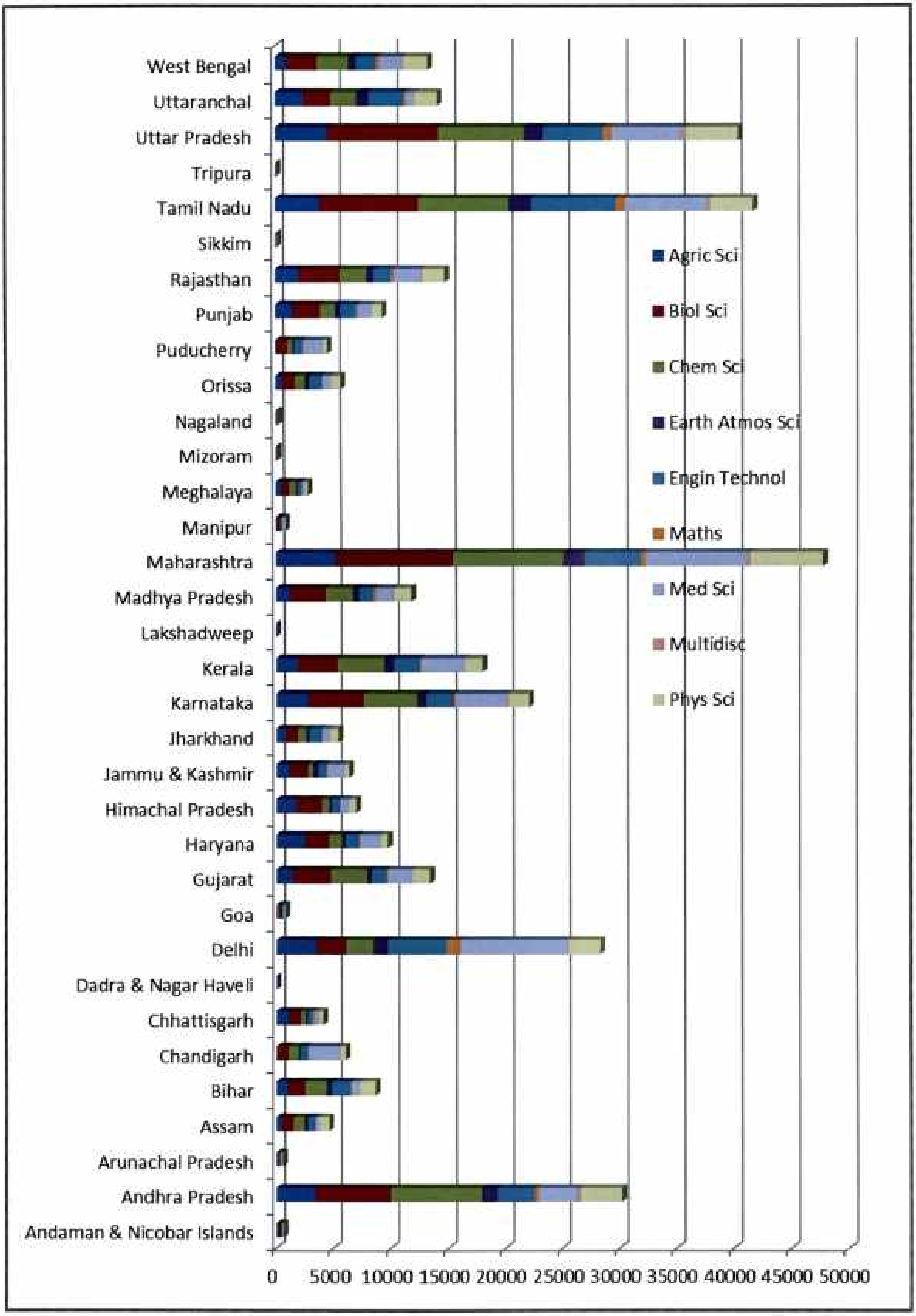
State	Agric Sci	Biol Sci	Chem Sci	Earth Atmos Sci	Engin Technol	Maths	Med Sci	Multidisc	Phys Sci	Others	Total Papers*
Maharashtra	5534	9901	10294	1928	5316	495	9360	233	6626	81	49768
Tamil Nadu	4203	7903	8473	2064	7853	940	7534	398	4130	92	43590
Uttar Pradesh	4879	7673	8076	1663	5817	821	6641	296	4848	72	40786
Andhra Pradesh	3444	2622	2962	1323	5477	1105	8782	162	3011	76	28964
Delhi	3512	2594	8295	1458	3641	494	3869	190	3843	93	27989
Karnataka	3150	4882	5235	853	2821	327	4895	222	2050	81	24516
Kerala	2104	2912	4681	904	2726	201	4278	62	1740	87	19695
Rajasthan	2712	2280	2813	1135	3556	325	1110	62	2299	65	16357
Uttaranchal	2227	2396	2946	676	1988	361	2738	140	2334	69	15875
Gujarat	1512	3413	3751	491	1759	250	2536	105	1791	58	15666
West Bengal	1113	1970	3374	673	2246	396	2455	106	2359	49	14741
Madhya Pradesh	1319	2673	3021	585	1698	331	1951	169	765	52	12564
Punjab	1637	1672	2019	432	1903	126	1750	80	1144	53	10816
Haryana	1638	1910	1713	352	1630	120	2295	66	922	61	10707
Bihar	1106	1402	1972	495	2022	158	1066	99	1710	64	10094
Himachal Pradesh	1846	1831	1332	194	1007	75	1165	33	895	74	8452
Jammu & Kashmir	1237	1666	1079	466	867	130	1904	113	689	86	8237
Chandigarh	230	976	1123	120	876	94	3191	23	816	49	7498

Orissa	625	850	1049	400	1299	127	1137	58	1114	68	6727
Jharkhand	902	1004	994	273	1086	103	990	134	1033	77	6596
Assam	585	1057	1097	310	724	108	798	30	1083	62	5854
Pondicherry	281	908	588	148	802	94	2185	44	589	46	5685
Chhattisgarh	1181	885	539	153	511	169	829	49	626	61	5003
Meghalaya	642	684	745	132	397	30	678	42	517	53	3920
Manipur	243	246	172	49	48	9	356	11	204	49	1387
Goa	68	85	197	228	144		227	2	182	28	1161
Andaman & Nicobar Islands	144	175	57	12	93	6	81		98	18	684
Arunachal Pradesh	104	100	27	39	140	6	155	7	146	9	733
Nagaland	98	62	61	12	70	1	76		29	3	412
Sikkim	38	49	45	12	21		77	1	31		274
Mizoram	36	43	30	21	47	1	41		31	1	251
Tripura	15	36	33	3	19	11	35		29		181
Dadra & Nagar Haveli		9					3				12
Lakshadweep				1			1				2
Total**	48365	66869	78793	17605	58604	7414	75189	2937	47684	1737	**405197**

(3.92% papers are covered in more than one area)*

*(** 3,799 paper of the total were not having institutional affiliation)*

State wise contribution of papers in subject areas



Institutional Analysis

The difficulty of unifying name variants has several implications for any attempt to carry out any analyses at institutional level. First, ongoing unification is needed, a process required us to work three to four weeks. We developed customized utility programs for unification procedures but, even then it is difficult. The complexity and high manual component meant that all work was to be checked for consistency to ensure compliance with agreed unification conventions and to eliminate inevitable errors. Quality control is essential if data are to be consistent - i.e. if the data are to be usable.

Another class of difficulties was conceptual. First, the relationship between addresses and institutions is not entirely straightforward. The technique assumes that addresses indicate the institutional affiliation of authors. This may not be true. For example, the address of a researcher may be a university but the institutional affiliation may be something else. Alternatively, independent institutes may be located on the same campuses, for example the 'All India Institute of Medical Sciences' and ' Dr Rajendra Prasad Center for Ophthalmology' are in the same building.

Second, institutions change their names. Some universities / institution had three names in the last 10 years. Government laboratories have been privatized and consolidated. Companies merge, split and acquire.

Third, an institution may not always be clearly assigned to one sector. Fortunately, this is an infrequent problem. Indicators developed at the sectoral level assume that institutions can be assigned to one of the following sectors: Institutes of National Importance, Universities and Colleges, Mission oriented R&D, Industry and others Now a days, in India, new institutions seem to be appearing that get funding from several sources - governmental, industrial and sometimes NGO's. These institutions transcend the sectoral boundaries as traditionally defined. Fortunately only few exist at the moment.

The most pervasive problem in institutional and sectoral assignment is determining which institutions belong to the health sector. Clinical researchers often have dual medical college-hospital affiliations; there are two streams of funding. Separating the two is not just a problem of bibliometric method, clinicians are not clear about which stream of money paid for what themselves. We resolved the dilemma with the following rules which are based on the principle that we do not second guess the author of the paper:

1. As we unified to the institutional not the departmental level, Hospitals were unified to their institution – Medical Colleges.

2. If an author lists hospital and medical college on one line as one address, which occurs infrequently the paper was assigned to the first affiliation.

3. If an author lists hospital and medical college affiliations as two separate addresses on two lines, the paper is counted as collaborative between the hospital and medical college.

The conceptual difficulties of unification, namely complex and changing institutional structures and multiple sector affiliations, have several consequences for multi-national indicator development. First, the process will only be possible in countries where addresses reflect institutional affiliation to a reasonable degree. Second, national experts must oversee unification. Only local knowledge brought to bear on institutional complexity will produce sound data. Third, no single sector classification will suit all countries. Therefore, carrying out any collaboration analysis for 'Institutions' was not possible in the scope of the present study.

The institutions pursuing S&T research in India are categorized broadly as Institutes of National Importance, Universities and Colleges, Mission oriented R&D, Industry and others. The institutions under the universities and colleges include universities, deemed universities, inter-university centers, general colleges, medical colleges, and special institutions. Those under the mission-oriented R&D sector fall under the administrative and financial control of R&D agencies/departments as well as socio-economic ministries/departments of Central/State governments. The institutions under the industry sector include both private and public enterprises Institutions categorized as 'others' derive their funds from international, private and non-profitable sources.

A total of 5,801 institutions have contributed the total papers (3,43,599). Academic and R&D institutions have contributed 2,15,880 papers among the total output. In the year 2009, maximum Indian institutions (5,710) have contributed papers in the field of the study. For the remaining years also the academic institutions contribute significantly towards the output. Academic institutions share the major responsibility of S & T research in India.

Year	Total Institutes	Avg Paper / Institute	Total records where Inst Was NA
2005	3381	5828	763
2006	3668	6323	747
2007	3668	6323	748
2008	5298	9132	798
2009	5710	9843	743

The universities and colleges sector contributed the significant but declining share (from 52.2 per cent to 46.6 per cent) during 2005-2009. In contrast, mission-oriented R&D sector showed rise in its publications share from 28.37 per cent to 37.93 per cent, followed by INI from 17.23 per cent to 20.42 per cent, and industry from 17.8 per cent to 20.1 per cent during the corresponding period. The universities and colleges sector is the largest in terms of size of institutional participation (accounting for 48-50 per cent share), followed by mission-oriented R&D institutions (22-30 per cent), industry (14-20 per cent), and INI (less than 1 per cent). Mission-oriented R&D sector showed the fastest growth in publications output during these 5 years, followed by INI (7.98 per cent), and Industry (7.22 per cent). The growth in universities and colleges sector (accounting for the largest institutional participation) showed the slowest growth (3.56 per cent) and well below the country average growth of 5.17 per cent.

Institutional Productivity and their Ranking:

The numerical strength of high productivity institutions in S&T in the country is very low. In all, only 45 institutions had been successful in publishing on an average ≥600 paper per institute during the five years (2005-09). But, their publications activity index indicated a rise over the years.

No of Institutes	Range (Papers)	Total Papers	Avg Paper/ Institute
45	1000-3000	27880	619.56
60	500-999	39084	651.40
57	499-250	37152	651.79

107	250-200	10253	95.82
147	200-100	33792	229.88
244	99-50	29578	121.22
318	49-25	27426	86.25
578	24-15	20835	36.05
429	14-10	12312	28.70
563	9 to 5	29195	51.86
1447	5 to 1	72293	49.96

*(*Institutional affiliation was not available in a total of 3,799 papers)*

The 23 top most institutions, having more than 1,000 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 Inst Med Sci, Banaras, Indian Inst Chem Technol, Indian Inst Sci, Aligarh Muslim Univ, GB Pant Agric Technol Univ, Tamil Nadu Agric Univ, Kakatiya Univ, Sanjay Gandhi Postgrad Inst Med Sci, Natl Chem Lab, Indian Vet Res Inst, Punjabi Univ, Indian Agric Res Inst and Panjab Univ* in decreasing order of contribution.

Institute	**2005**	**2006**	**2007**	**2008**	**2009**
Indian Inst Technol	2205	2153	2269	2812	2561
Banaras Hindu Univ	1189	1103	2085	2540	3083
CCS Haryana Agric Univ	1245	2475	2349	2249	1682
Andhra Univ	1582	1804	2159	2113	2342
All India Inst Med Sci	2342	1657	1867	2209	1926
Annamalai Univ	1340	1569	2991	2208	1891
Christian Med Coll Hosp, Vellore	2164	1729	1678	2853	2576
Postgrad Inst Med Educ Res	2199	1956	1931	2475	2439
Natl Inst Technol	1135	1488	2054	3046	3277
Punjab Agric Univ	1165	2281	2481	2425	1648
Inst Med Sci, Banaras	891	851	1554	3182	3522
Indian Inst Chem Technol	2065	2437	2856	2552	2090
Indian Inst Sci	5000	1657	1167	1435	1741
Aligarh Muslim Univ	1734	1633	2278	2450	2905
GB Pant Agric Technol Univ	973	2961	2577	2653	836
Tamil Nadu Agric Univ	866	1973	2488	2667	2007
Kakatiya Univ	897	1574	2179	2628	2721
Sanjay Gandhi Postgrad Inst Med Sci	2065	1998	1755	2799	2383
Natl Chem Lab	2610	2000	2564	2379	2448
Indian Vet Res Inst	786	2831	2013	1825	2545
Punjabi Univ	1067	1108	2663	2779	2382
Indian Agric Res Inst	1703	3779	1952	1553	1013
Panjab Univ	821	1222	3009	3051	2897

Bhabha Atom Res Ctr	3723	2238	2972	2554	2513
Univ Agric Sci	778	2996	1706	2260	2260
Univ Delhi	1800	2066	2426	2810	2898
Sri Venkateshwer Univ	1206	1470	2762	3136	2425
Sree Chitra Tirunal Inst Med Sci Technol	1825	1622	1496	2555	3102
Marathwada Agric Univ	302	2897	1738	2343	2720
Dr Hari Singh Gour Vishwavidyalaya	244	1041	2886	3821	3008
Kasturba Med Coll Hosp, Manipal	1671	1957	1700	2800	2871
Jawaharlal Inst Postgrad Med Educ Res	1521	2106	2258	2642	2473
Himanchal Pradesh Univ	1691	1725	2271	2850	2464
Mahatma Phule Krishi Vidyapeeth	1574	1075	2534	3800	1017
Pune Univ	698	756	2791	2965	2791
Armed Forces Med Coll	2059	1941	2059	1647	2294
Kasturba Med Coll Hosp, Mangalore	1183	1968	2000	3075	2774
Sardar Patel Univ	1493	1041	882	2692	3891

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*, *Aligarh Muslim Univ, Sanjay Gandhi Postgrad Inst Med Sci, Panjab Univ, Dr Hari Singh Gour Vishwavidyalaya, Jawaharlal Inst Postgrad Med Educ Res, Kasturba Med Coll Hosp, Mangalore, Sri Venkateshwer Univ*.

Year-Wise Activity Index of Top Institutions (2005-09)

Institute	2005	2006	2007	2008	2009
Bhabha Atom Res Ctr	6.94	3.08	4.61	4.76	4.69
Natl Chem Lab	4.87	2.76	3.97	4.44	4.57
Indian Inst Technol	4.11	2.97	3.52	5.24	4.78
Indian Inst Chem Technol	3.85	3.36	4.43	4.76	3.90
Univ Delhi	3.36	2.85	3.76	5.24	5.40
Himanchal Pradesh Univ	3.15	2.38	3.52	5.32	4.60
Christian Med Coll Hosp, Vellore	4.04	2.38	2.60	5.32	4.80
Postgrad Inst Med Educ Res	4.10	2.69	2.99	4.62	4.55
Natl Inst Technol	2.12	2.05	3.18	5.68	6.11
Indian Inst Sci	9.32	2.28	1.81	2.68	3.25
Aligarh Muslim Univ	3.23	2.25	3.53	4.57	5.42
Sanjay Gandhi Postgrad Inst Med Sci	3.85	2.75	2.72	5.22	4.44
Panjab Univ	1.53	1.68	4.66	5.69	5.40

Dr Hari Singh Gour Vishwavidyalaya	0.46	1.43	4.47	7.13	5.61
Jawaharlal Inst Postgrad Med Educ Res	2.84	2.90	3.50	4.93	4.61
Kasturba Med Coll Hosp, Mangalore	2.21	2.71	3.10	5.73	5.17
Sri Venkateshwer Univ	2.25	2.03	4.28	5.85	4.52
Kasturba Med Coll Hosp, Manipal	3.12	2.70	2.63	5.22	5.35
Sree Chitra Tirunal Inst Med Sci Technol	3.40	2.23	2.32	4.77	5.79
All India Inst Med Sci	4.37	2.28	2.89	4.12	3.59
Tamil Nadu Agric Univ	1.62	2.72	3.86	4.97	3.74
Pune Univ	1.30	1.04	4.33	5.53	5.21
Banaras Hindu Univ	2.22	1.52	3.23	4.74	5.75
CCS Haryana Agric Univ	2.32	3.41	3.64	4.19	3.14
Andhra Univ	2.95	2.49	3.35	3.94	4.37
Punjab Agric Univ	2.17	3.14	3.85	4.52	3.07
Inst Med Sci, Banaras	1.66	1.17	2.41	5.93	6.57
GB Pant Agric Technol Univ	1.81	4.08	3.99	4.95	1.56
Indian Vet Res Inst	1.47	3.90	3.12	3.40	4.75
Indian Agric Res Inst	3.18	5.21	3.03	2.90	1.89
Univ Agric Sci	1.45	4.13	2.64	4.21	4.21
Marathwada Agric Univ	0.56	3.99	2.69	4.37	5.07
Mahatma Phule Krishi Vidyapeeth	2.94	1.48	3.93	7.09	1.90
Armed Forces Med Coll	3.84	2.67	3.19	3.07	4.28
Annamalai Univ	2.50	2.16	4.64	4.12	3.53
Kakatiya Univ	1.67	2.17	3.38	4.90	5.07
Punjabi Univ	1.99	1.53	4.13	5.18	4.44
Sardar Patel Univ	2.78	1.43	1.37	5.02	7.26

There was no significant change in the activity index of publications in case of Indian Institute of Technology (all the IIT's have been clubbed together), whereas on an average all the top institutions in the category, like *Banaras Hindu Univ, Christian Med Coll Hosp, Vellore, Natl Inst Technol* etc. have presented an increase in the activity index over the years (2005-09).

However, the analysed data have indicated some of the issues of concern. Some of the premier institutions *eg. All India Inst Med Sci, Indian Inst Sci, GB Pant Agric Technol Univ, Indian Agric Res Inst and Bhabha Atom Res Ctr* have shown a decline towards their average activity index over the years.

The data was also analysed to find out the total institutions contributing papers on the basis of Broad subject Area during the period of study (2005-09) in the database (INSI) some of the institute have published in more than one area.

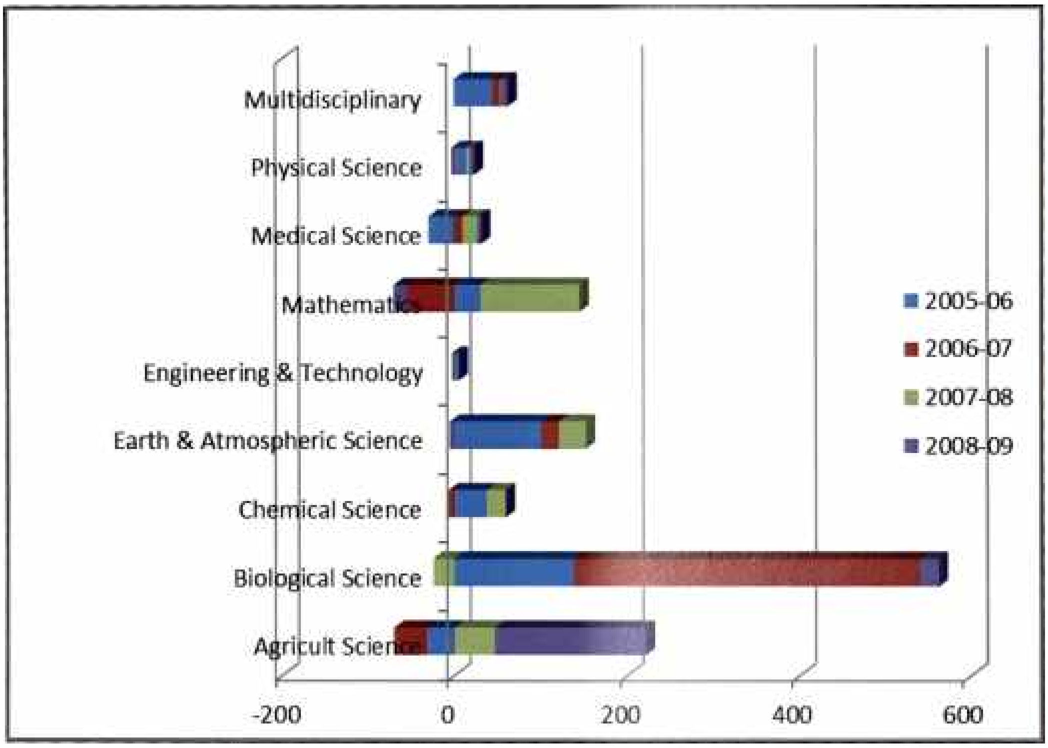
Broad Area	**Total Institute***
Agricultural Science	1782
Biological Science	1353

Chemical Science	1231
Earth & Atmospheric Science	52
Engineering & Technology	1500
Mathematics	936
Medical Science	1701
Physical Science	1254
Multidisciplinary	179
Others	122

(some of the institute have published in more than one area)*

In the field of Agricultural Sciences maximum institutes contributed papers followed by Medical Sciences, Engineering & Technology, Biological Sciences, Physical Sciences, Chemical Sciences, Mathematics and Earth & Atmospheric Sciences in the decreasing order.

The analysis on the basis of 'annual growth' of institution year wise (2005-6, 2006-7, 2007-8 and 2008-9) for each broad area individually have indicated that maximum growth has occurred in the field of Biological Sciences followed by Agricultural Sciences. Although the total number of papers in the field of Earth & Atmospheric Sciences and Mathematics is on the lower side, but the annual growth of institutions for both of these subject fields are ahead of other subject areas *eg.* Chemical Sciences, Engineering & Technology, Medical Sciences or Physical Sciences. Some of the areas have negative growth also in a year.



The top most five research institutions from India for each broad subject area were as follows:

Agricultural Sciences: *CCS Haryana Agricult Univ, GB Pant Univ Agricult Technol, Banaras Hindu Univ, Punjab Agricult Univ, Tamil Nadu Agricult Univ*

Biological Sciences : *Banaras Hindu Univ, Annamalai Univ, Indian Inst Technol, Kakatiya Univ, Andhra Univ*

Chemical Sciences: *Banaras Hindu Univ, Andhra Univ, Bhabha Atom Res Ctr, Indian Inst Chem Technol, Indian Inst Technol*

Earth & Atmospheric Science: *Banaras Hindu Univ, Annamalai Univ, Punjab Agricult Univ, Indian Inst Trop Meteorol, Indian Inst Technol*

Engineering & Technology: *Banaras Hindu Univ, Natl Inst Technol, Annamalai Univ, Indian Vet Res Inst, Indian Inst Technol*

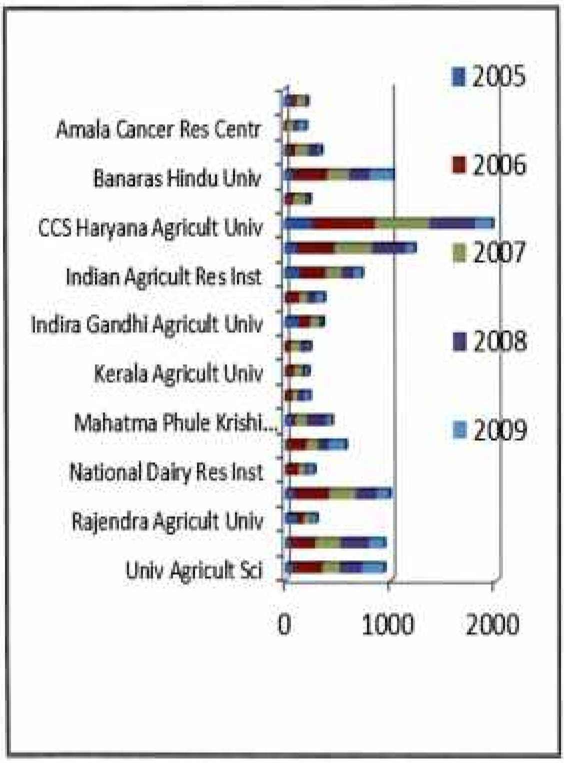
Mathematics: *Andhra Univ, Banaras Hindu Unv, Natl Coll Trichy, KG Arts Sci Coll*

Medical Sciences: *All India Inst Med Sci, Christian Med Coll & Hosp Vellore, Inst Med Sci Varanasi, Postgrad Inst Med Educ & Res, Sree Chitra Tirunal Inst Med Sci & Technol*

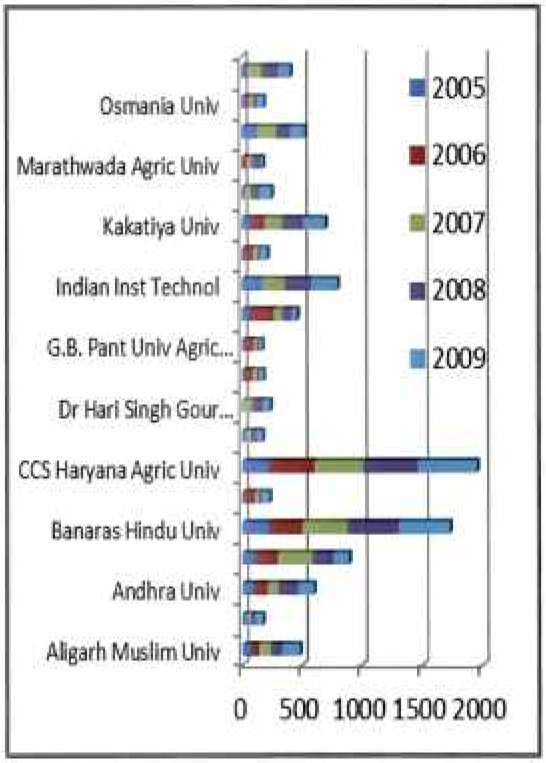
Physical Sciences: *Indian Inst Technol, Banaras Hindu Univ, Natl Inst Technol, Andhra Univ, Natl Chem Lab*

Multidisciplinary: *Banaras Hindu Univ, Kakatiya Univ, Birsa Agricult Univ, Andhra Univ,* and *Annamalai Univ.*

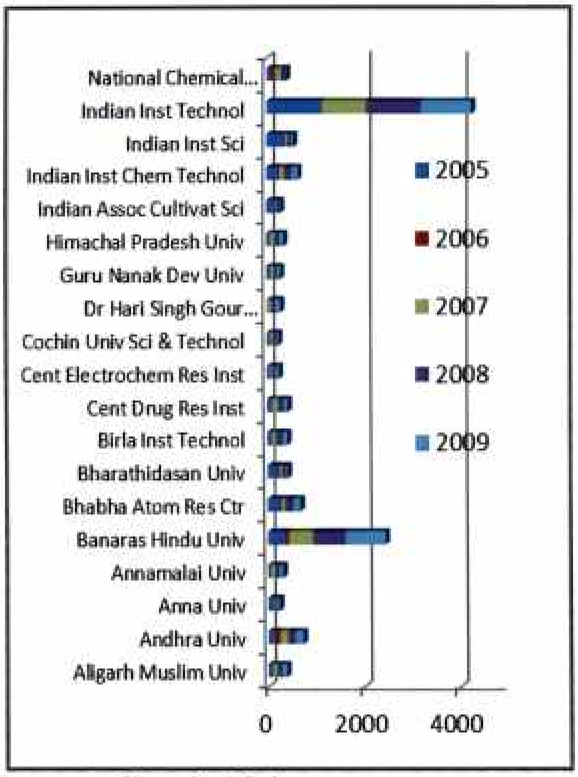
The data was also analyzed to identify top 20 most prolific institute of each subject area during 2005-09 in the following Figures.



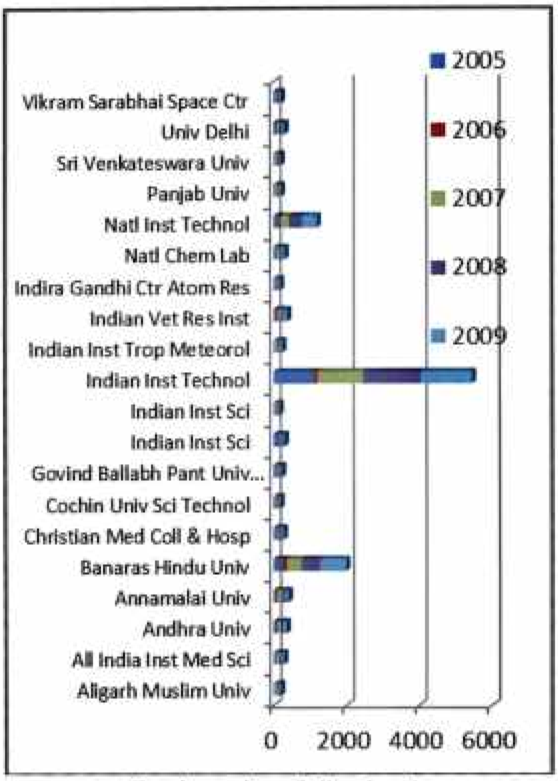
Agricultural Sciences



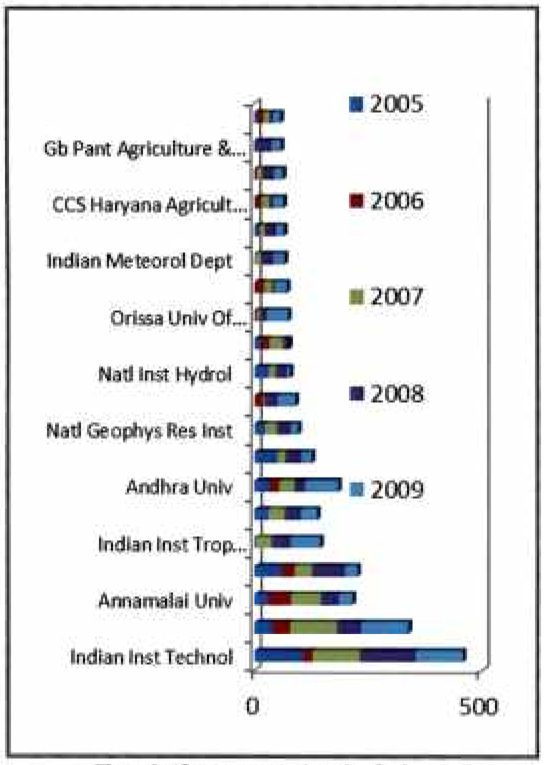
Biological Sciences



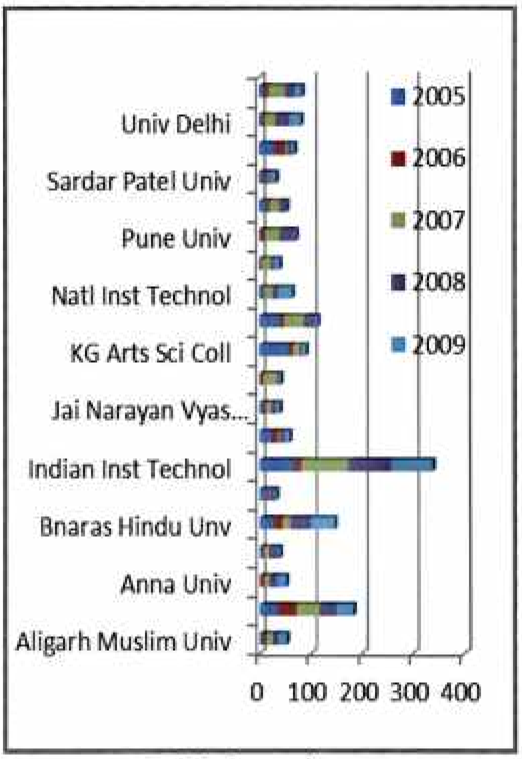
Chemical Sciences



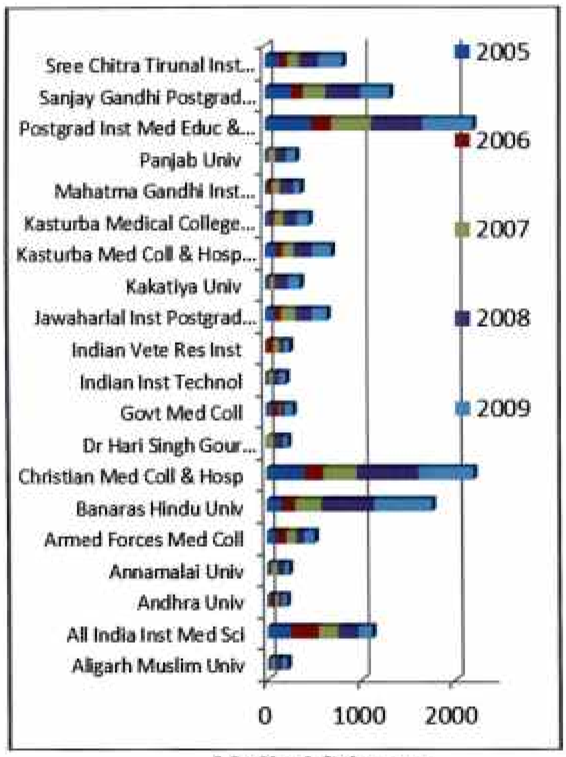
Engineering & Technology



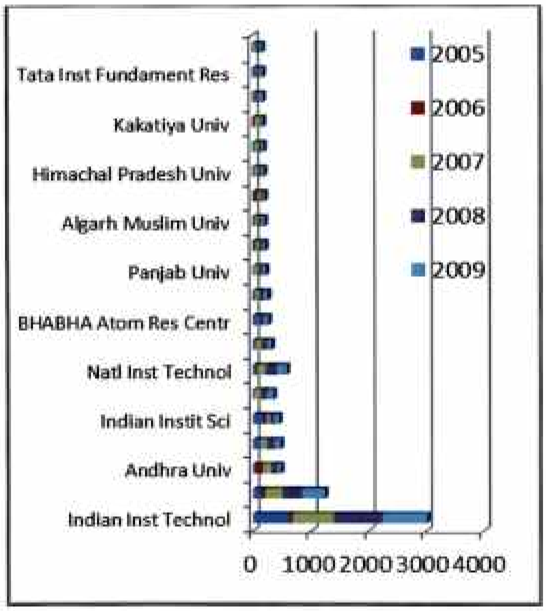
Earth & Atmospheric Sciences



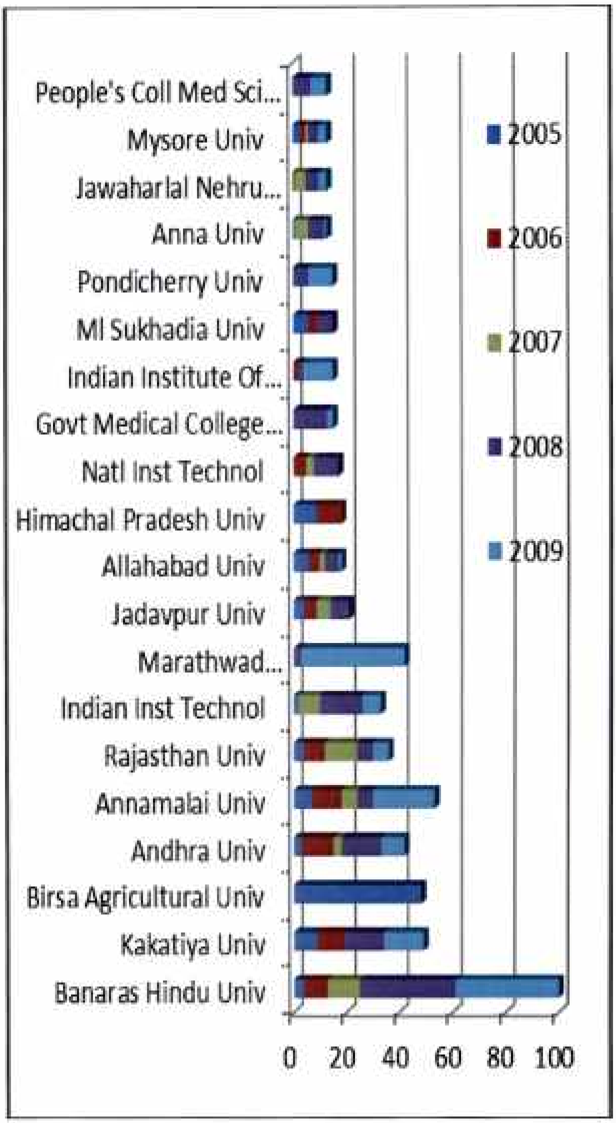
Mathematics



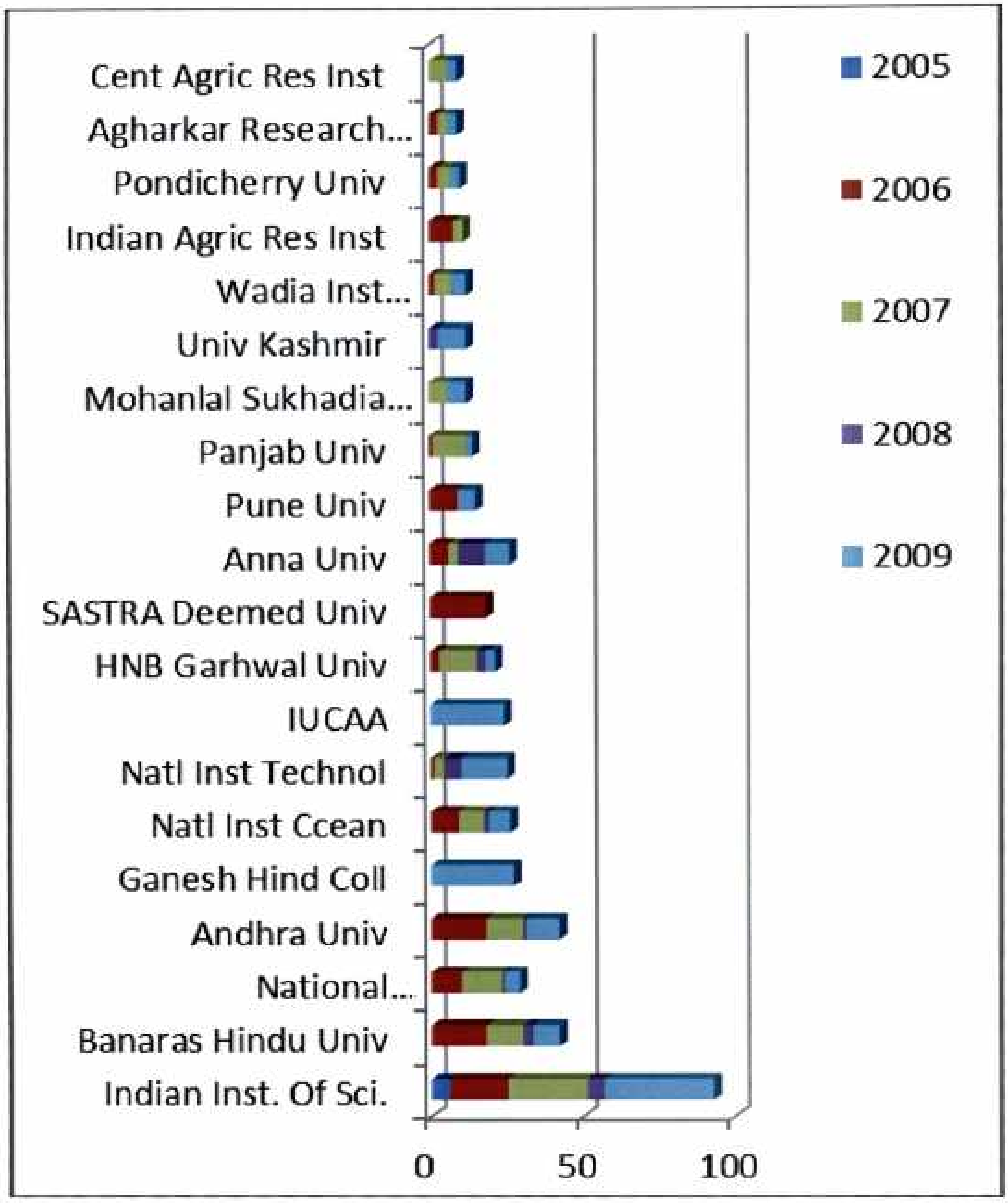
Medical Sciences



Physical Sciences



Multidisciplinary



Cent Agric Res Inst
Agharkar Research...
Pondicherry Univ
Indian Agric Res Inst
Wadia Inst...
Univ Kashmir
Mohanlal Sukhadia...
Panjab Univ
Pune Univ
Anna Univ
SASTRA Deemed Univ
HNB Garhwal Univ
IUCAA
Natl Inst Technol
Natl Inst Ccean
Ganesh Hind Coll
Andhra Univ
National...
Banaras Hindu Univ
Indian Inst. Of Sci.
0
50
100
2005
2006
2007
2008
2009

Others

Authorship Pattern

Derek John De Solla Price (1963) came up with a work called "Little Science, Big Science" where he explained the trend of authorship and highly appreciated scientific research collaboration among authors. He also 'suggested that "by 1980 the single – author paper will extinct". Authorship trends characterize both the social and the cognitive structure of scientific research realms. Scientists have a burning desire for reputation, recognition, visibility and the benefit they win through the exchange of tools, skills and expertise from colleagues. Although, there are certain exceptions, as observed in the case of 'Bigger Institutions' from India, who does not corroborate this particular prediction, one can, however, see the superiority of multiple authorship from the Table presented below which provides the number of single- and multi-authored papers during the observed period.

Multi authorship Analysis 2005-09

Total Authors	Total Papers	% Papers
1	28208	8.21
2	87880	25.58
3	86671	25.22
4	61908	18.02
5	36758	10.70
6	19286	5.61
7-15	20920	6.09
16-25	1359	0.40
26-85	609	0.18
Total Papers	**343599**	**100**

The result indicated that just 8.2% of total papers involved single authors. An astonishing 91.8 % of papers were multi-authored.

Broad Area wise co-author analysis (2005-2009)

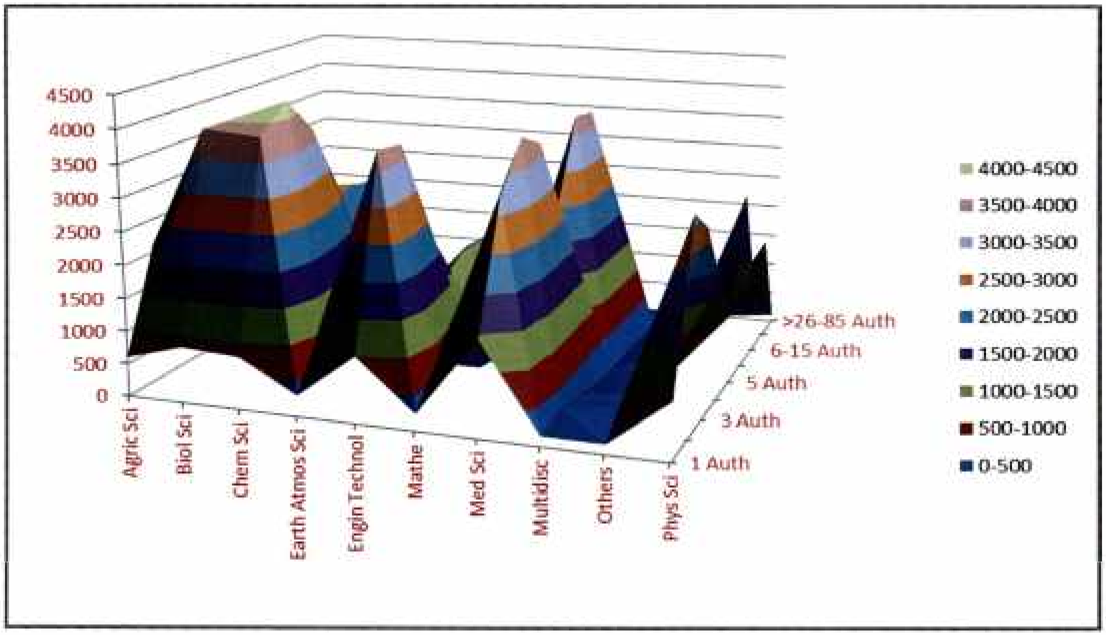
Broad Area*	1 Auth	2 Auth	3 Auth	4 Auth	5 Auth	6 Auth	7-15 Auth	16-25 Auth	> 26-85 Auth	Total Papers*
Agricultural Science	2422	11929	13724	9649	4848	3801	2640	132	12	49157
Biological Science	3805	17832	16784	11501	5852	6703	6189	304	21	68991
Chemical Science	1431	16699	18353	14761	9449	9246	8935	241	81	79196
Earth and Atmospheric Science	1729	4984	4627	2624	1194	1230	1262	72	12	17734

Engineering & Technology	4354	16232	14699	8391	3951	5552	5279	270	108	58836
Mathematics	1200	3411	1889	476	99	287	228	146	0	7736
Medical Science	4140	11880	14657	12622	8093	12545	12393	92	19	76441
Physical Science	3065	12825	11210	6490	2920	6196	3108	1927	105	47846
Multidisciplinary	675	1108	625	273	120	131	115	12	0	3059
Others	200	316	208	85	68	486	94	282	8	1747
Total*	23021	97216	96776	66872	36594	46177	40243	3478	366	410743

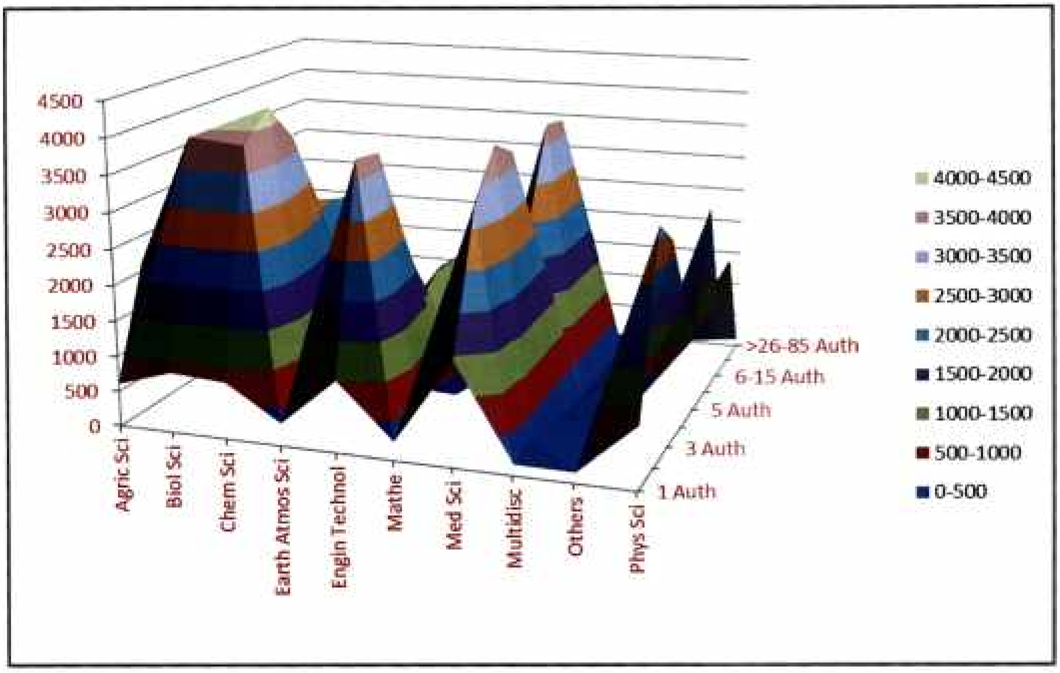
*(*Some of the papers are grouped under more than one category)*

As for single-authored papers, in 2005, it was 2.7 % but was just 2.0 % in the following year. The largest increase was 12.5% for the year 2007. There was a decrease in 2006 (-39%) and in 2009 (-13%). As for multi-authored publications, the relative increase rate was larger. The greatest increase was in 2007 at 19.6%, followed by 15.6% in the following year.

Multi-authorship Pattern (2005)



Multi-authorship Pattern (2009)

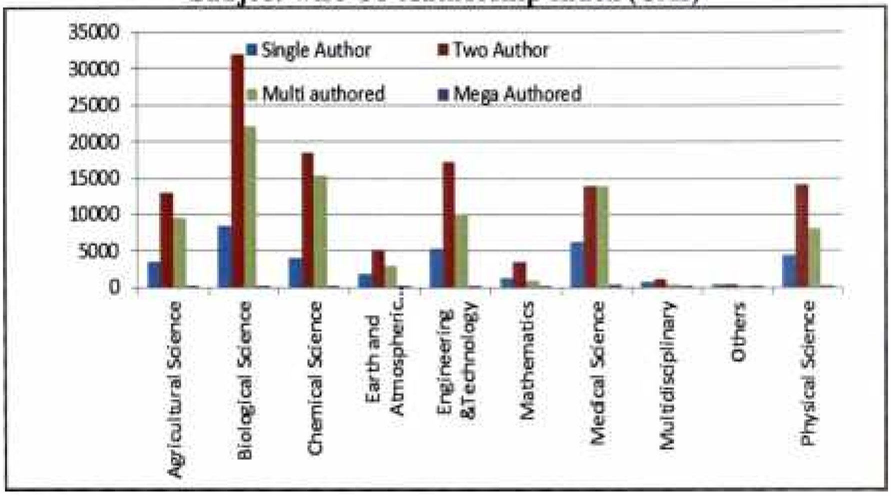


In a study performed at Netherlands, it was found out that multi-authored papers were dominant over single-authored papers although the study was restricted to just three subject fields Biomedical Research, Chemistry & Mathematics. In our study also same pattern was observed at the level of 'Broad Subject Area'. On an average the subject areas of Mathematics, Agricultural Sciences and Physical Sciences have a tendency to publish, more single or at the most double authored papers but in case of Physical Sciences there was an increase in the number of multi-authored papers by the year of 2009 from 2005.

Co-authorship Index:

Co-authorship Index (CAI) has been elaborated by Schubert and Braun (1986), and is obtained by calculating proportionally the publication by single, two, multi-and mega authored papers for different Broad Areas. CAI=100 indicates that the number of publications correspondence to the average within a co –authorship pattern CAI >100 reflects higher than the average, and CAI <100 indicates lower than average. Here the papers have been divided into four categories according to the number of authors, namely single-authored, two authored, multi-authored papers with three or four authors and mega authored papers with five or more authors. It is clearly evident from the data which shows that the CAI for multi authored papers for Biological Sciences, Chemical Sciences and Physical Sciences is more than average. The relatively CAI of multi-authored papers indicate that Biological sciences is at the top followed by Chemical Sciences and Engineering & Technology. As per the assumption of Schubert and Braun, the subject areas having CAI lower than average are Mathematics, Earth & Atmospheric Sciences and Multidisciplinary Sciences. The Mega Authored papers are figuring only in the Broad Areas of Medical & Biological Sciences.

Subject-wise Co-Authorship Index (CAI)



Collaboration Analysis

Studying research collaborations has evolved into a major focus of bibliometrics and receives increasing attention from policy-makers and more general users. Modern research is regarded as increasingly complex and specialized, making it impossible for an individual researcher to master all the knowledge and technical skills needed. In a collaboration, different skills complement each other and this complementarity is hoped to stimulate knowledge sharing and the generation of innovation and new ideas. As a result, collaborative research activities do not only enable the pooling and sharing of resources for enhanced efficiency but are also linked to the quality of the research outcome.

This growing interest in research collaborations is also reflected in research funding programs. Grants awarded by many different funding institutions and for many different disciplines often seek to encourage – and at times require as a condition – collaborations between different countries, research fields or institutions. Being able to map and analyze research networks and collaboration has therefore evolved into a key issue for the design and assessment of research policies and related funding programs.

Collaboration is now actively promoted with a view to breaking down the barriers between research institutions, industry, commerce, government and the public services. Specific driving factors include: the growth of the knowledge economy and attempts to strengthen the economic and social contribution of research; a shift towards more applied research in collaboration with other knowledge creators and users; greater concentration of research activity and partnership in the use of plant, equipment and expertise; the growth of the directed mode of funding based on priority areas and problem oriented project funding . Collaboration occurs at various levels including individuals, groups, departments, institutions, sectors and countries. The latter may emerge from political memoranda of understanding between nations, although definitions of higher levels of collaboration are no easier to arrive at than for inter-individual collaboration. Nevertheless, it is important to make this distinction between the different levels because an inter-institutional or international collaboration may not necessarily entail an inter-individual collaboration. What constitutes a collaboration varies across institutions, fields, sectors and countries, and changes with time. Some collaboration is formal, much more is informal.

Bibliometrics can make an important contribution in this regard. For decades the multiple-author publication, frequently referred to as a co-authored publication, has been used as a basic counting unit to measure collaborative activity. Smith was one of the first researchers to observe an increase in the incidence of multiple-author papers and to suggest that such papers could be used as a proxy measure for collaboration among groups of researchers. In the present study explicit networks of such connections have been constructed by using data drawn from SCOPUS, for Indian Papers during the period of 2005-09. The results include distribution of numbers of collaborators of authors, demonstrate the presence of clustering in the networks, and highlight a number of apparent differences in the patterns of collaboration between the fields studied. Differences among 'institutions' have been investigated with regard to productivity, number and rate of national/international collaborations. Here we refer to collaboration in terms of intra- national & international collaboration. The degree of (national, international) collaboration is the percentage of collaborative articles out of the total number of articles. All Indian institutional addresses on the papers were unified to a set of standard institutional names and each standard name was assigned to an institutional sector. Using co-publication as unit of analysis bibliometrical studies have for example empirically demonstrated that researchers collaborate more than ever.

Data sources for Collaboration Analysis - advantages and disadvantages:

There are many databases indexing the scientific and technical literature; COMPENDEX, INSPEC, Medline, CABI, Forestry Abstracts, Physics Abstracts to name but a few. Any collaboration analysis is primarily based on the SCI produced by the Institute for Scientific Information (ISI) in Philadelphia, USA or SCOPUS produced by Elsevier. The first advantage is that both the services cover all science fields. This is a necessity if one is looking at whole research systems. In addition, their coverage is unambiguous because every item from every journal is indexed. Coverage in other databases is ambiguous for indicator purposes because although they include all items from core journals, only items considered relevant to the subject of the database are included from secondary journals.

The second advantage is that all author addresses listed on the paper are included in these Databases. This is a necessity for studying institutional output as collaboration is so extensive. Only first addresses are included in other databases, and so papers on which an institution's address was not listed first cannot be credited to the institution. This source of error is substantial and growing as the rate of institutional collaboration increases. Only the first address is needed to contact authors of a paper, so listing only the first address is not a problem from the perspective of scientists searching the literature. From the policy perspective, the address that happens to be listed first is a social artifact and not of great policy interest in comparison to the total output of the institution. Of course, only if all addresses are listed can collaboration be studied.

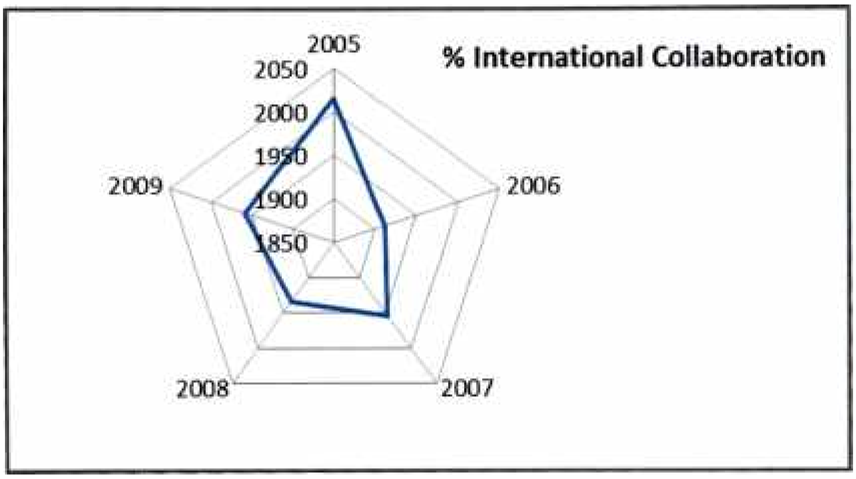
The third advantage is that total number of references is also included in these databases. Citation counts can be derived from these references and used as a partial indicator of the impact previous research has had on succeeding work Citation counts are such a useful adjunct to policy analysis that almost by themselves their presence justifies using this data for policy analysis.

Coverage and cost are the disadvantages of these Databases because it indexes all science, its coverage of a single area is not as broad or deep as specialist databases such as Medline, INSPEC, COMPENDEX, or CABI.

In our research we have used bibliometrics principals to study international collaboration patterns from an evolutionary point of view. Using co-authorship we have explored the collaboration of researchers in India with those in other countries (international) and with Indian Institutions (intra-national) We have examined how collaboration patterns are different among the different broad subject areas. In the present study, for India the share of publications with multiple institutions represented on them grew from 40% to 61% between 2005 and 2009.

Collaboration- International (Source: SCOPUS 2005-09):

The pattern of international collaboration has indicated that maximum international collaboration occurred during the year of 2005 followed by 2009, 2007, 2008 and finally 2006 in the same order.



At international level the data has indicated that a total of 159 countries have collaborated with an Indian authored paper. This may be noted that more than one country may have appeared in the same paper. The collaborating countries are distributed around the globe (2005-09).

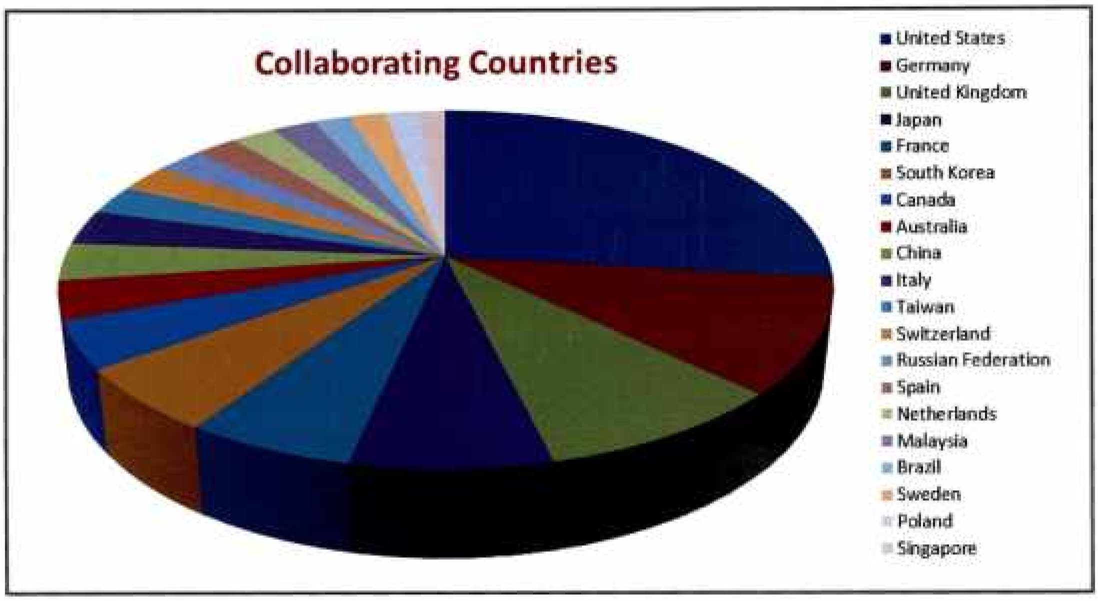
S No.	Collaborat. Country	Total papers in Collaborat.
1	Afghanistan	11
2	Albania	6
3	Algeria	27
4	Argentina	318
5	Armenia	29
6	Australia	1,521
7	Austria	461
8	Azerbaijan	10
9	Bahrain	22
10	Bangladesh	200
11	Barbados	5
12	Belarus	23
13	Belgium	497
14	Benin	9
15	Bhutan	17
16	Bolivia	11
17	Bosnia and Herzegovina	3
18	Botswana	21
19	Brazil	798
20	British Indian Ocean Territory	3
21	Brunei Darussalam	3
22	Bulgaria	129
23	Burkina Faso	4
24	Burundi	2
25	Cambodia	12
26	Cameroon	22
27	Canada	1,857
28	Cayman Islands	6
29	Chile	148
30	China	1,477
31	Colombia	228
32	Congo	8
33	Costa Rica	24
34	Cote d'Ivoire	4
35	Croatia	120
36	Cuba	20
37	Cyprus	37
38	Czech Republic	501
39	Democratic Republic Congo	1
40	Denmark	328
41	Dominican Republic	5
42	Ecuador	183
43	Egypt	145
44	El Salvador	1
45	Eritrea	24
46	Estonia	42
47	Ethiopia	140
48	Fiji	59
49	Finland	347
50	France	2,625
51	Gabon	5
52	Georgia	21
53	Germany	4,504
54	Ghana	25
55	Greece	218
56	Guadeloupe	5
57	Guatemala	6
58	Guinea	2
59	Guyana	2
60	Hong Kong	288
61	Hungary	312
62	Iceland	12
63	Indonesia	104
64	Iran	363
65	Iraq	26

66	Ireland	358
67	Israel	434
68	Italy	1,390
69	Jamaica	8
70	Japan	3,118
71	Jordan	51
72	Kazakhstan	24
73	Kenya	83
74	Kuwait	131
75	Kyrgyzstan	8
76	Laos	8
77	Latvia	12
78	Lebanon	23
79	Lesotho	4
80	Libyan Arab Jamahiriya	43
81	Liechtenstei n	1
82	Lithuania	14
83	Luxembourg	5
84	Macedonia	4
85	Madagascar	11
86	Malawi	10
87	Malaysia	950
88	Maldives	7
89	Mali	13
90	Malta	7
91	Mauritius	11
92	Mexico	495
93	Mongolia	13
94	Montenegro	6
95	Morocco	24
96	Mozambiqu e	9
97	Myanmar	28
98	Namibia	8

99	Nepal	252
100	Netherlands	952
101	New Caledonia	3
102	New Zealand	141
103	Niger	12
104	Nigeria	109
105	North Korea	2
106	Norway	193
107	Oman	119
108	Pakistan	161
109	Palestine	6
110	Panama	12
111	Papua New Guinea	11
112	Paraguay	2
113	Peru	33
114	Philippines	164
115	Poland	723
116	Portugal	370
117	Puerto Rico	56
118	Qatar	9
119	Romania	183
120	Russian Federation	1,011
121	Rwanda	4
122	Saint Lucia	3
123	Saudi Arabia	242
124	Senegal	6
125	Serbia	45
126	Sierra Leone	2
127	Singapore	622
128	Slovakia	127
129	Slovenia	236

130	South Africa	406
131	South Korea	2,538
132	Spain	956
133	Sri Lanka	133
134	Sudan	21
135	Sweden	776
136	Switzerland	1,105
137	Syrian Arab Republic	19
138	Taiwan	1,140
139	Tajikistan	1
140	Tanzania	22
141	Thailand	311
142	Tonga	1
143	Trinidad and Tobago	61
144	Tunisia	14
145	Turkey	254
146	Turkmenista n	2
147	Uganda	23
148	Ukraine	101
149	United Arab Emirates	139
150	United Kingdom	3,942
151	United States	11,824
152	Uruguay	11
153	Uzbekistan	38
154	Venezuela	37
155	Viet Nam	81
156	Yemen	30
157	Yugoslavia	9
158	Zambia	12
159	Zimbabwe	23

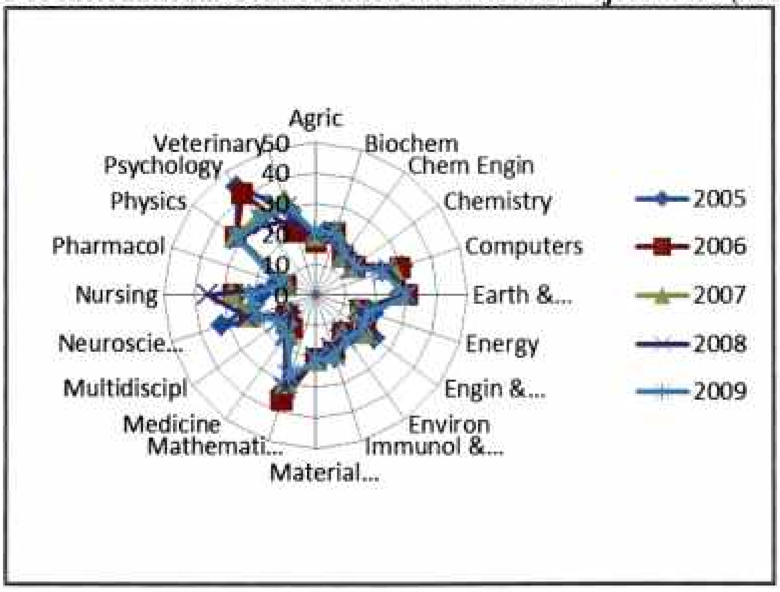
The top most 20 countries as a co-authors were United States, Germany, United Kingdom, Japan, France, South Korea, Canada, Australia, China, Italy, Taiwan, Switzerland, Russian Federation, Spain, Netherlands, Malaysia, Brazil, Sweden, Poland and Singapore in the same order.



Collaboration- International (Subject Area wise) :

We have also found significant differences in collaboration patterns across fields, through the analysis of 'Collaboration Index' (CI), Mathematics, Agricultural Sciences, Engineering, Computing & Technology is the field with the highest level of national publications whereas Biological Sciences, Medical Sciences, Physical Sciences, Chemical sciences and Earth & Atmospheric Sciences including Environmental studies are the fields with the highest level of both intra-national and international collaborations. These are the areas of scientific disciplines where teamwork and collaboration was priority during 2005-09. This characteristic can be considered as an indicator of maturity of research teams. In India, Medicine is a scientific discipline with a great tradition that counts with numerous well-established, internationally recognized teams International collaboration of these groups has been favored by the great diversity and complexity of Indian territory that has arouse the interest of many foreign scientists, mainly Americans, French, German and British. International Collaboration Index is a relative measure of the collaborative activity of a country.

Trend of International Collaboration in different Subject areas (2005-09)



Any bibliometric analysis for the comparisons between fields also need to be done with caution. Differences here may be due to different publication strategies Mathematicians and other theoreticians tend to publish fewer papers than researchers in experimentally-intensive fields such as life sciences, biological sciences or medical sciences Publications in the field of medicine do on average involve more authors than papers in the field of chemistry, agricultural or engineering. Technological scientists have on average a lower publication rate than others since the way of communicating research results often involves other means such as working papers, presentations or books etc. The top 15 Subject areas were covered by more than 50 % of papers. This indicates a clear shift towards more applied and frontline areas.

Analysis of Institutions having Collaboration: The bibliometric evidence indicates that the majority of scientific research is collaborative. The size and geographical location of an institution influences its collaboration profile. An institution and its researchers do not work in isolation; they work within broad and extensive research networks. The implications of the findings suggest that evaluation activities may need to make adjustments for the non-linear effect of institutional size when making comparisons. They also suggest we need a better understanding of how much collaboration policy actually influences a science system where the emerging nature and culture of scientific research appears to encourage collaborative activity.

We carried out an analysis of National Collaboration (% NC) & International Collaboration (% IC) also, institution's output ratio produced in collaboration with national & foreign institutions. The values are computed by analyzing an institution's output whose affiliations include more than one institution or country address. All Indian institutional addresses on the papers were unified to a set of standard institutional names and each standard name was assigned to an institutional sector. The bibliometric analysis involved examining the patterns of various types of collaboration in different S&T fields. There are a total of 5801 institutions contributing the total of 343895 papers. Out of this, ≥ 91.9% papers were produced as co-authored papers. A total of 50% papers were having co-authors from other institutions, national as well as international. The top most 150 institutes for all the five years in terms of 'international collaboration' are:

Rank	Institute	% IC
1	Mangalore University	63.47
2	Inter-University Centre for Astronomy and Astrophysics	57 82
3	Tata Institute of Fundamental Research	53.34
4	IBM India Research Laboratory	49.27
5	Institute of Mathematical Sciences	44.76
6	Institute of Physics Bhubaneswar	41.65
7	Variable Energy Cyclotron Centre	41.42
8	Raman Research Institute	39.74
9	Physical Research Laboratory	38.44
10	Inter-University Accelerator Centre	37.71
11	Harish Chandra Research	37.5
	Institute	
12	Bharathiar University	36.48
13	Panjab University	34.43
14	Bharathidasan University	30.48
15	UGC-DAE Consortium for Scientific Research Indore	30
16	Saha Institute of Nuclear Physics	29.41
17	Indian Association for the Cultivation of Science	28.52
18	University of Hyderabad	27.99
19	University of Mysore	27.76
20	North-Eastern Hill University	27.6
21	Indian Institute of Technology, Bombay	27.54
22	S.N. Bose National Centre for Basic Sciences	27.07
23	Indian Institute of Technology, Kanpur	27.01

24	Indian Statistical Institute	26.13
25	Jawaharlal Nehru Centre for Advanced Scientific Research	26.01
26	National Geophysical Research Institute (sub)	25.91
27	Centre for Cellular and Molecular Biology (sub)	25.89
28	Sri Venkateswara University	25.64
29	University of Jammu	25.35
30	Indian Institute of Science	25.22
31	National Institute of Oceanography (sub)	24.66
32	University of Calcutta	23.56
33	University of Pune	23.53
34	Jamia Millia Islamia Central University	23.43
35	Madurai Kamaraj University	23.15
36	Indian Institute of Chemical Biology (sub)	22.73
37	Raja Ramanna Centre for Advanced Technology	22.65
38	Jawaharlal Nehru University	22.34
39	Bose Institute Kolkata	22.03
40	University of Delhi	21.87
41	Bengal Engineering and Science University, Shibpur	21.77
42	Jadavpur University	21.6
43	VIT University	21.53
44	Indian Institute of Technology, Delhi	21.45
45	Guru Nanak Dev University	21.32
46	National Institute for Interdisciplinary Science and Technology (sub)	21.14
47	Pondicherry University	21.04
48	Indian Institute of Technology, Madras	20.86
49	International Institute of Information Technology, Hyderabad	20.29
50	Devi Ahilya University	20.28
51	University of Burdwan	19.94
52	Indian Council of Medical Research	19.87
53	National Chemical Laboratory (sub)	19.64
54	Christian Medical College, Vellore	19.57
55	Birla Institute of Technology	19.38
56	National Physical Laboratory India (sub)	19.37
57	Tata Sons Ltd.	19.25
58	University of Madras	19.1
59	Bhabha Atomic Research Centre	18.48
60	Indian Institute of Technology, Kharagpur	18.45
61	National Institute of Mental Health and Neuro Sciences	18.45
62	Aligarh Muslim University	18.39
63	Indian Institute of Technology, Roorkee	18 . 22
64	National Institute of Technology Karnataka	18.18
65	Institute of Genomics and Integrative Biology (sub)	18.04
66	Tata Memorial Centre	17.92
67	Central Electrochemical Research Institute (sub)	17.79
68	Visva-Bharati University	17.74
69	Birla Institute of Technology and Science	17.67
70	Indian Institute of Technology, Guwahati	17.53
71	Banaras Hindu University	17.26
72	Cochin University of Science and Technology	17.17
73	Central Glass and Ceramic Research Institute (sub)	17.02
74	Karnatak University	16.91
75	Anna University	16.82
76	National Metallurgical Laboratory (sub)	16.73
77	Tamil Nadu Agricultural University	16.67
78	National Institute of Pharmaceutical Education and Research	16.38
79	University of North Bengal	16.33
80	Andhra University	16.01
81	Jamia Hamdard University	15.66
82	National Institute of Technology, Tiruchirappalli	15.39
83	Council of Scientific and Industrial Research*	15.29
84	University of Kalyani	15.24
85	Indira Gandhi Centre for Atomic Research	15.15
86	Sri Ramaswamy Memorial University	14.74
87	Shivaji University	14.54
88	Indian Space Research Organization	14.54
89	Chhatrapati Shahuji Maharaj	14.39

	Medical University	
90	University of Rajasthan	14.38
91	Institute of Minerals and Materials Technology (sub)	14.21
92	National Institute of Technology Durgapur	13.24
93	Central Leather Research Institute (sub)	13.22
94	National Institute of Technology Rourkela	12.89
95	All India Institute of Medical Sciences	12.86
96	Motilal Nehru National Institute Of Technology	12.75
97	University of Lucknow	12.64
98	Gulbarga University	12.62
99	Manipal University	12.53
100	National Environmental Engineering Research Institute (sub)	12.45
101	Jawaharlal Nehru Technological University, Hyderabad	12.28
102	University of Mumbai	12
103	Jai Narain Vyas University	11.86
104	Chaudhary Charan Singh Haryana Agricultural University	11 72
105	Tezpur University	11.59
106	Punjab Agricultural University	11.53
107	Indian Institute of Toxicology Research (sub)	11.48
108	Bangalore University	11.45
109	University of Kerala	11.44
110	Seth Gordhandas Sunderdas Medical College and	11 05
111	Annamalai University	11.02
112	National Botanical Research Institute (sub)	11.02
113	Sri Siva Subramania Nadar College of Engineering	10.77
114	Govind Ballabh Pant University of Agriculture and Technology	10.7
115	Indian Institute of Chemical Technology (sub)	10.51
116	Sanjay Gandhi Postgraduate Institute of Medical Sciences	10.32
117	Osmania University	10 12
118	Sree Chitra Tirunal Institute for Medical Sciences and Technology	10 12
119	Shanmugha Arts, Science, Technology and Research Academy	
120	Indian Council of Agricultural Research	9.92
121	Rashtrasant Tukadoji Maharaj Nagpur University	9.92
122	Indian School of Mines	9.9
123	Postgraduate Institute of Medical Education and Research	9.77
124	Thiagarajar College of Engineering	9.75
125	National Institute of Technology Warangal	9.65
126	Allahabad University	9.46
127	Sardar Patel University	9.27
128	Kurukshetra University	9.09
129	Central Drug Research Institute (sub)	9.08
130	Central Food Technological Research Institute (sub)	8.82
131	Central Salt and Marine Chemicals Research Institute (sub)	8.47
132	The Maharaja Sayajirao University of Baroda	8.46
133	Kakatiya University	8.32
134	Kuvempu University	8.02
135	Thapar University	7.96
136	Himachal Pradesh University	7.91
137	Mohan Lal Sukhadia University	7.62
138	Vidyasagar University	7.57
139	Defence Research and Development Organisation	7.51
140	Indian Veterinary Research Institute	7.51
141	Guru Jambheshwar University of Science and Technology	7.32
142	Doctor Harisingh Gour University	7.14
143	Government Medical College and Hospital	7.13
144	Punjabi University	7.06
145	Dr. Babasaheb Ambedkar Marathwada University	6.64
146	University College of Medical Sciences	6.42
147	PSG College of Technology	6.37
148	Jawaharlal Institute of Postgraduate Medical Education and Research	5.83

149	Guru Tegh Bahadur Hospital	5.83
150	Tamil Nadu Veterinary and Animal Sciences University	5.29

This use of bibliometric has yielded some important insights: We find that researchers in smaller institutions co-author more with other intra-institutions than bigger institutes, while the international co-authorship rate is not dependent on the 'status' of the research institutes. It is interesting to note that some of the premier institutions from the sciences & technology field of India *eg.* Indian Institute of Science (30), Bhabha Atomic Research Centre (59), All India Institute of Medical Sciences(95), Indian Institute of Chemical Technology (115), Sanjay Gandhi Postgraduate Institute of Medical Sciences (116), Sree Chitra Tirunal Institute for Medical Sciences and Technology (118), Postgraduate Institute of Medical Education and Research (123), Central Drug Research Institute (129), Central Food Technological Research Institute (130), and Central Salt and Marine Chemicals Research Institute (131) are quite far off from the ranking list of the institutions in terms of 'international collaboration. We also have analysed the pattern of 'intra-national collaboration' of institutes. Here the ranking have changed very significantly:

Rank	Institute	% NC
1	Centre for Cellular and Molecular Biology	1
2	Variable Energy Cyclotron Centre	1.57
3	Indian Institute of Toxicology Research	1.5
4	Jawaharlal Nehru Centre for Advanced Scientific Research	1.49
5	Inter-University Centre for Astronomy and Astrophysics	1.44
6	Central Salt and Marine Chemicals Research Institute	1.42
7	Institute of Physics Bhubaneswar	1.41
8	National Institute for Interdisciplinary Science and Technology	1.39
9	Harish Chandra Research Institute	1.2
10	Panjab University	1.2
11	National Institute of Pharmaceutical Education and Research	1.2
12	University of Jammu	1.17
13	Indian Institute of Technology, Bombay	1.16
14	Birla Institute of Technology and Science	1.15
15	IBM India Research Laboratory	1.14
16	Indian Institute of Technology, Guwahati	1.13
17	Indian Institute of Technology, Delhi	1.11
18	Indian Institute of Technology, Kanpur	1.1
19	National Chemical Laboratory	1.09
20	Shivaji University	1.09
21	Tata Institute of Fundamental Research	1.08
22	Indian Institute of Technology, Kharagpur	1.08
23	Indian Institute of Technology, Roorkee	1.08
24	Indian Institute of Science	1.06
25	Indian Association for the Cultivation of Science	1.04
26	Central Glass and Ceramic Research Institute	1.04
27	Govind Ballabh Pant University of Agriculture and Technology	1.04
28	University of Hyderabad	1.01
29	Indian Institute of Technology, Madras	1.01
30	Gandhigram Rural Institute	1.01
31	National Physical Laboratory India	1
32	Council of Scientific and Industrial Research*	0.98
33	Guru Jambheshwar University of Science and Technology	0.98
34	Institute of Mathematical Sciences	0.97
35	Central Electrochemical Research Institute	0.97
36	Central Food Technological Research Institute	0.96
37	Annamalai University	0.95
38	Doctor Harisingh Gour University	0.95
39	Institute of Genomics and Integrative Biology	0.94

40	Bose Institute Kolkata	0.93
41	Motilal Nehru National Institute Of Technology	0.93
42	Tezpur University	0.93
43	Indian Council of Medical Research	0.92
44	International Institute of Information Technology, Hyderabad	0.91
45	Jamia Millia Islamia Central University	0.9
46	Bengal Engineering and Science University, Shibpur	0.9
47	Guru Nanak Dev University	0.9
48	Banaras Hindu University	0.9
49	Jadavpur University	0.89
50	Tata Memorial Centre	0.89
51	UGC-DAE Consortium for Scientific Research Indore	0.88
52	Karnatak University	0.88
53	National Metallurgical Laboratory	0.88
54	Jamia Hamdard University	0.88
55	Institute of Minerals and Materials Technology	0.88
56	National Institute of Technology Rourkela	0.88
57	National Environmental Engineering Research Institute	0.88
58	Inter-University Accelerator Centre	0.87
59	University of Pune	0.87
60	Indian Institute of Chemical Biology	0.87
61	Bhabha Atomic Research Centre	0.87
62	Raman Research Institute	0.86
63	Bharathiar University	0.86
64	Central Drug Research Institute	0.85
65	Institute of Chemical Technology, Mumbai	0.85
66	University of Delhi	0.84
67	National Institute of Technology, Tiruchirappalli	0.83
68	Central Leather Research Institute	0.83
69	Gulbarga University	0.83
70	Physical Research Laboratory	0.82
71	VIT University	0.82
72	University of Burdwan	0.82
73	National Institute of Mental Health and Neuro Sciences	0.82
74	National Institute of Technology Durgapur	0.82
75	S.N. Bose National Centre for Basic Sciences	0.81
76	Tata Sons Ltd.	0.81
77	Saha Institute of Nuclear Physics	0.79
78	Indian Statistical Institute	0.79
79	Anna University	0.79
80	Indira Gandhi Centre for Atomic Research	0.79
81	University of Mumbai	0.79
82	Aligarh Muslim University	0.78
83	National Botanical Research Institute	0.78
84	Bharathidasan University	0.77
85	Sri Venkateswara University	0.77
86	Pondicherry University	0.77
87	University of Rajasthan	0.77
88	University of Kerala	0.77
89	National Institute of Oceanography	0.76
90	Chhatrapati Shahuji Maharaj Medical University	0.76
91	Defence Research and Development Organisation	0.76
92	Raja Ramanna Centre for Advanced Technology	0.75
93	Jawaharlal Nehru University	0.75
94	National Institute of Technology Karnataka	0.75
95	Visva-Bharati University	0.75
96	Indian Institute of Chemical Technology	0.75
97	University of Calcutta	0.74
98	All India Institute of Medical Sciences	0.74
99	Sardar Patel University	0.74
100	Kuvempu University	0.73
101	Christian Medical College, Vellore	0.72
102	Cochin University of Science and Technology	0.72
103	Shanmugha Arts, Science, Technology and Research Academy	0.72
104	Thapar University	0.71
105	Himachal Pradesh University	0.71

106	Vidyasagar University	0.71
107	University of Madras	0.7
108	Allahabad University	0.7
109	Birla Institute of Technology	0.69
110	Jai Narain Vyas University	0.69
111	Thiagarajar College of Engineering	0.69
112	Dr. Babasaheb Ambedkar Marathwada University	0.69
113	Punjabi University	0.68
114	Jaypee University of Information Technology	0.68
115	University of Kalyani	0.67
116	*National Geophysical Research Institute*	0.66
117	Mangalore University	0.65
118	The Maharaja Sayajirao University of Baroda	0.65
119	Devi Ahilya University	0.64
120	Osmania University	0.64
121	Sree Chitra Tirunal Institute for Medical Sciences and Technology	0.64
122	University of Lucknow	0.63
123	Bangalore University	0.61
124	Postgraduate Institute of Medical Education and Research	0.61
125	Madurai Kamaraj University	0.6
126	Indian Space Research Organization	0.6
127	Seth Gordhandas Sunderdas Medical College and	0.59
128	Kurukshetra University	0.56
129	National Institute of Technology Warangal	0.54
130	Mohan Lal Sukhadia University	0.54
131	University of Mysore	0.53
132	Manipal University	0.52
133	Rashtrasant Tukadoji Maharaj Nagpur University	0.52
134	Sanjay Gandhi Postgraduate Institute of Medical Sciences	0.51
135	Indian Council of Agricultural Research	0.51
136	University College of Medical Sciences	0.51
137	PSG College of Technology	0.51
138	Indian School of Mines	0.49
139	North-Eastern Hill University	0.48
140	Jawaharlal Nehru Technological University, Hyderabad	0.48
141	Andhra University	0.47
142	Sri Ramaswamy Memorial University	0.47
143	Kakatiya University	0.47
144	Jawaharlal Institute of Postgraduate Medical Education and Research	0.47
145	Guru Tegh Bahadur Hospital	0.47
146	Government Medical College and Hospital	0.46
147	University of North Bengal	0.45
148	Indian Veterinary Research Institute	0.45
149	Lady Hardinge Medical College	0.44
150	Tamil Nadu Agricultural University	0.4

The top most 25 institutes in terms of 'intra-national collaboration were: Centre for Cellular and Molecular Biology, Variable Energy Cyclotron Centre, Indian Institute of Toxicology Research, Jawaharlal Nehru Centre for Advanced Scientific Research, Inter-University Centre for Astronomy and Astrophysics, Central Salt and Marine Chemicals Research Institute, Institute of Physics Bhubaneswar, National Institute for Interdisciplinary Science and Technology, Harish Chandra Research Institute, Panjab University, National Institute of Pharmaceutical Education and Research, University of Jammu, Indian Institute of Technology, Bombay, Birla Institute of Technology and Science, IBM India Research Laboratory, Indian Institute of Technology, Guwahati, Indian Institute of Technology, Delhi, Indian Institute of Technology, Kanpur, National Chemical Laboratory, Shivaji University, Tata Institute of Fundamental Research, Indian Institute of Technology, Kharagpur, Indian Institute of Technology, Roorkee, Indian Institute of Science and Indian Association for the Cultivation of Science.

Evidence from the study provides the following headline findings:

• Collaboration is an essential feature of the research base. Collaboration in research is pervasive throughout. In all the papers the basic building block is inter-personal collaboration. They are based on individual researchers, who work collaboratively in a climate of shared intellectual interest and trust.
• 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.
• Although ,the inter-institutional or international collaboration may not necessarily entail inter-personal collaboration, evidence from the case studies suggests that a strong collaborative research base is an important success factor in the operationalization of higher levels of aggregation
• 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.
• 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.

Finally, with regard to mapping collaborations it is important to keep in mind that much collaboration do not result in co-published papers but may involve the sharing of research infrastructure, exchange of material or samples or some kind of informal collaboration which involve knowledge stimulation Using this policy makers will be able to understand the underlying factors and the cognitive behavior of researchers qualitative methods are needed to complement bibliometric analysis

The citation analysis of collaborative papers have been used to study the visibility of different types of collaborations. The analyzed data indicates that papers having international collaboration have achieved higher visibility. More specifically, co-authorship with researchers in the US have received the highest citation rates and thus highest visibility England and Germany came second and third.

Citation Analysis

Citations are used to measure impact. The premise underlying this indicator is that a research finding frequently referenced by other researchers has had greater impact on the research community than an infrequently cited paper. Impact is not the same as quality. However, in many instances impact and quality may be congruent. On the other hand, a contentious research finding, for example in Indian context, the claim of 'Therapy through Stem Cell', may be highly cited not because the work was of high quality but because it stimulated a vibrant debate about a research claim. In other words, it impacted the research community. We must never forget that negative impact can spawn new research ideas.

The simplest measure of impact is citations per paper. For example, one might count the number of papers published in a given year and then count the number of citations to those papers in the publication year and the subsequent two, three or four years. The choice of the citation window width is somewhat arbitrary. Typically, within five years most papers will receive about 40-50% of their citations. Narin has shown that the citation peak usually occurs in the second or third year after publication although this can vary across science fields. Normally, in bibliometric analyses we use a three-year citation window (i.e. publication year plus two subsequent years). The result is that 2012 impact information is based on 2010 publications. This narrower citation window provides a measure of the impact of faster moving, perhaps leading edge and research. However, one must keep in mind that the citation culture can vary from field to field and in some areas of research the rate of diffusion of new research findings can be much slower than in others *e.g.* Mathematics or Engineering.

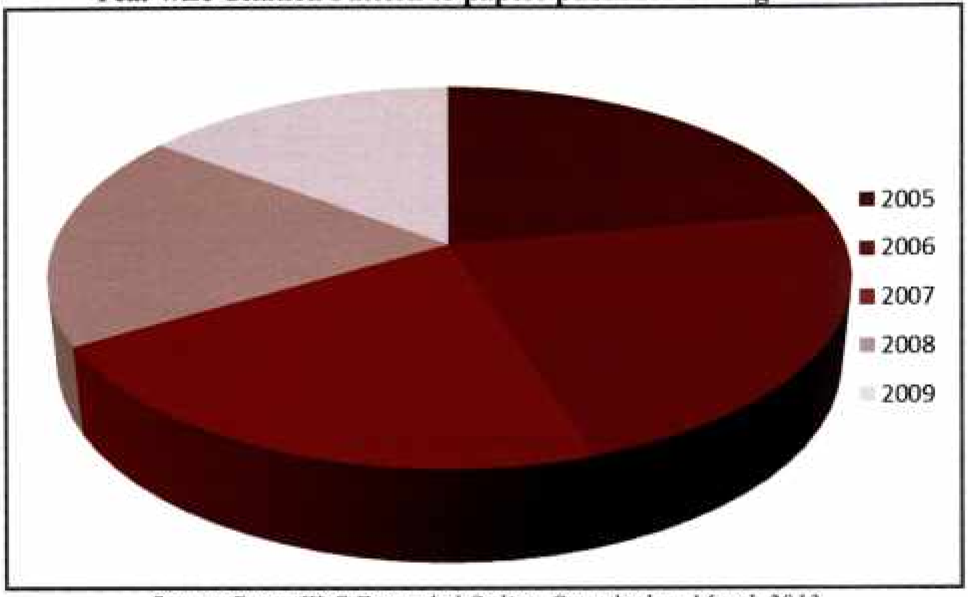
Another factor to consider is the effect of self-citation (i.e. an author citing previously published work in a current paper) on the impact measure. Removing the effect of self-citation in a large corpus of publications is computationally difficult so the effect of self-citations is rarely considered. However, it has been demonstrated that for a large cohort of papers, such as those for a institution or a broad subject area, the percentage of self-citations remains fairly constant thus affecting the 'impact' in a similar and comparable manner across most institutions and subject area. On the other hand one could argue that only excessive self-citations should be removed as it is common practice for researchers to build on their previous work since knowledge production is cumulative and by necessity cite it.

Total Citations to the Papers Published during 2005-09

Year	Total Papers	Total Citations	Self-Citation	Citation /paper	Cited Papers
2005	28187	320648	109.6	15.84	20242
2006	31652	328389	113.859	10.23	32093
2007	36919	310326	107.357	10.15	30586
2008	43373	266414	92.238	7.34	36309
2009	44775	214443	76.567	5.72	37485

Source Data: WoS Expanded Online. Searched on March 2013

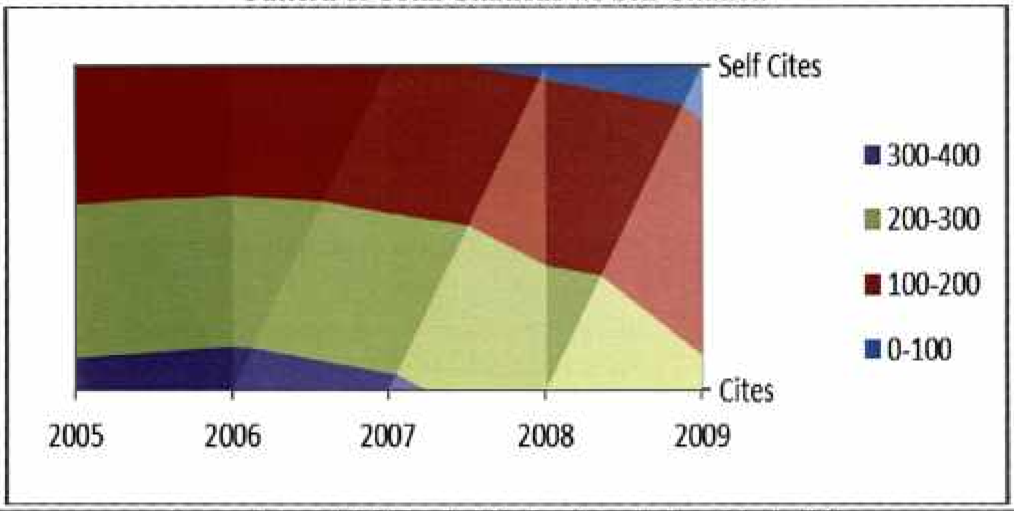
Year wise Citation Pattern to papers published during 2005-09



Source Data: WoS Expanded Online. Searched on March 2013

For computing the 'Citation' data, WoS (SCOPUS for calculating *h* index) has been used, as this has got a good coverage of Indian Papers being published in the area of Science & Technology including Medicine. More over the database is better structured and follow a standard formatting for the rendering of different data elements of particular field. The data base provides full support for 'Citation' as well as 'Co-citations Analyses'.

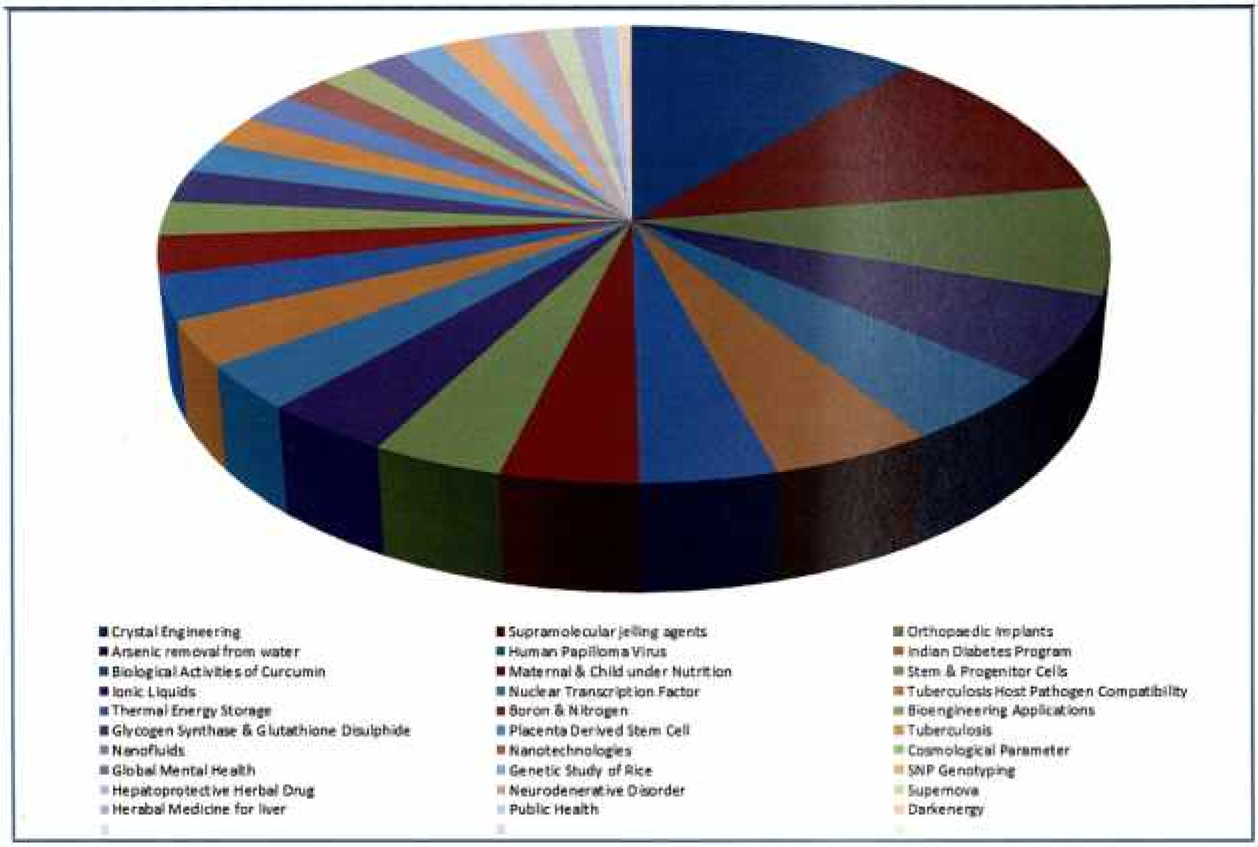
Pattern of Total Citations v/s Self Citation



Source Data: WoS Expanded Online. Searched on March 2013

India's share of world papers and the relative number of citations to these papers received have both increased in recent years. However, while India is currently ranked seventh in terms of total output of papers within the group of Asian countries (SCOPUS data 2005-09), it remains tenth in terms of citation impact. While most of India's research is cited less frequently than world average it continues to improve. This growth suggests that India, along with other emerging economies, will become increasingly important to the global research community and that opportunities to collaborate with Indian researchers will increase. The Impact Profiles for India's research publications show that while most of India's research is cited less frequently than the world average, India produces a significant volume of more frequently cited research. India published a total of 16 highly-cited papers (total 290- 700 Citations to each paper) in science and technology during the period of study (2005-09) as seen from the publications output data for 2005-09.

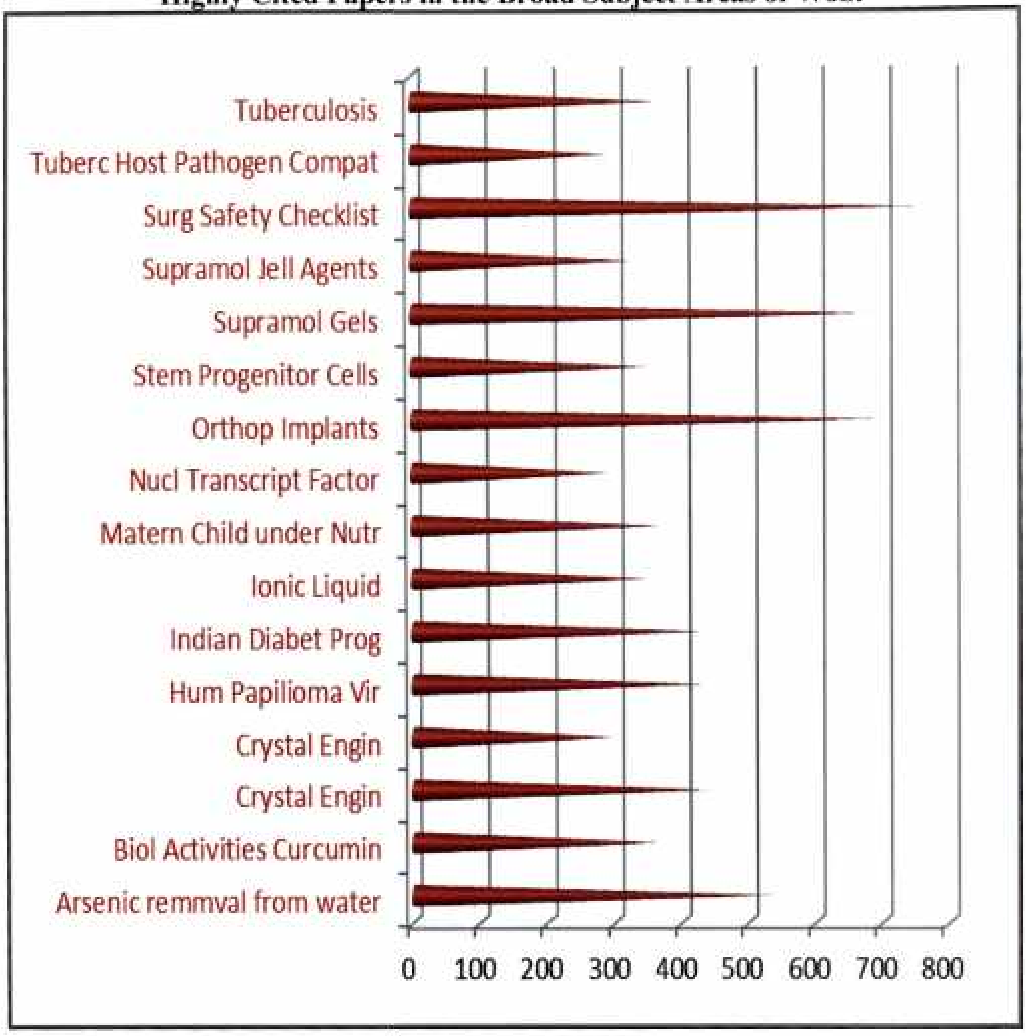
Subject Area Wise Citation Pattern:



Source Data: WoS Expanded Online. Searched on March 2013

An analysis of 'Citation pattern of top 10' papers from each 'Broad Subject area' as defined by SCI (excluding two papers in the field of 'Particle Physics') have indicated that the topmost paper getting maximum citation among all the ' Top major discipline' was from the field of Crystal Engineering. The other top 15 papers from different disciplines, receiving ≥ 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.

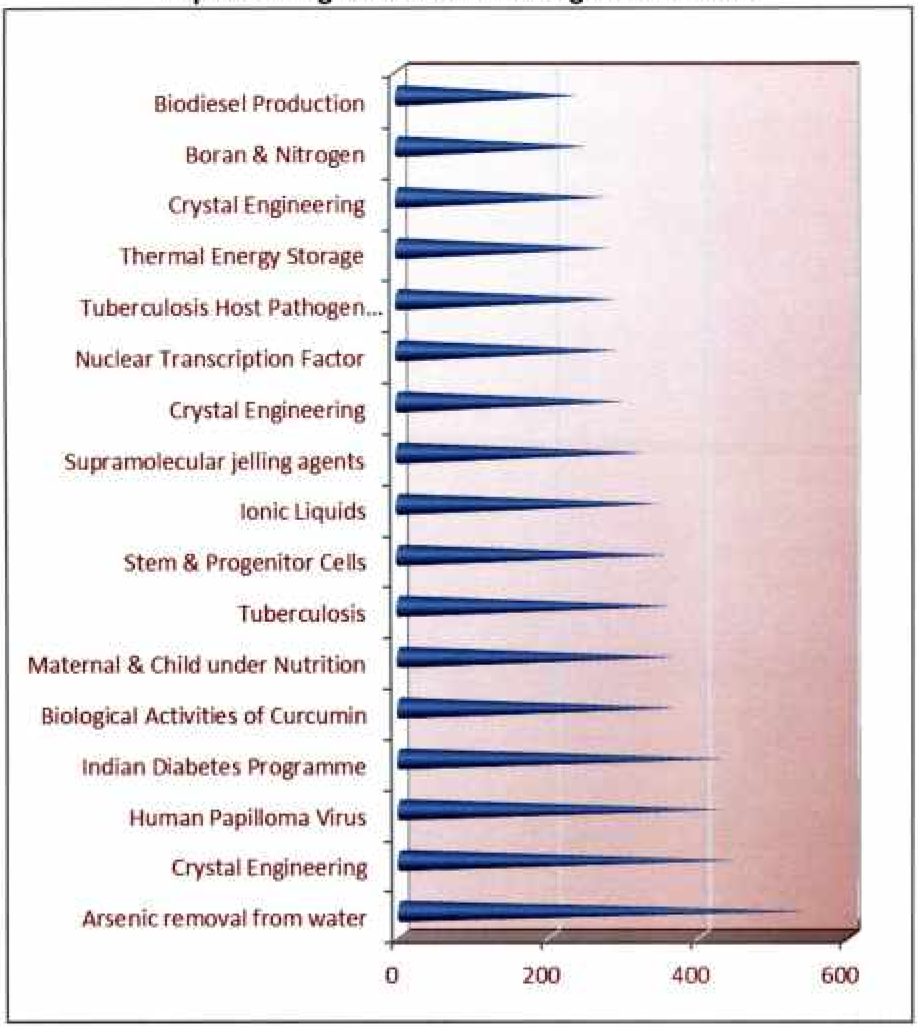
Highly Cited Papers in the Broad Subject Areas of WoS.



Source Data: WoS Expanded Online. Searched on March 2013

Further analysis at the level of 'major discipline' was also carried out. 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. The next one is a paper with maximum citation (543 citation) dealing in the area of 'Arsenic removal from water' followed by Crystal Engineering, Human Papilloma Virus, Indian Diabetes Program, Biological Activities of *Curcumin*, Maternal & Child under Nutrition, Tuberculosis, Stem & Progenitor Cells, Ionic Liquids, Supra-molecular jelling agents, Crystal Engineering, Nuclear Transcription Factor, Tuberculosis Host Pathogen Compatibility, Thermal Energy Storage, Boron & Nitrogen and Biodiesel Production.

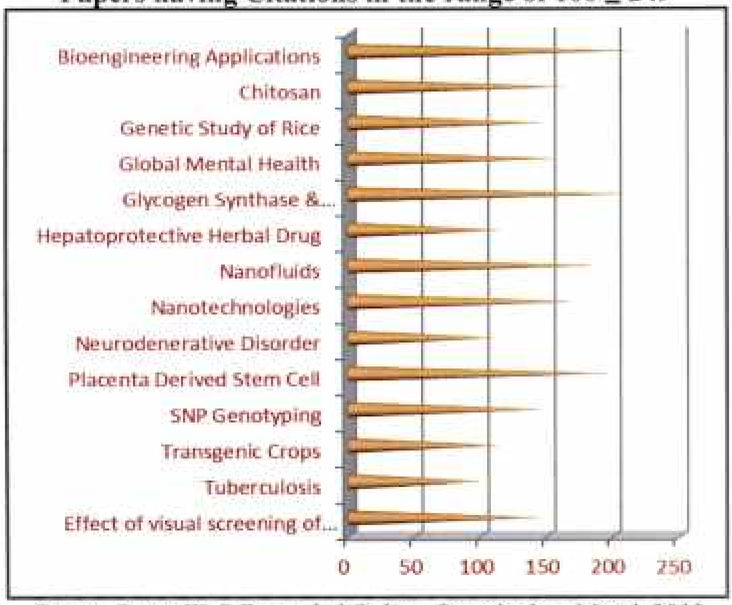
Papers having Citations in the range of 250 ≥ 550



Source Data: WoS Expanded Online. Searched on March 2013

The next group of papers was of those having Papers with Citations in the range of 100 ≥ 249. The top most papers was from the field of 'Bioengineering Applications' followed by Glycogen Synthase & Glutathione Disulphide, Placenta Derived Stem Cell, Nano-fluids, Nanotechnologies, Chitosan, Global Mental Health, Genetic Study of Rice, SNP Genotyping, Effect of visual screening of cervix for Cancer, Hepato-protective Herbal Drug, Transgenic Crops, Neurodenerative Disorder and Tuberculosis.

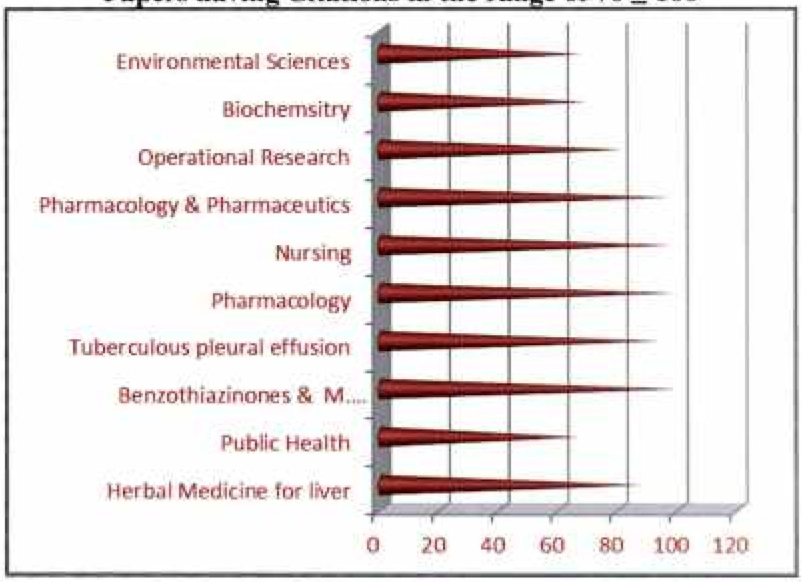
Papers having Citations in the range of 100 ≥ 249



Source Data: WoS Expanded Online. Searched on March 2013

Next group of papers were having citations in the range of ≥ 60. The top most paper was on the topic of Benzothiazinones & M. Tuberculosis followed by Pharmacology, Nursing, Pharmacology & Pharmaceutics, Tuberculous pleural effusion, Herbal Medicine for liver, Operational Research, Biochemistry-General, Environmental Sciences and Public Health.

Papers having Citations in the range of 70 ≥ 100

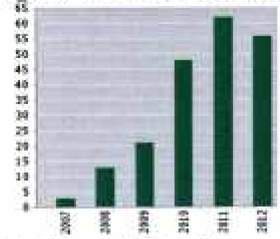


Source Data: WoS Expanded Online. Searched on March 2013

We have computed the data on the subject wise level also. In terms of 'Citation / paper' the highest citation was received by a paper from the field of Statistics & Probability followed by Chemical Sciences, Agricultural Sciences, Material Sciences, Environmental Sciences, Nursing, Biological Sciences, Genetics (***Source Data: WoS Expanded Online. Searched on March 2013***).

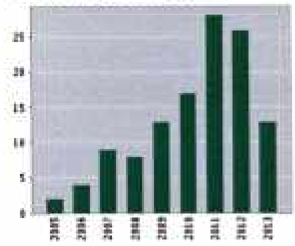
Agricultural Sciences:

Agriculture & Food Technology



Total Papers:21, Total Citations:236:, Avg. Citations / Papers: 11.24

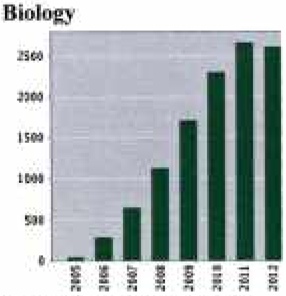
Veterinary Sciences



Total Papers:23, Total Citations:120:, Avg. Citations / Papers: 5.22

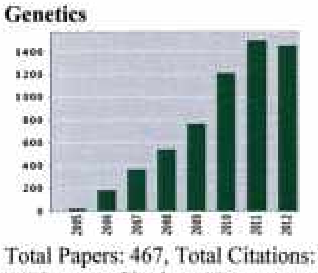
Biological Sciences:

Biology



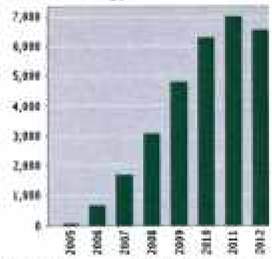
Total Papers: 12421, Total Citations: 12450, Avg. Citations / Papers: 10.07

Genetics



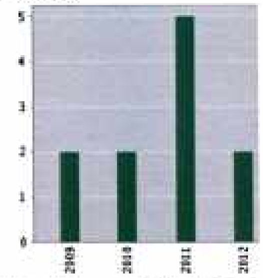
Total Papers: 467, Total Citations: 6628, Avg. Citations / Papers: 14.29

Microbiology



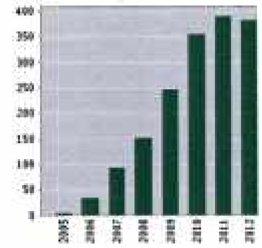
Total Papers: 3311, Total Citations: 33327:, Avg. Citations / Papers:10.07

Zoology



Total Papers: 7, Total Citations: 12, Avg. Citations / Papers: 1.41

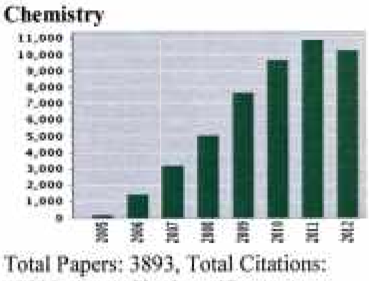
Biochemistry



Total Papers: 190, Total Citations: 1804:, Avg. Citations / Papers: 9.49

Chemical Sciences:

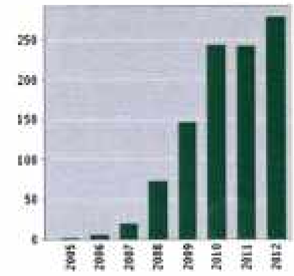
Chemistry



Total Papers: 3893, Total Citations: 53090, Avg. Citations / Papers: 13.74

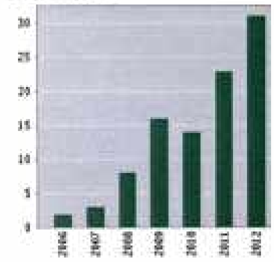
Earth & Atmos. Scienes:

Environmental Sciences



Total Papers:67, Total Citations: 1140, Avg. Citations / Papers: 5.24

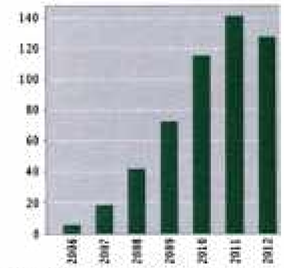
Geosciences



Total Papers: 20, Total Citations: 105, Avg. Citations / Papers: 5.02

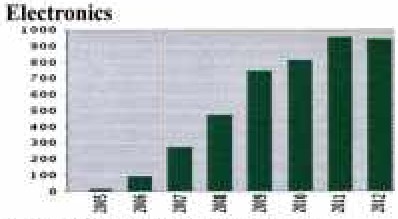
Engineering & Technol:

Computer Science



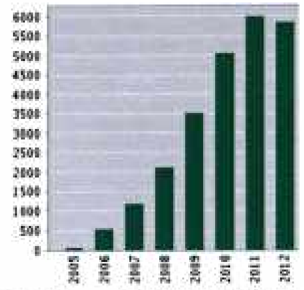
Total Papers: 455, Total Citations: 840, Avg. Citations / Papers: 1.84

Electronics



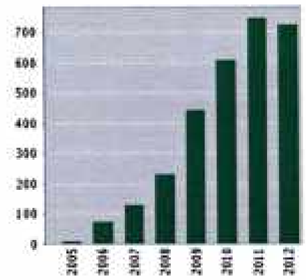
Total Papers: 337, Total Citations: 4721, Avg. Citations / Papers: 13.98

Engineering



Total Papers: 2178, Total Citations: 27084, Avg. Citations / Papers: 12.44

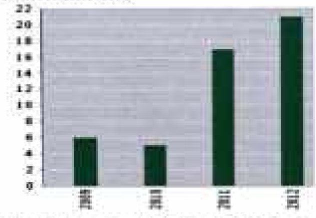
Instrumentations



Total Papers: 3201, Total Citations: 3131, Avg. Citations / Papers: 0.97

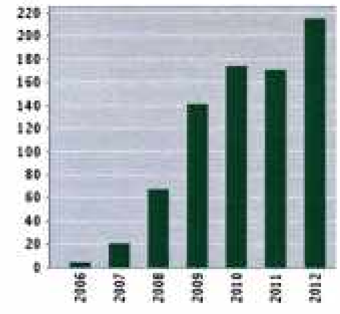
Mathematics:

Mathematics



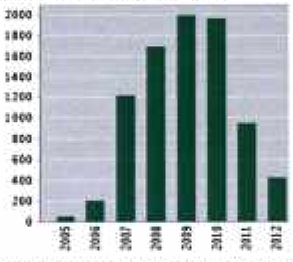
Total Papers: 13, Total Citations: 50, Avg. Citations / Papers: 3.85

Operational Research



Total Papers: 83, Total Citations: 880, Avg. Citations / Papers: 10.60

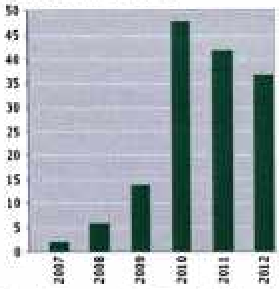
Statistics & Probability



Total Papers: 100, Total Citations: 8633, Avg. Citations / Papers: 86.33

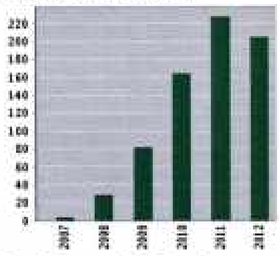
Medical Sciences:

Behavioral Science



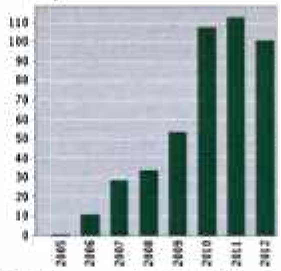
Total Papers: 17, Total Citations: 165:, Avg. Citations / Papers: 9.71

Biomedical Sciences



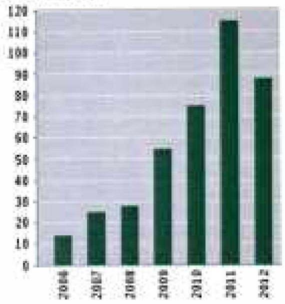
Total Papers:19, Total Citations:831, Avg. Citations / Papers: 43.27

Family Studies



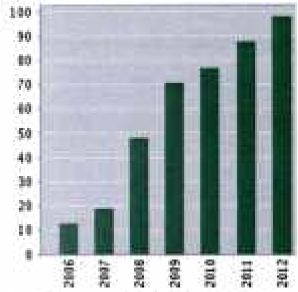
Total Papers: 44, Total Citations:: 493 Avg. Citations / Papers: 11.20

Geriatrics



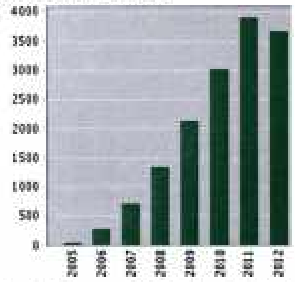
Total Papers: 57, Total Citations: 436, Avg. Citations / Papers: 7.65

Health Rehabilitation



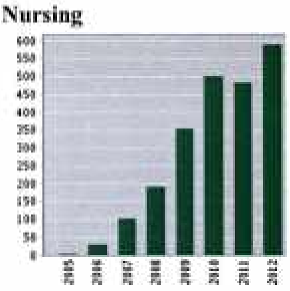
Total Papers: 35, Total Citations: 455, Avg. Citations / Papers: 13.00

Medical Sciences



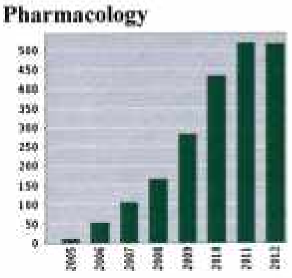
Total Papers: 1658, Total Citations: 16818, Avg. Citations / Papers: 10.16

Nursing



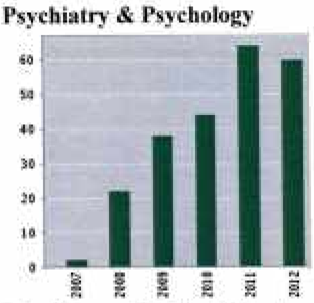
Total Papers: 159, Total Citations: 2516, Avg. Citations / Papers:

Pharmacology



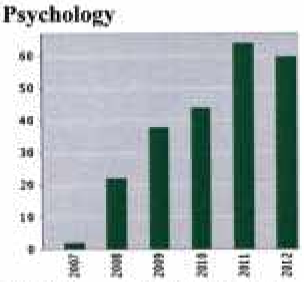
Total Papers: 168, Total Citations: 2293, Avg. Citations / Papers: 13.65

Psychiatry & Psychology



Total Papers: 33, Total Citations: 251, Avg. Citations / Papers: 7.61

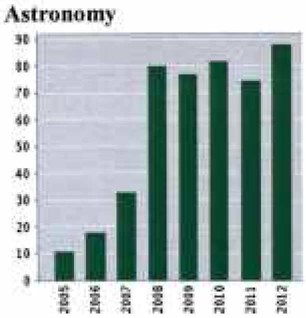
Psychology



Total Papers: 33, Total Citations: 251, Avg. Citations / Papers: 7.61

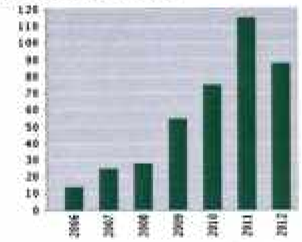
Physical Sciences:

Astronomy



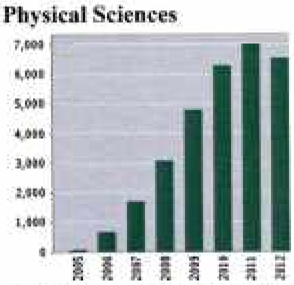
Total Papers: 79, Total Citations506:, Avg. Citations / Papers: 78

Nuclear Sciences



Total Papers: 57, Total Citations: 436, Avg. Citations / Papers: 7.65

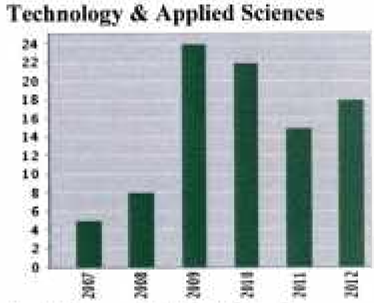
Physical Sciences



Total Papers: 3311, Total Citations: 33327:, Avg. Citations / Papers:10.07

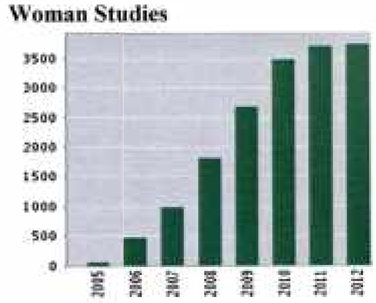
Multidisciplinary

Technology & Applied Sciences



Total Papers: 17, Total Citations: 100, Avg. Citations / Papers: 5.68

Woman Studies



Total Papers: 1506, Total Citations: 16532, Avg. Citations / Papers: 12.31

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 Indian was among the top 10 countries occupying 3[rd] or 4[th] position throughout the period of study (***Source Data: SCOPUS Online. Searched on May 2013***).

2005

	Country	Total Papers	Citations	Cits / Paper	H index
1	Japan	108,184	1,270,580	11.49	602
2	China	154,940	968,120	6.22	353
3	South Korea	34,462	369,588	10.59	309
4	India	35,716	320,648	8.48	281
5	Taiwan	23,694	247,699	10.24	249
6	Hong Kong	10,634	157,518	14.27	268
7	Singapore	8,763	129,646	14.32	240
8	Thailand	4,242	57,974	13.28	156
9	Malaysia	2,971	20,325	6.66	116
10	Pakistan	2,506	15,811	5.92	101

2006

1	Japan	113,239	1,124,922	9.7	602
2	China	184,200	1,023,131	5.53	353
3	South Korea	40,313	348,298	8.51	309
4	India	42,572	328,389	7.31	281
5	Taiwan	26,788	240,166	8.77	249
6	Hong Kong	11,825	142,235	11.54	268
7	Singapore	10,380	123,565	11.49	240
8	Thailand	5,412	49,513	8.91	156
9	Malaysia	3,986	22,998	5.63	116
10	Pakistan	3,139	18,201	5.51	101

2007

1	China	208,313	1,035,319	4.94	353
2	Japan	109,110	953,575	8.52	602
3	South Korea	44,218	327,459	7.29	309
4	India	46,826	310,326	6.27	281
5	Taiwan	29,866	220,309	7.22	249
6	Hong Kong	11,943	133,631	10.77	268
7	Singapore	10,448	115,059	10.61	240
8	Thailand	6,188	52,135	8.26	156
9	Malaysia	4,700	24,356	5.09	116
10	Pakistan	3,791	21,157	5.35	101

2008

1	China	242,438	996,100	4.08	353
2	Japan	107,169	751,265	6.81	602
3	South Korea	47,170	293,390	6.11	309
4	India	51,904	266,414	4.85	281
5	Taiwan	32,132	194,491	5.91	249
6	Singapore	11,241	102,755	8.77	240
7	Hong Kong	11,742	102,684	8.43	268
8	Thailand	7,322	42,279	5.62	156
9	Malaysia	6,972	25,000	3.51	116
10	Pakistan	4,632	22,248	4.63	101

2009

1	China	284,372	823,957	2.87	353
2	Japan	107,025	531,006	4.8	602
3	South Korea	49,093	232,387	4.61	309
4	India	58,380	214,443	3.48	281
5	Taiwan	34,384	151,049	4.28	249
6	Singapore	11,702	81,989	6.73	240
7	Hong Kong	12,070	75,006	5.98	268
8	Thailand	7,599	34,797	4.4	156
9	Malaysia	10,262	28,389	2.72	116
10	Pakistan	5,664	17,543	3	101

Mapping of Indian Science:

A science map is two or three dimensional representation of one or more science fields. The items in the map refer to themes or topics that are positioned in relation to each other. Topics that are cognitively related to each other are positioned in each other's vicinity, and those not related or weakly related are positioned distant from each other. For strategic decision-makers in charge of national, institutional or R&D programs, the most valuable maps often are those based on co-occurring reference citations reveals. These co-citation maps reveal the cognitive structure of a scientific field, i.e., how the researchers themselves link different areas of knowledge.

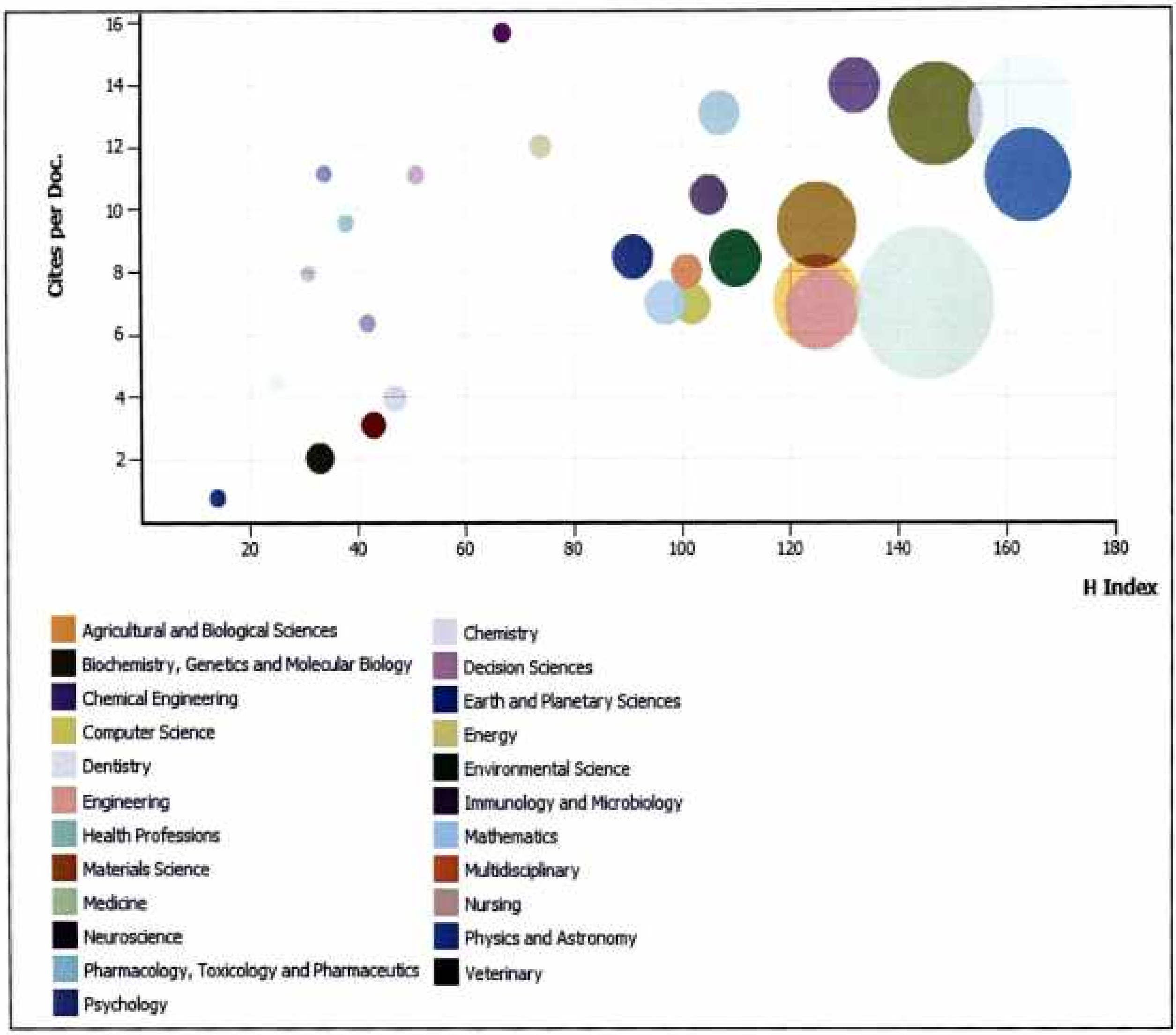
The Map Generator software has been used to generate metrics to depict two types of Maps of Science & Technology, based upon national science indicators for 2 year periods between 2005 and 2009. These maps are intended to help reveal the existence of underlying scientific structures and plot science outputs and performance at a national level. The maps depict: Co-citation networks and Bubble charts of pattern of Citations and Co-citations. Both the maps has been generated for two time periods only; 2005-06 and 2008-09 to see if there is any change. Although, for this kind of study we need to do extended time periods for reaching to a conclusive results which is out of the scope of present project.

Bubble charts:

Scientific output for India has been analyzed through customizable Bubble Charts for a richness of performance metrics. These charts also offer two levels of detail based on Scopus Classification's Science Areas (21 major fields) and Subject Categories (313 narrower thematic categories).Bubble charts features includes:

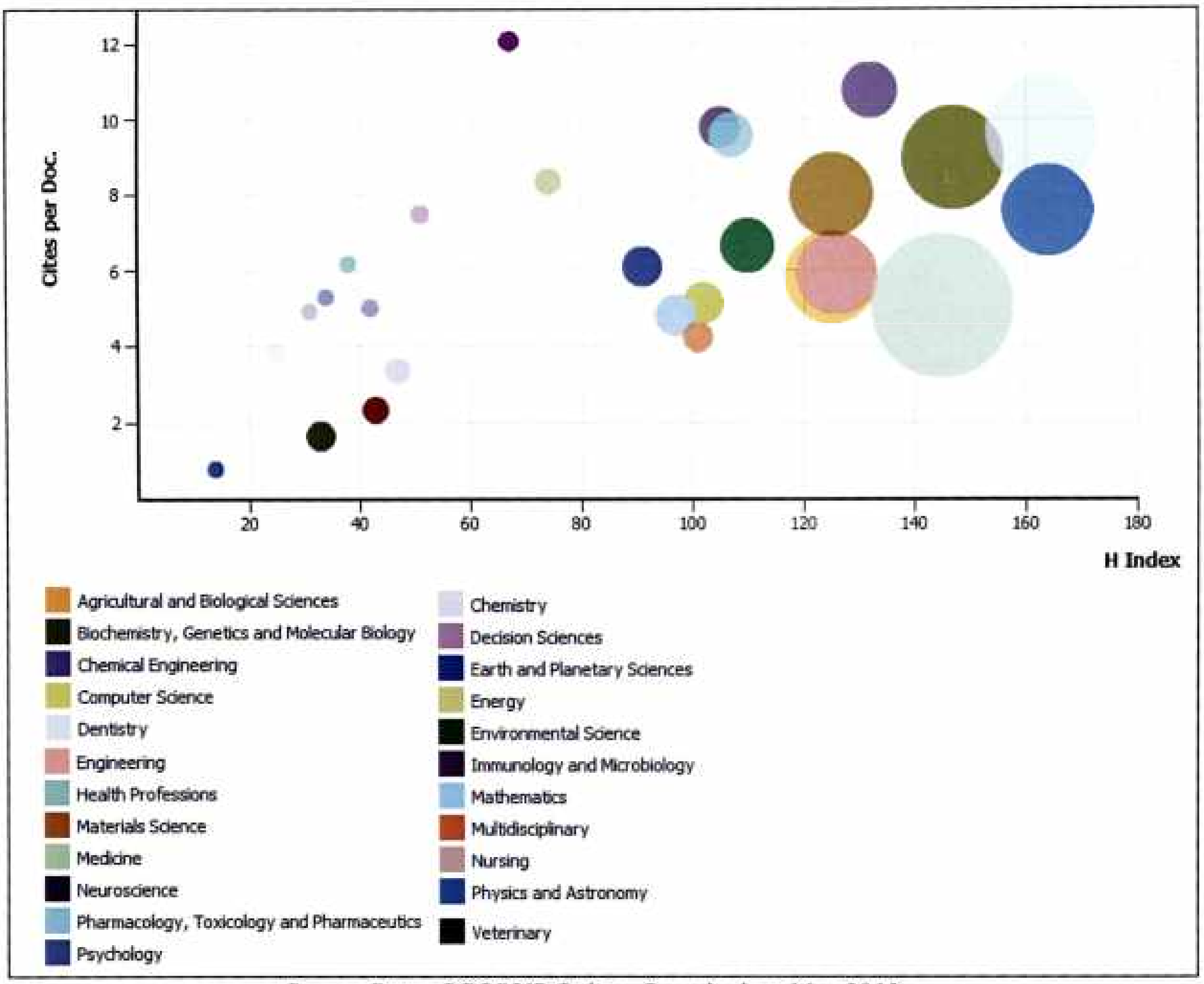
- Default view plots H index (on X axis) versus Citations / Papers (on Y axis), corresponding the bubble size to the field publication size.

Bubble Chart of Citations / Paper and H index (2005-06)



Source Data: SCOPUS Online. Searched on May 2013

Bubble Chart of Citations / Paper and H index (2008-09)



Source Data: SCOPUS Online. Searched on May 2013

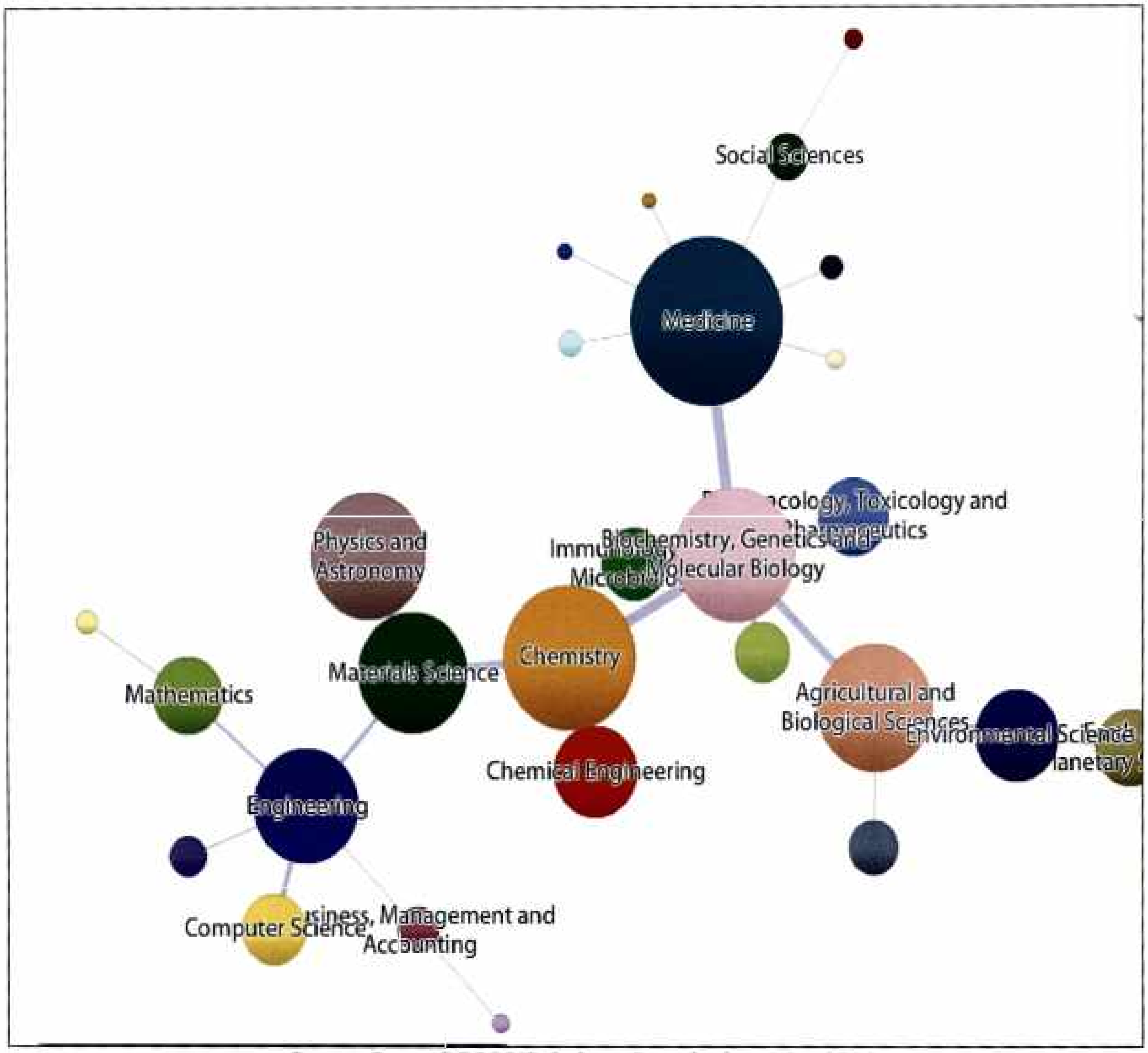
The size of the circles is proportional to the number of papers published in that year in a given discipline (small circle) or meta-discipline (large circle). A close look at the 'Bubble Charts' of both the time periods (2005-06 & 2008-09) indicates that there are two main distinctly visible groups- Medicine in close 'contact' of Biological & Agricultural Sciences, Material Sciences and Engineering Sciences. This indicates a clear 'trend' of Publication / Citations of Indian Papers in the field of cutting edge technologies of Medicine like Nanotechnology .

The next group is of Mathematics linked with Physical Sciences & Astronomy, Biochemistry, Genetics and Molecular Biology; indicating towards impact of Indian research in the field of 'Bioinformatics' and Modern Biology.

Co-citation networks: National scientific structures were analyzed through two levels of detail for Co-citation Network Maps based on Scopus Classification's Science Areas (21 major fields) and Subject Categories (313 narrower thematic categories). The maps show the following features:

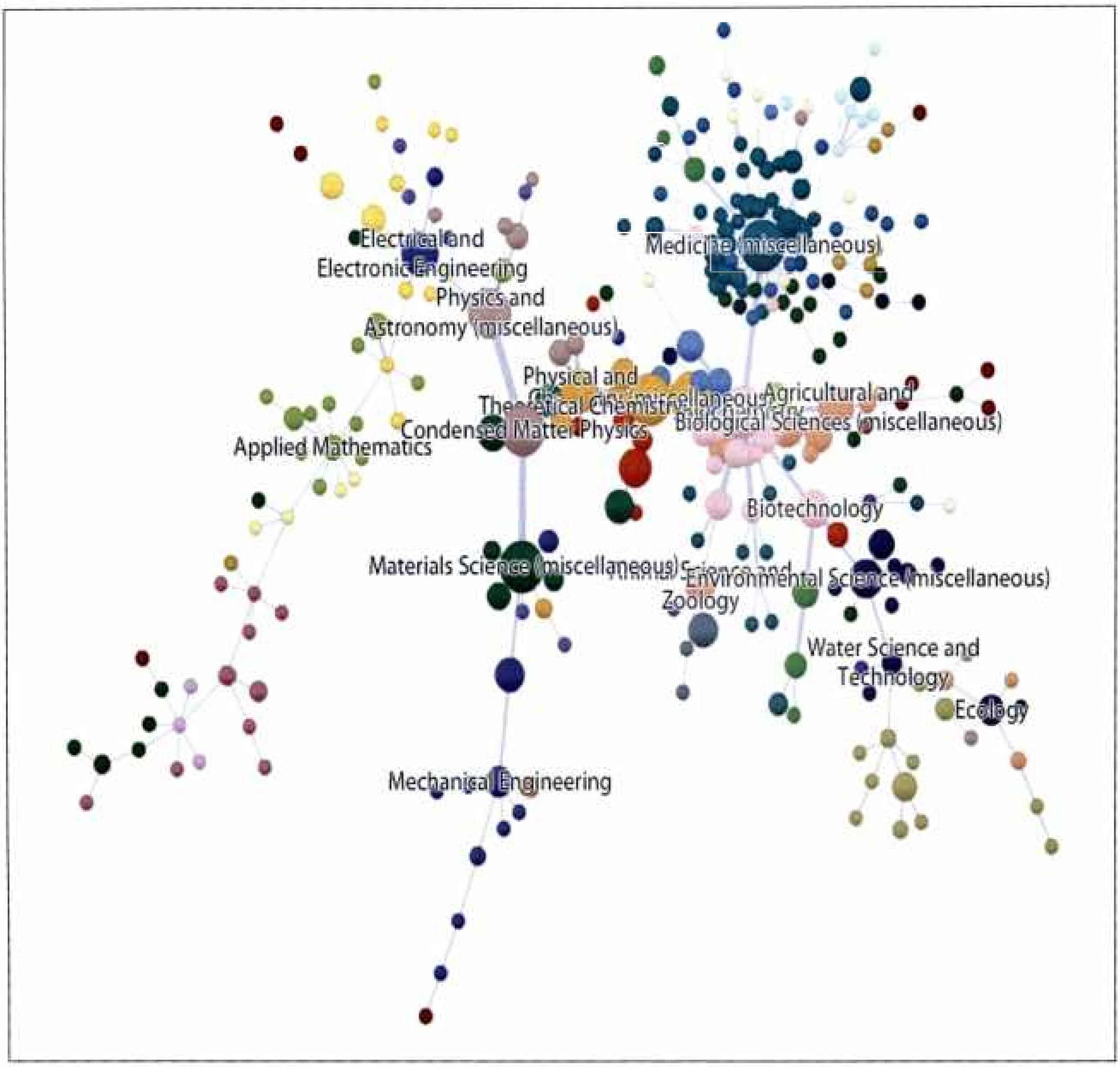
- Field/category size is depicted by the node size
- Relationship (similarity) intensity is displayed through thick / thin lines.

Co-Citation Map (broad subject areas) 2005-06



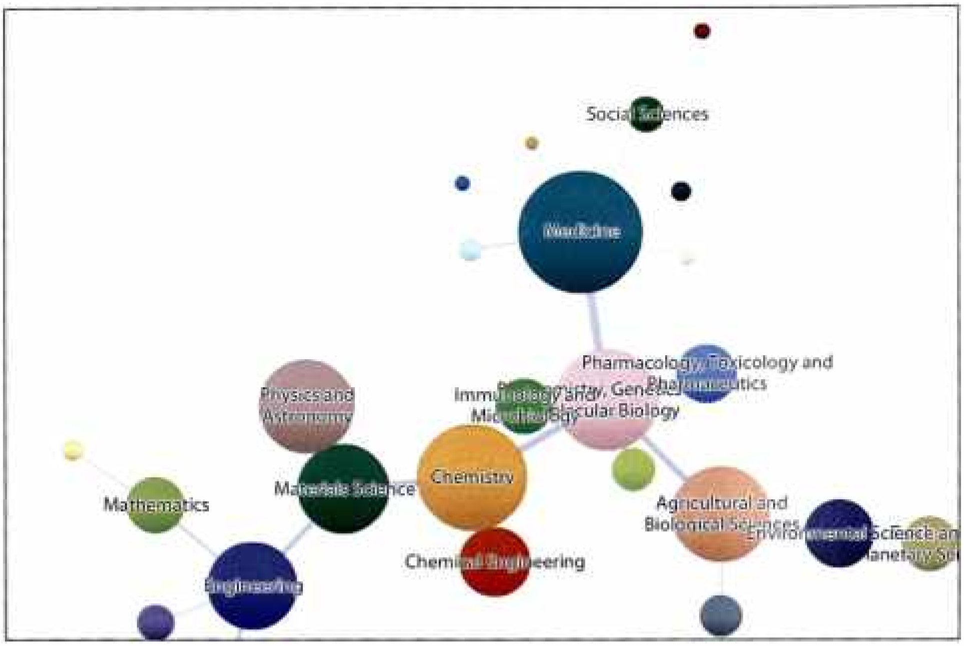
Source Data: SCOPUS Online. Searched on May 2013

Co-Citation Map (with major subject disciplines) 2005-06

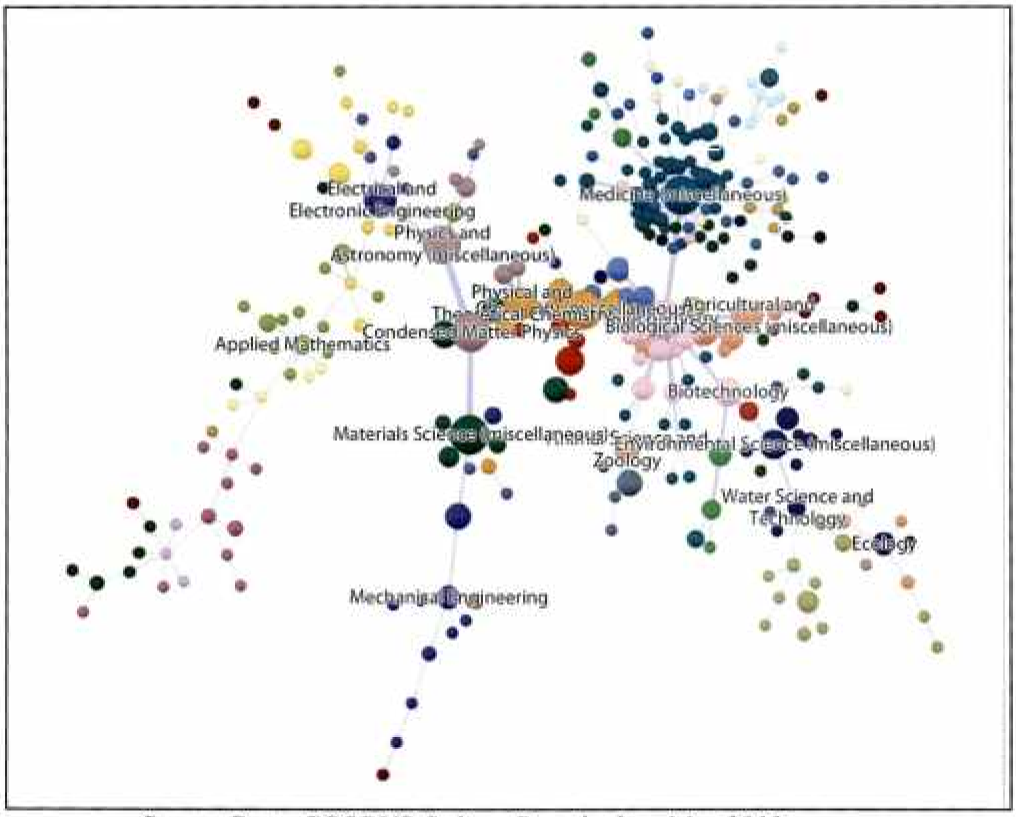


Source Data: SCOPUS Online. Searched on May 2013

Co-Citation Map (broad subject areas) 2008-09

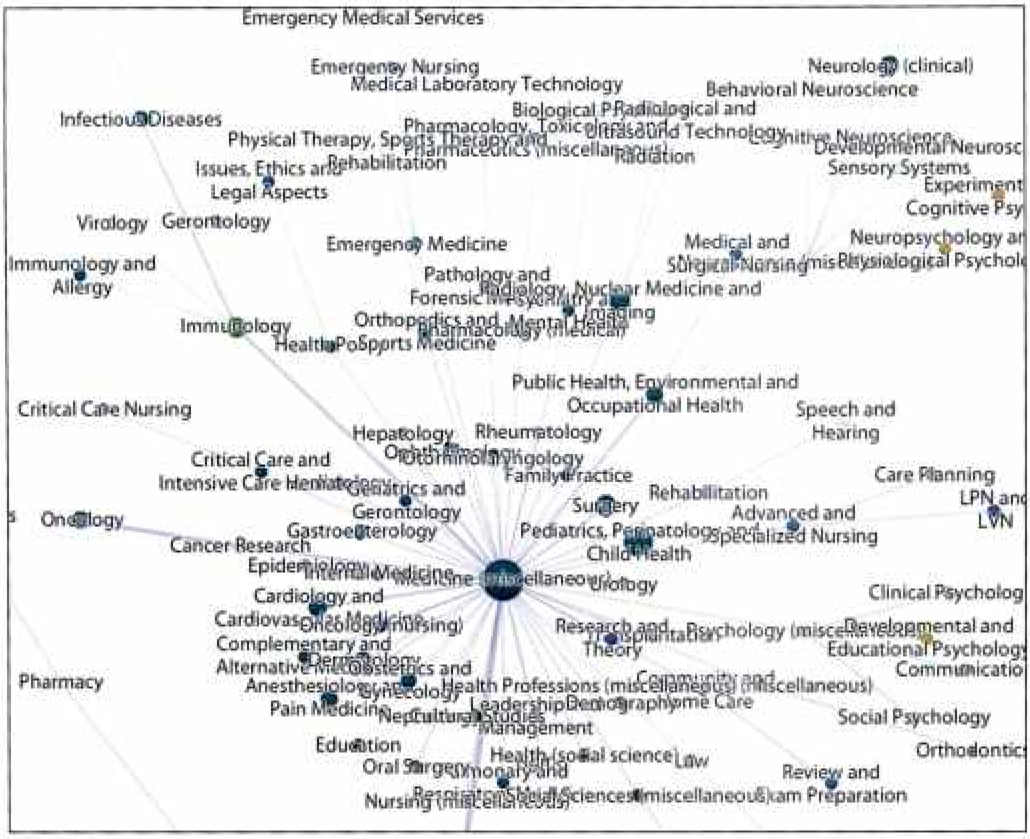


Co-Citation Map (with major subject disciplines) 2008-09



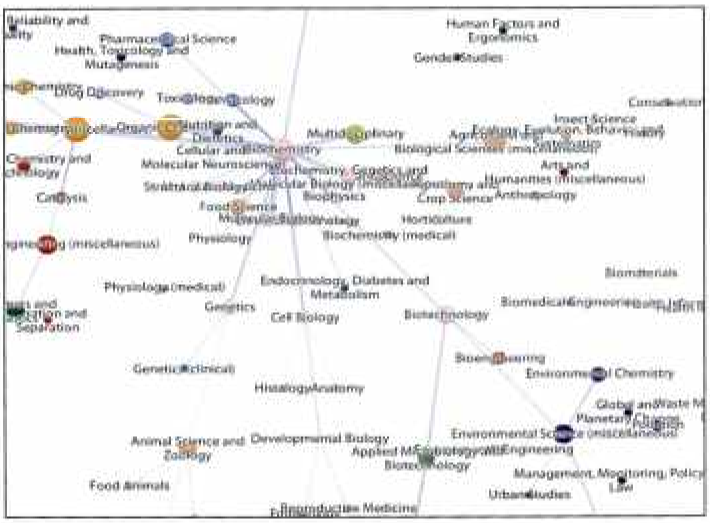
Source Data: SCOPUS Online. Searched on May 2013

Medical Sciences



Biological Sciences, Biochemistry & Environmental Studies

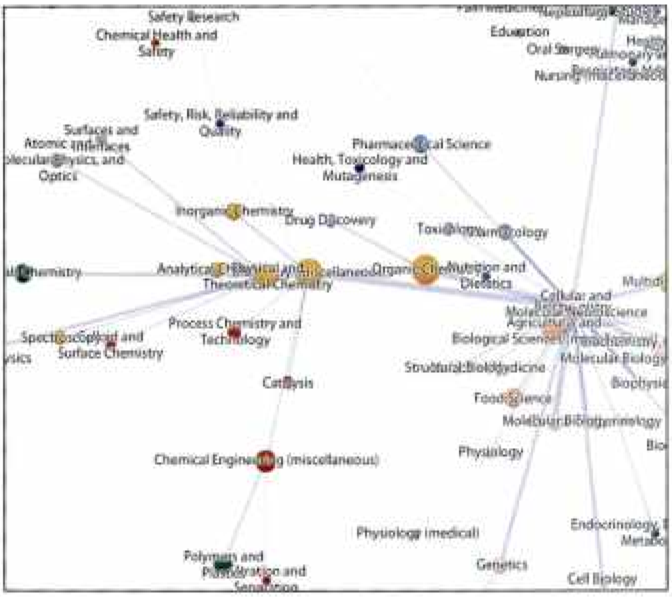
Source Data: SCOPUS Online. Searched on May 2013



Source Data: SCOPUS Online. Searched on May 2013

We should not forget, because co-citation-based maps reflect the connections between disciplines that thousands of researchers make each year, the linkages between disciplines can shift over time. From the 'Map' it is evident that the meta-discipline of biology no longer exists now. The majority of biology researchers during the period of study (2005-06 & 2008-09) focused their investigations on medical aspects of biology or on the chemical aspects of biology along with aspects of modern biology *eg.* Cell Biology, Developmental Biology, Embryology, Molecular Biology, Immunology or Reproductive Medicine. During the same years, the chemistry researchers drew more towards physical sciences and vice versa.

Chemical Sciences

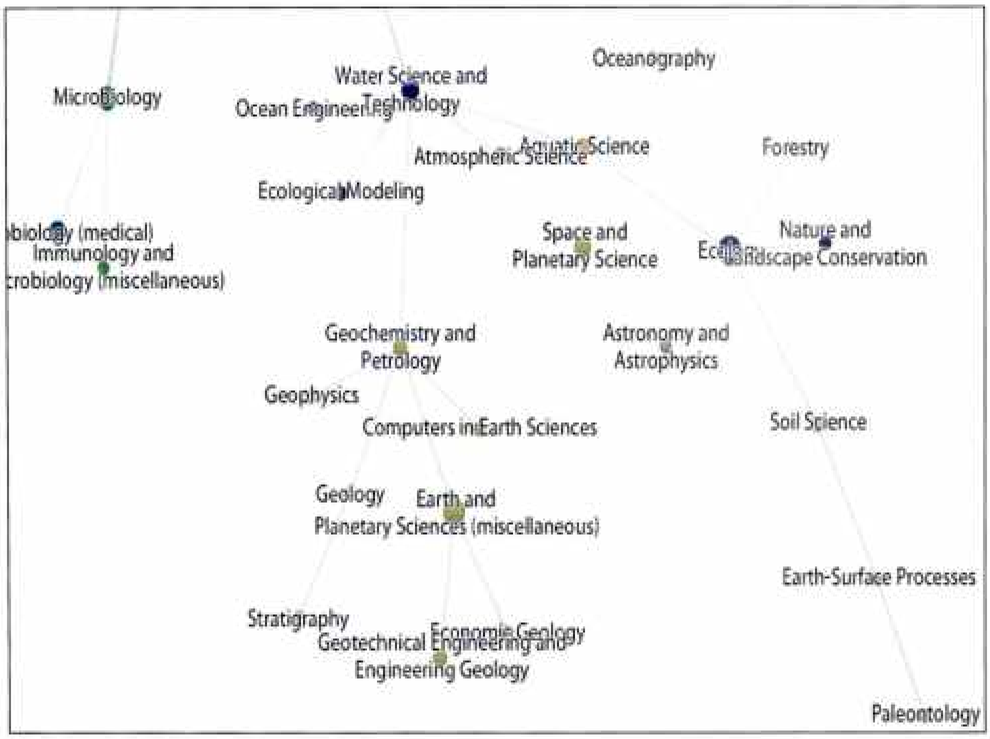


Source Data: SCOPUS Online. Searched on May 2013

The Co-Citation Map for both the time periods (2005-06 & 2008-09), and Broad Areas along with Major discipline indicates that Medicine is very well established in terms of 'Citation Network' followed by 'Chemistry' and 'Material Science'. These maps shows that 'Medical Sciences' related research accounts for most of the science published during 2005-06 & 2008-09. In addition, 'Chemical Sciences research is linked to both biology and physics, but there no links between biology and physics.

The other subjects field with a little less impact at international level were as follows:

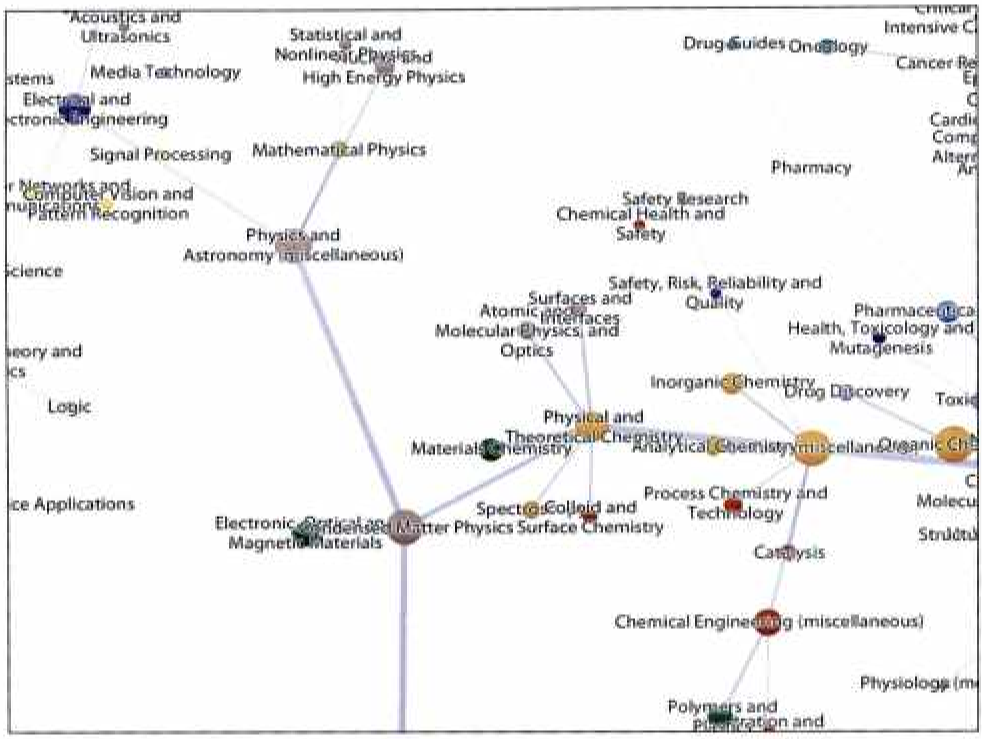
Earth & Atmospheric Sciences



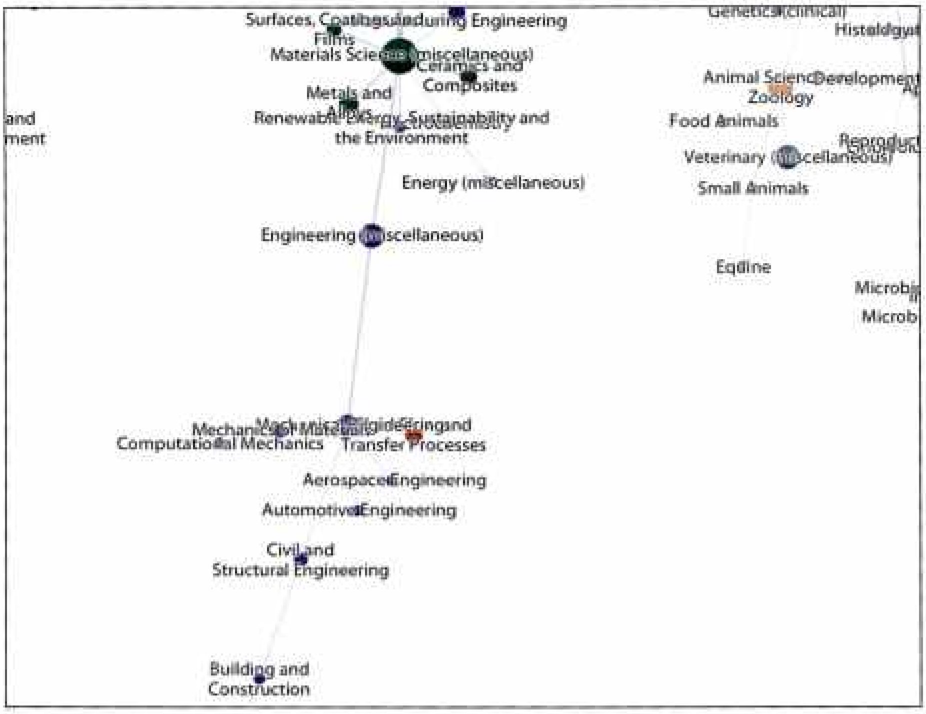
Source Data: SCOPUS Online. Searched on May 2013

The field of Earth & Atmospheric Sciences, is an upcoming field for Indian researchers in terms of international visibility. None the less India has stepped into many new & very important frontiers as seen from the map like water science & technology, atmospheric science, geochemistry & petrology and Nature and conservation *etc.*

Physical Sciences & Astronomy

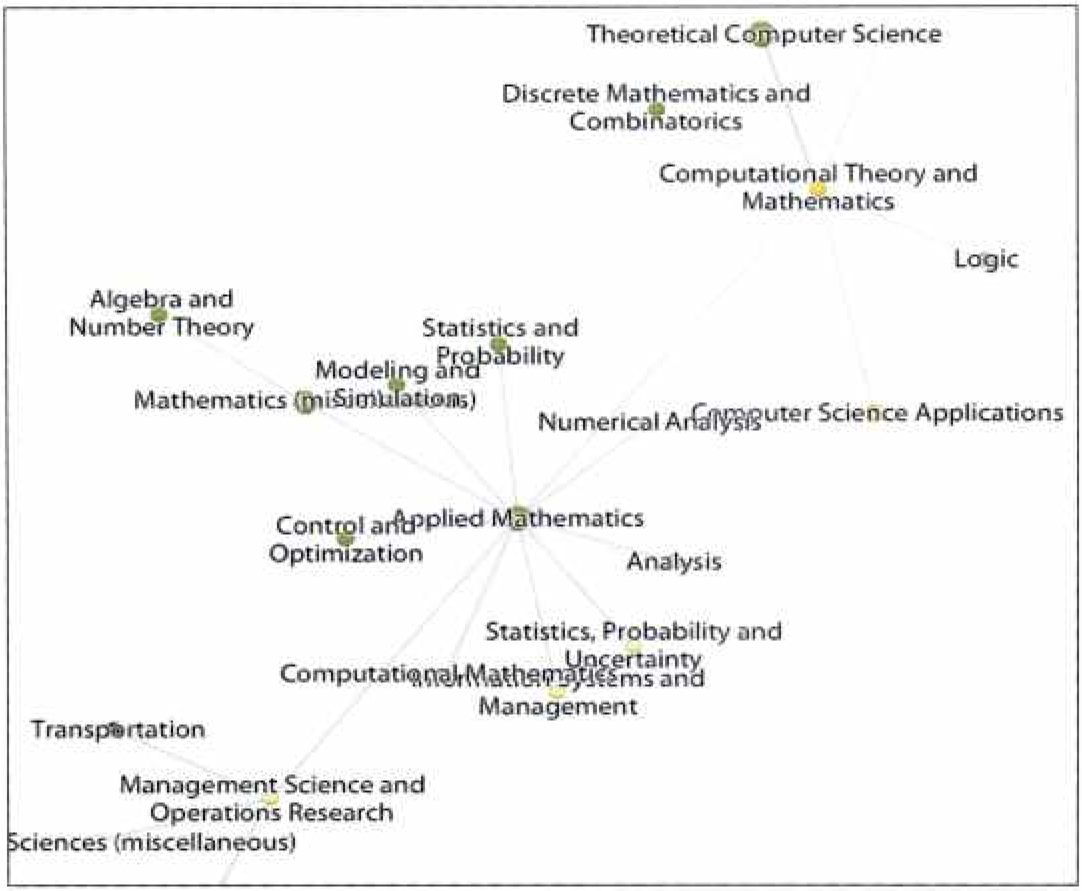


Engineering & Material Sciences



Source Data: SCOPUS Online. Searched on May 2013

Mathematics & Computer Sciences



Source Data: SCOPUS Online. Searched on May 2013

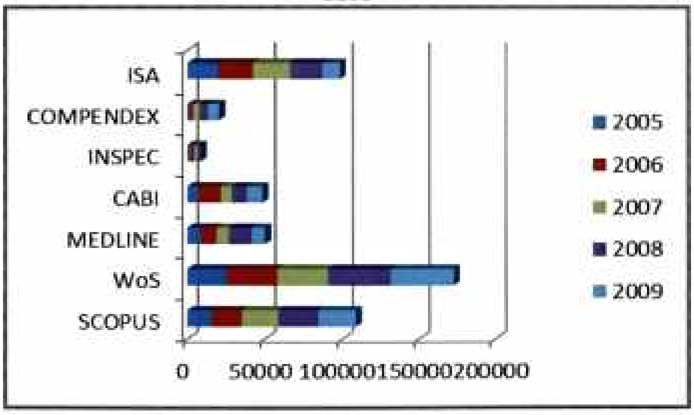
The other subject fields – Mathematics & Computer Sciences, Physical sciences & Engineering and Material sciences are yet to make their presence felt at international level in terms of Citations' to Indian papers from these areas.

Monitoring of Indian Research Papers through Major Global Secondary Services

The term secondary services apply to current bibliographical list of indexes and abstracts which are regularly published either in hard copy or as machine- readable database (say on CDROM or online through the net). Examples of secondary services are Physics Abstracts (hard copy), INSPEC (machine-readable), MEDLINE, SCOPUS, Science Citation Index, CABI and Indian Science Abstracts (ISA), etc. These services, both traditional abstracting and indexing services and citation indexes are now used heavily for researches and investigations on output or productivity studies, science of science, science policy, etc. But usefulness of almost all of the secondary services as source of data is frustrating. Whether hard copy or machine-readable form, the sources do not supply complete data about the Indian contribution. Our experiences with a number of these services have made us realize that unless the data is extracted from all the available global services and complemented with the total research papers from all the Indian journals, bibliometric studies will always remain crippled and severely partial. In the present study a time period (2005-2009) has been identified for analyses. In this study the databases namely WoS, SCOPUS MEDLINE, CABI, COMPENDEX and INSPEC have been selected. The data has been analyzed separately for each database for computing trend of papers and journals being covered by that particular secondary service

Output Analysis : The present assessment of Indian science is based on the publication data extracted for the years 2005-2009. Five years data have been used to avoid year-to-year fluctuations in the coverage of Indian papers appearing in Journals by individual secondary services. The objectives of the study were to study the trend of coverage of journals / papers by individual secondary services. Apart from focusing on publications as indicators of R&D output and patterns therein, contributions under this theme also employ other novel methods for gauging India's research capability and potential. In the period 2005 - 2009, the Indian S & T output as reflected in all the databases, is skewed. The Figure (below) shows the consolidated total S & T papers produced by Indian scientists in the five years period, which has been covered by all the databases namely Scopus, WoS, MEDLINE, ISA, CABI, INSPEC & COMPENDEX.

Total Indian Papers covered by SCOPUS, WoS, MEDLINE, CABI, INSPEC, COMPENDEX and ISA



Year wise coverage of Indian Papers by individual secondary services.

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 (year 2005); 5832 (year 2006); 6630 (year 2007); 7436 (year 2008); and 6958 records from the year of 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.

The contribution of Indian scientists to the world's scientific outputs increased during the last five years. This performance results mainly from the investments made in human resource training during the last thirty years mostly by the institutions and research laboratories. India established a large number of institutions in the recent period which is yielding currently large number of research papers. The figures in table above presents the pattern of coverage of papers by SCOPUS, WoS, MEDLINE, CABI, INSPEC, COMPENDEX and ISA during the last five years.

SCOPUS:

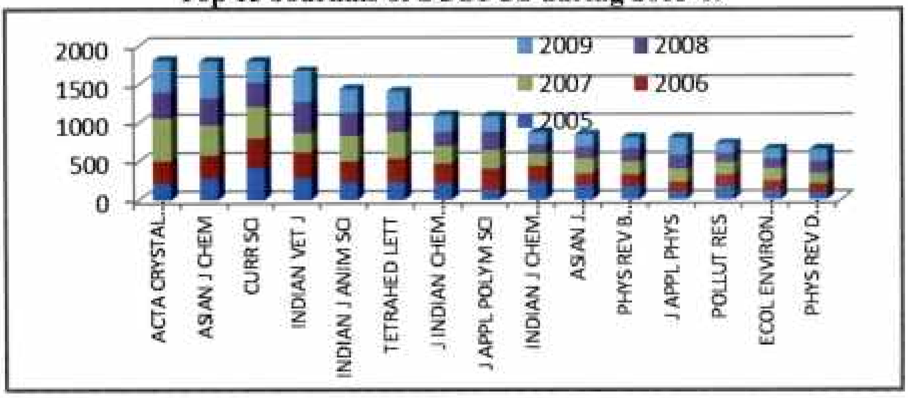
Scopus is a product of Elsevier and was commercially launched in November 2004 reputedly spanning the full spectrum of science-technology-medicine (STM) literature plus more limited coverage of the social sciences. Scopus currently contains nearly 27,000,000 document entries extending back to the mid-1960s, covering approximately, 14,200 source titles (primarily journals, but the database also includes books and various kinds of reports. Additional information on open source materials can be accessed via a link provided in the Scopus Info web site.

SCOPUS covers different subject areas (categorized by source titles that are utilized) *eg*. Chemistry, Physics, Mathematics, Engineering, Life Sciences, Health Sciences, Social Sciences, Psychology, Economics, Biological Sciences, Agricultural Sciences, Environmental Sciences and General Sciences.

Scopus identifies 14 different document types. The top category is article followed by review, letter, note, editorial and short survey. It also includes erratum, conference review and books. Searches can be limited to any one or more of these categories if so desired.

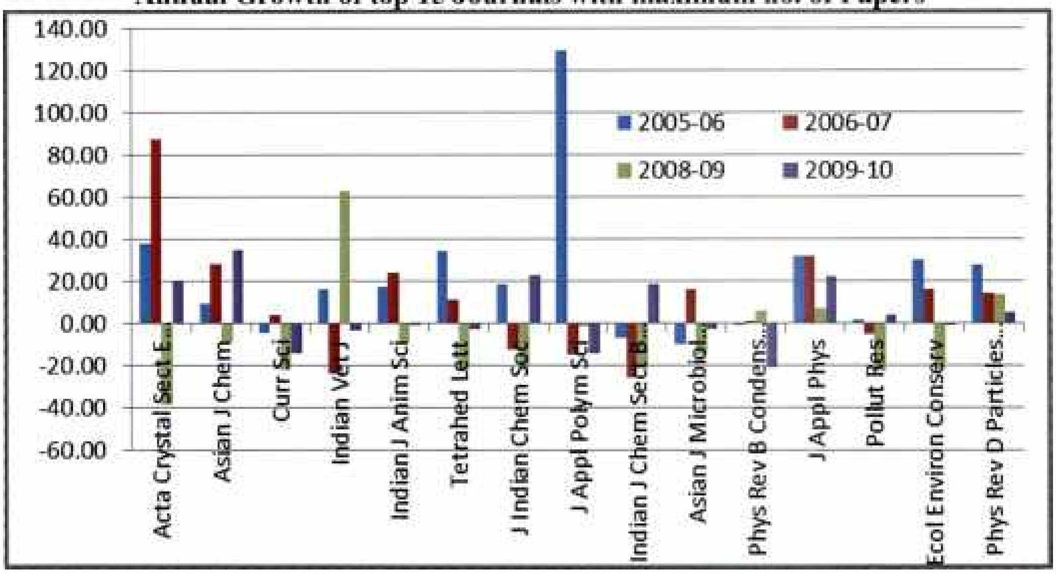
Output Analysis : During 2005-09 there were total 5441 Journals, having 1,98,689 Indian Papers were covered by SCOPUS with an average of 20.01 papers per year. The Top 15 Journals indexed in SCOPUS having maximum share of Indian papers during 2005-09.

Top 15 Journals of SCOPUS during 2005-09



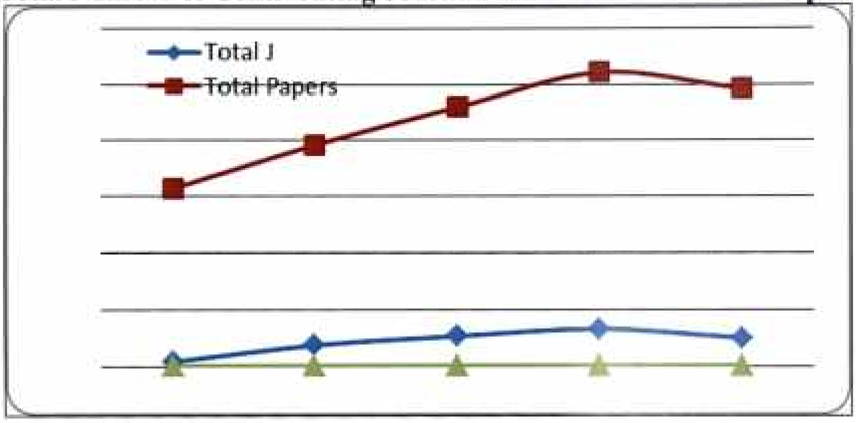
During the period of study annual growth of top 15 Journals in SCOPUS was at its maximum in 2005-06 followed by 2006-07 and 2007-08 while in 2008-09 the annual growth rate of SCOPUS having Indian Papers.

Annual Growth of top 15 Journals with maximum no. of Papers



During the year of 2005-2009, a total of 5441 Journals contributed 1, 98,689 Indian Papers indexed in SCOPUS. During the year of 2009, maximum (49965) papers were indexed in SCOPUS and the Number of Journals having Indian papers was also maximum during 2009. The ratio of indexed paper and indexed journal was maximum in 2005

Total Number of Contributing Journals with Total number of Papers

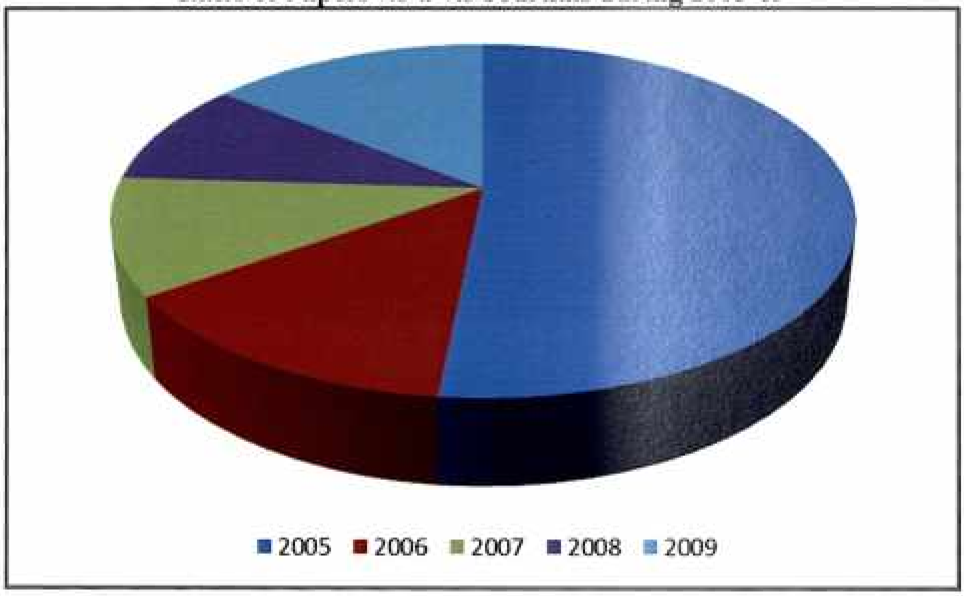


Ratio of Papers *Vis a Vis* Journals

	2005	2006	2007	2008	2009
Total Journals	422	1851	2650	3283	2477
Total Papers	30336	35368	39328	43692	49965
Ratio of Papers/Journal	71.89	19.11	14.84	13.31	20.17

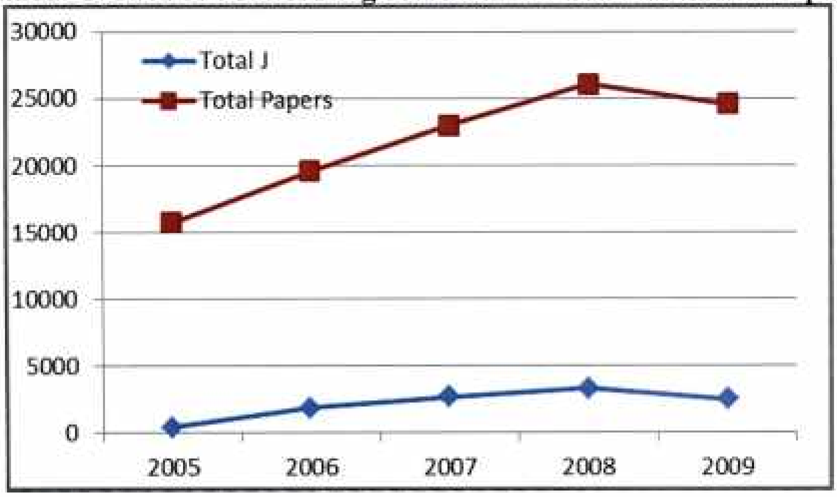
The average Indian Papers per Journal was maximum (71%) during the year of 2005. The average of papers *vis a vis* journals, during the succeeding years was 19%(2006), 14%(2007), 13%(2008) and 20% during 2009

Ratio of Papers *vis-à-vis* Journals during 2005-09



During the period of study annual growth of Journals and coverage of Indian Papers indexed in SCOPUS was at its maximum in 2005-06 followed by 2006-07 and 2007-08 while in 2008-09 the annual growth rate of Journals covered in SCOPUS having Indian Papers can be seen in figure below.

Annual Growth of Contributing Journals with Total number of Papers



Web of Science :

Web of Science provides researchers, administrators, faculty, and students with quick, powerful access to the world's leading citation databases. Authoritative, multidisciplinary content covers over 12,000 of the highest impact journals worldwide, including Open Access journals and over 150,000 conference proceedings. Any researcher can find current and retrospective coverage in the sciences, social sciences, arts, and humanities, with coverage to 1900. The service overcomes information overload and focus on essential data across more than 250 disciplines. According to Sul H. Lee, University Library, University of Oklahoma, U.S.

"Web of Science makes it possible to conduct cross-disciplinary research and 'drill down' into very specialized subfields within disciplines. The ability to navigate forward or backward within a field of literature, identifying citation patterns and core publications — which have always been a key feature of citation indices — is incredibly easy to conduct with Web of Science."

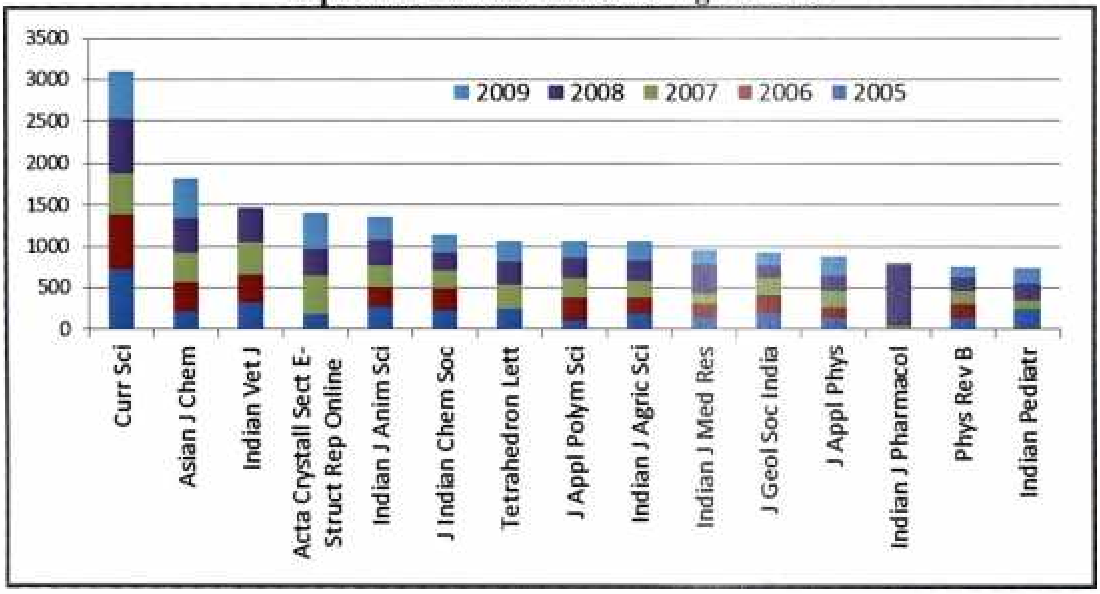
Silent Features:

- **Comprehensive and Relevant Coverage**: Every journal included in *Web of Science* has met the high standards of an objective evaluation process that eliminates clutter and excess and delivers data that is accurate, meaningful and timely.
- **Cited Reference Searching**: Track prior research and monitor current developments, see who is citing your work, measure the influence of colleagues' work, and follow the path of today's hottest ideas. Navigate forward, backward and through the journals and proceedings literature, searching all disciplines and time spans to discover information with impact.
- **Easy Author Identification**: Locate papers written by the same authors in a simple, single search. Find the right author, right away — eliminating the problems of similar author names or several authors with the same name.

- **Insightful Analysis Options**: Find hidden trends and patterns, gain insight into emerging fields of research, and identify leading researchers, institutions, and journals with the Analyze Tool. You can also capture citation activity with Citation Report, instantly creating formatted reports to view vital citation information for individuals or institutions. Citation Maps make it easy to visualize citation connections and discover an article's citation relationships.
- **Wide-ranging proceedings content**: Track the influence and impact of individual proceedings papers, conferences as a whole, or the conference series. Detect emerging trends that help you pursue successful research and grant acquisition, and create performance metrics that show the true impact of your work. This capability is especially valuable in fields such as computer science, engineering and the physical sciences, where proceedings can have a huge impact on the total number of citations to an individual's or institution's work.
- **Over 100 Years of Back file Data**: Track a century of vital data and find the supporting — or refuting — data you need. More back files give you the power to conduct deeper, more comprehensive searches and track trends through time.

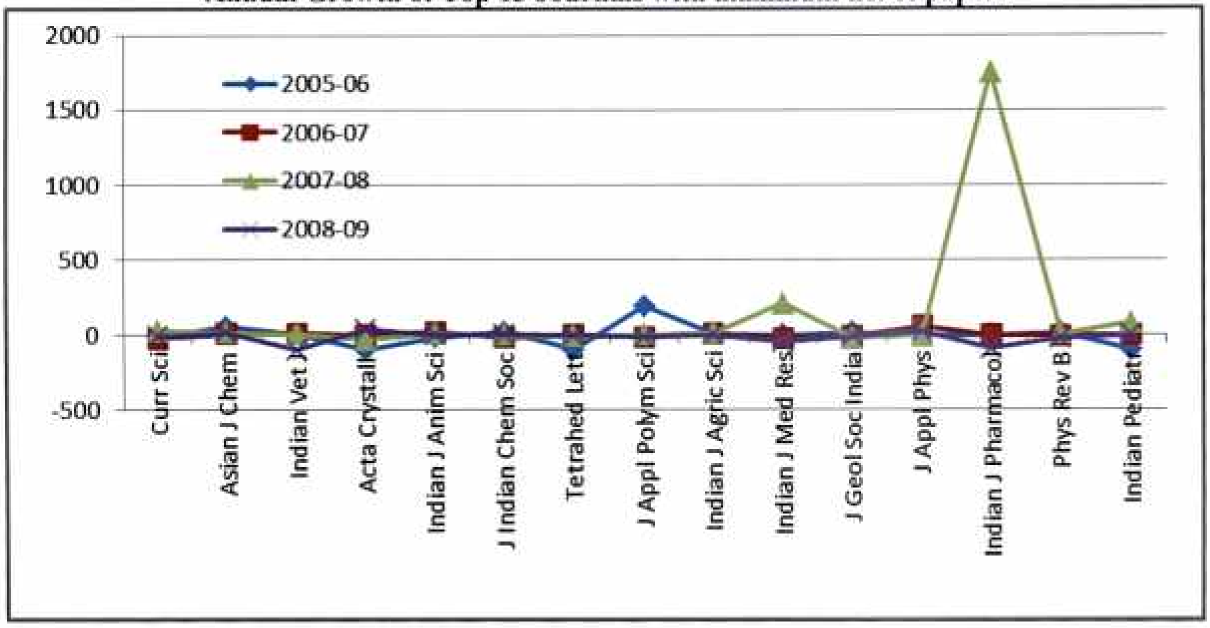
Output Analysis: There were a total of 7,443 Journals (publishing Indian papers) covered by Web of Science during 2005-09 having 1,84,906 Papers. The top 15 Journals indexed in WoS having maximum Indian Papers during 2005-09.

Top 15 Journals of WoS during 2005-09



During the period of study annual growth of top 15 Journals in WoS was at its maximum in 2007-08 followed by 2005-06 and 2006-07.

Annual Growth of Top 15 Journals with maximum no. of papers

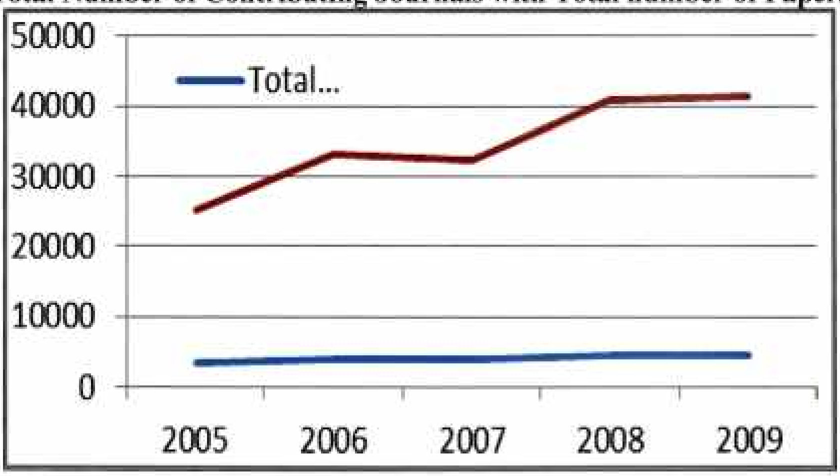


The ratio of indexed paper and indexed journal is presented below. The table clearly indicates that the ratio was maximum during 2008.

Ratio of Papers *Vis a Vis* Journals

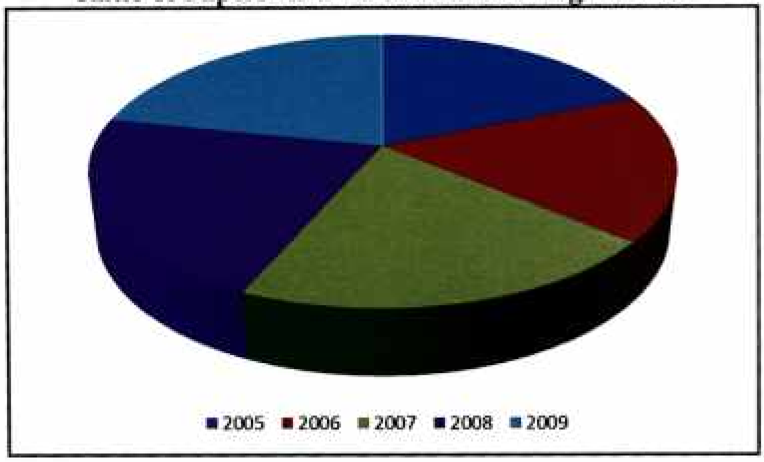
	2005	2006	2007	2008	2009
Total Journals	3292	4005	3981	4383	4556
Total Papers	28187	31652	36919	43373	44775
Avg.papers/Journals	8.56	7.90	9.27	9.90	9.83

Total Number of Contributing Journals with Total number of Papers



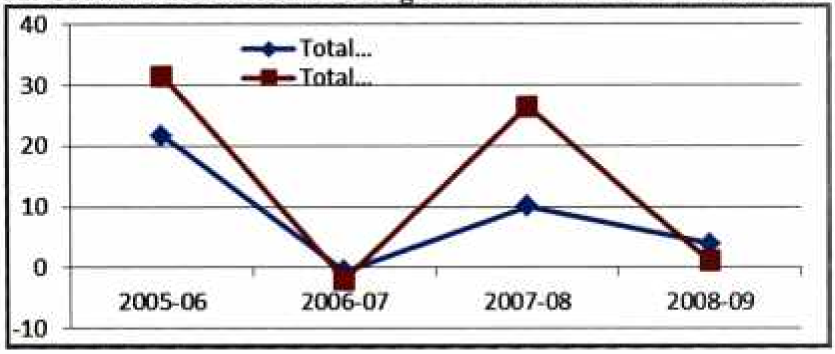
The ratio of Indian Papers per Journal was maximum (9.90%) during the year of 2008. The percentage of papers *vis-a-vis* journals, during the succeeding years was 8.56 % (2005), 7.90 % (2006), 9.27 % (2007) and 9.83% during 2009.

Ratio of Papers *vis-à-vis* Journals during 2005-09



During the period of study annual growth of Journals in WoS was at its maximum in 2005-06, During 2006-07 there was a dip in annual growth of journals as well as papers, but during 2007-08 it again increased.

Annual Growth rates of Contributing Journals with Total number of Papers

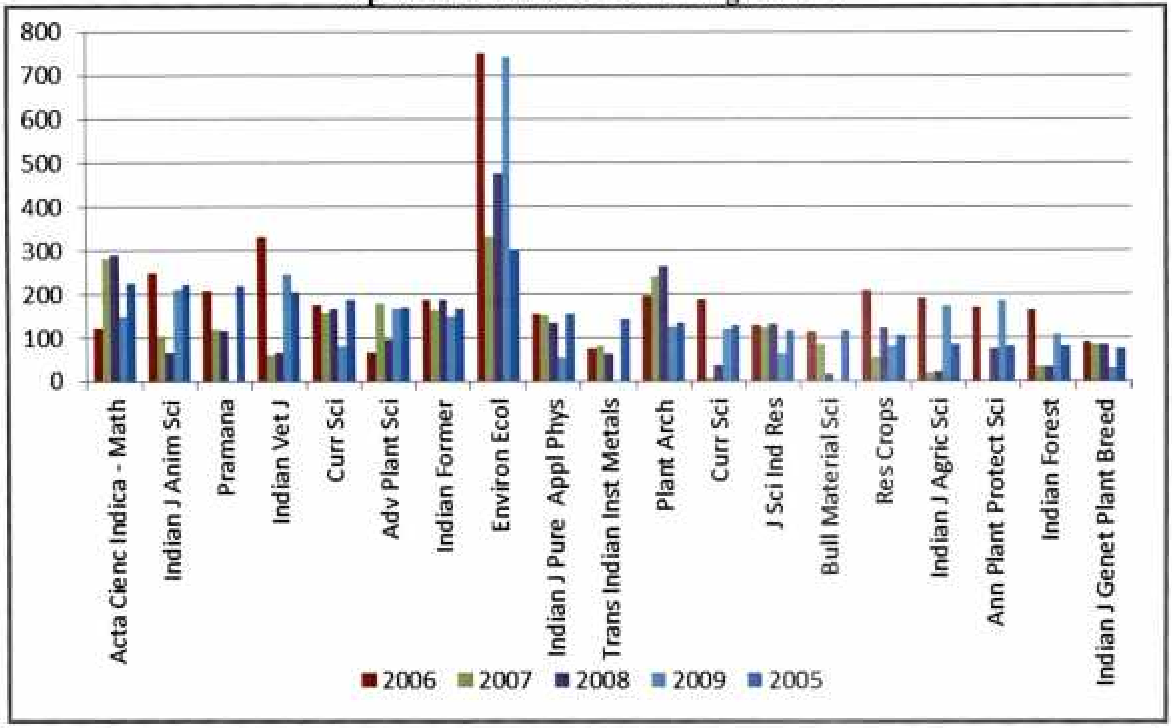


Commonwealth Agricultural Bureaux International (CABI):

The origin of CABI can be traced back to 1910. It began as an entomological research committee then developed into a Commonwealth organization before becoming a truly international service in agricultural information, pest identification and biological control. This provides information and scientific expertise to solve problems in agriculture and the environment. It produces key scientific publications CAB Abstracts – the world-leading database covering agriculture and environment and Global Health - the definitive bibliographic database for public health information & Tropical Disease Bulletin. Its expertise includes agriculture, animal and veterinary sciences, environmental sciences, human health, food and nutrition, leisure and tourism, microbiology and parasitology, and plant sciences.

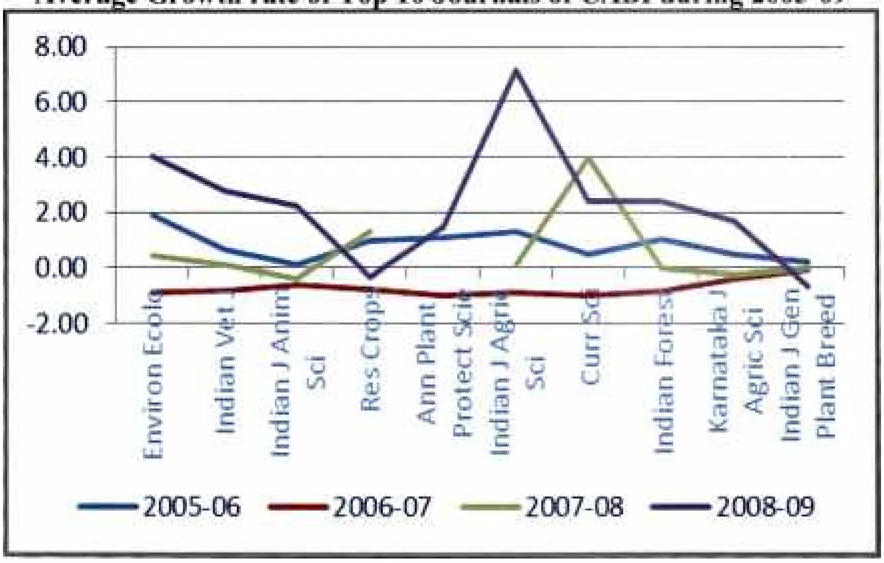
There were a total of 226 Journals (publishing Indian papers) covered by CABI during 2005-09 having 48,919 papers. The year wise coverage of the Papers was 6952, 14834, 6801, 9620 and 10712 during the period of 2005-09 respectively.

Top 20 Journals of CABI during 2005-09



Environ Ecol topped the list with 745 papers, followed by *Acta Cienc Indica Mat (290), Plant Arch(264) and Indian Former(184).*

Average Growth rate of Top 10 Journals of CABI during 2005-09

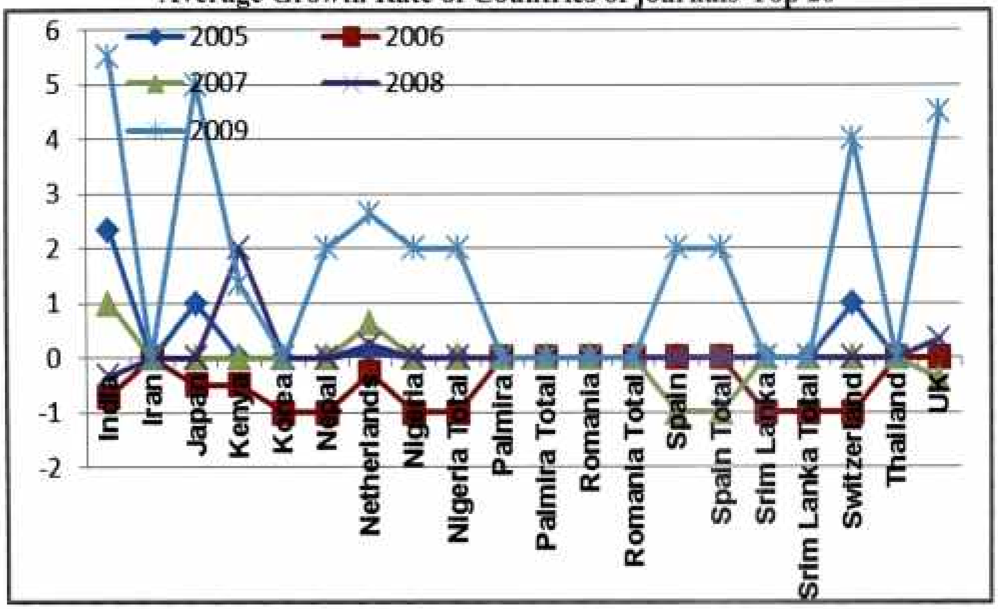


Countries of Publishing Journals of Indian S&T Papers INDEXED in CABI

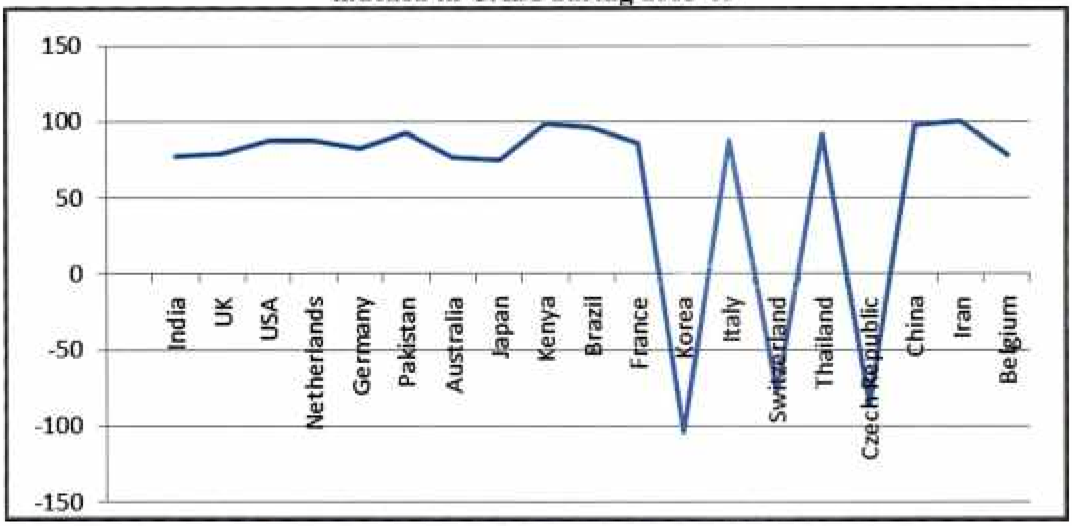
Country	2005	2006	2007	2008	2009	Total
India	4170	10260	4053	6532	5803	30818
UK	960	1288	765	724	1388	5125
USA	466	803	529	677	964	3439
Netherlands	484	973	514	481	974	3426
Germany	188	240	186	188	305	1107
Pakistan	38	169	167	168	122	664
Australia	70	116	74	44	96	400
Japan	47	101	29	81	61	319
Kenya	8	53	30	87	96	274
Brazil	14	25	52	76	74	241
France	41	44	32	42	77	236
Korea	57	82	40	8	26	213
Italy	27	56	20	36	57	196
Switzerland	31	70	14	20	24	159
Thailand	11	62	32	21	32	158
Czech Republic	34	55	13	17	23	142
China	6	32	6	30	58	132
Iran		16	32	27	57	132
Belgium	33	30	8	13	47	131
Total Papers*	**6685**	**14475**	**6596**	**9272**	**10284**	**47312**

* The publishing country of journals for the 267 (2005), 359 (2006), 211 (2007), 348 (2008), 428 (2009) papers (a total of 1607 papers 2005-09) could not be identified.

Average Growth Rate of Countries of journals-Top 20



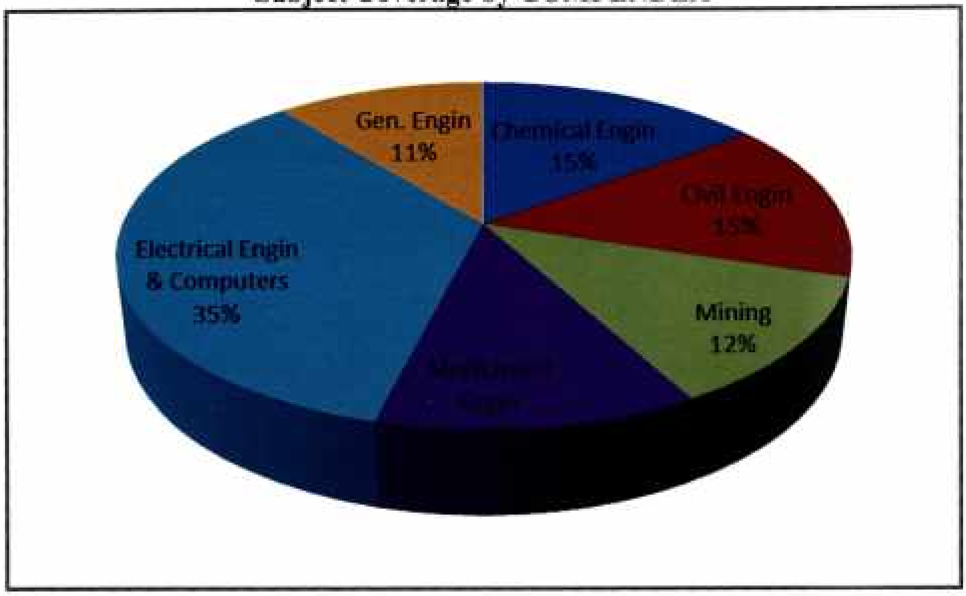
Compound Average Growth of Indian S&T publication indexed in CABI during 2005-09



Computers and Engineering Index (COMPENDEX):

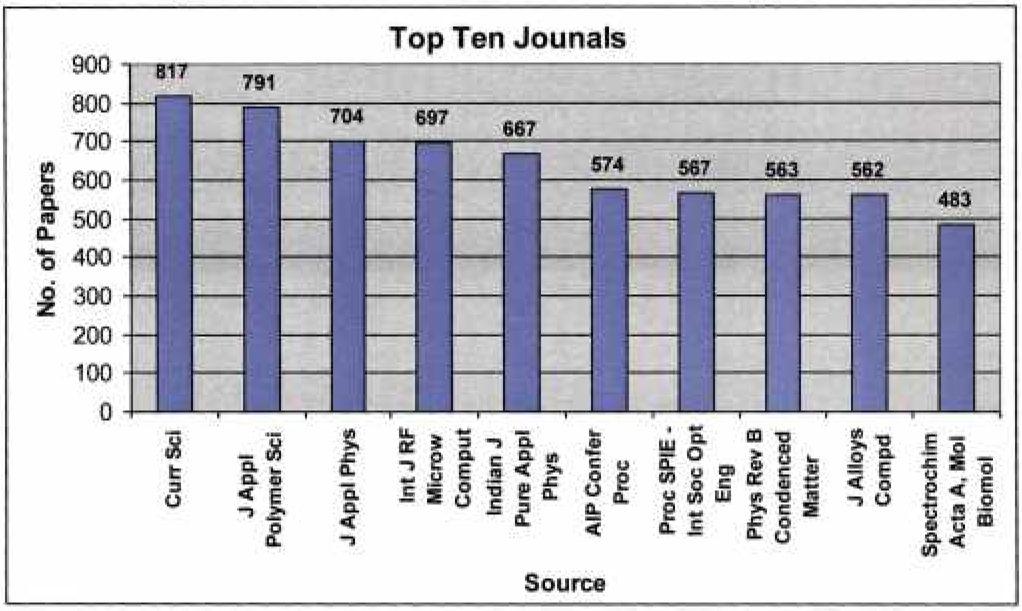
Compendex is the most comprehensive interdisciplinary engineering databases in the world, with over six million summaries of journal papers, technical reports, and conference papers and proceedings in electronic form, dating from 1970. Abstracts from over 5,000 international journals, conferences papers and technical reports are included. Each year, over 220,000 new abstracts are added from 175 disciplines and major specialties. Compendex covers subjects in every engineering discipline including: Chemical Engineering, Civil Engineering, Electrical Engineering, Mechanical Engineering &Mining Engineering, General Engineering.

Subject Coverage by COMPENDEX



There were a total of 20,740 papers indexed during the year of 2005-2009 in COMPENDEX. Total 98 indexed journals in COMPENDEX were having a total of 20,740 papers during the year of 2005-2009 from India.

Top 10 Journals indexed in COMPENDEX during 2005-09



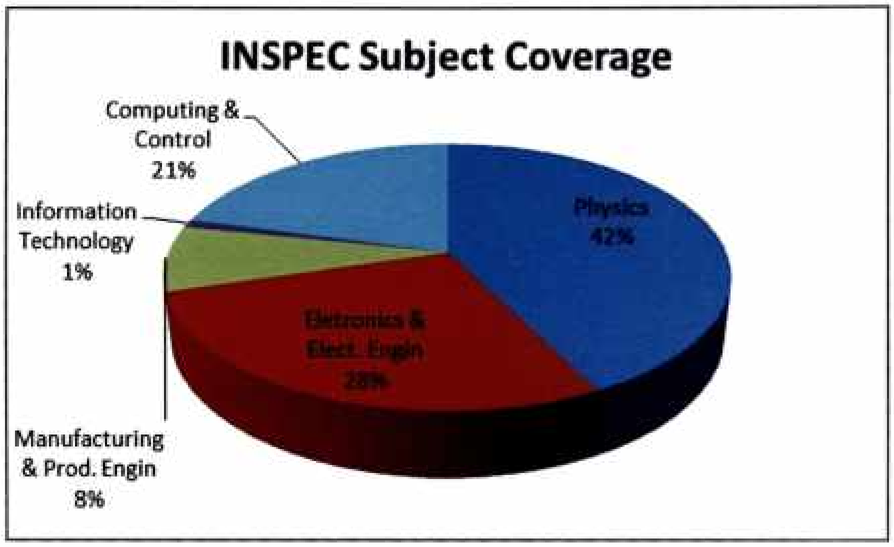
Curr Sci topped the list with 817 papers, followed by *J Appl Polymer Sci (791), J Appl Phys (704), Int J RF Microw Comput Aided Engin (697), Indian J Pure Appl Phys (667), AIP Confer Proc (574), Proc SPIE - Int Soc Opt Engin (567), Phys Rev B Conden Matter (563), J Alloys Comp (562), Spectrochim Acta A- Mol Biomol Spectrosc (483).*

Publishing Countries of Journals having Indian S&T Papers indexed in COMPENDEX

Country	2005	2006	2007	2008	2009	Total
USA	291	715	996	1643	2040	5685
India	228	561	781	1289	1601	4460
UK	170	419	584	963	1196	3332
Netherlands	143	352	489	807	1003	2794
Switzerland	83	205	283	468	581	1620
Germany	39	99	138	227	282	785
Austria	28	68	94	166	194	550
France	13	31	43	72	89	248
Greece	10	25	35	61	70	201
Poland	8	19	26	30	53	136
Canada	5	13	17	29	35	99
China	5	12	17	28	35	97
Denmark	5	12	17	28	35	97
Japan	5	12	17	28	35	97
Singapore	5	12	17	28	35	97
South Africa	4	12	17	28	35	96
Taiwan	4	12	16	28	35	95
Italy	3	7	9	15	18	52
Malaysia	3	6	9	14	18	50
Pakistan	3	6	9	14	18	50
Russia	3	6	9	14	18	50
Slovakia	2	6	9	14	18	49
Total Papers	1060	2610	3632	5994	7444	20740

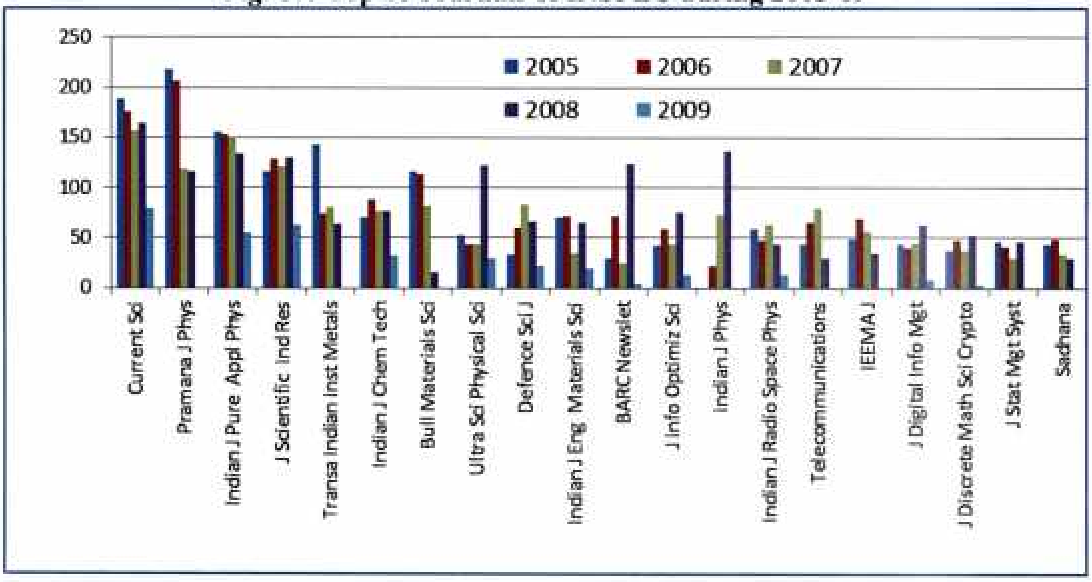
Information, Service for Physics Engineering and Computing (INSPEC):

The INSPEC database is an invaluable information resource for all scientists and engineers that contain 13 million abstracts and specialized indexing to the world's quality research literature in the fields of physics and engineering. INSPEC was started in 1967 as an outgrowth of the 'Science Abstracts Service'. It is a major indexing database of scientific and technical literature, published by the Institution of Engineering and Technology (IET), and formerly by the Institution of Electrical Engineers (IEE), one of the IET's forerunners. The coverage of INSPEC is extensive in the fields of physics, computer, control, and mechanical engineering. Also, its subject coverage includes astronomy, electronics, communications, ergonomics, computers & computing, computer science, control engineering, electrical engineering, information technology, and physics.



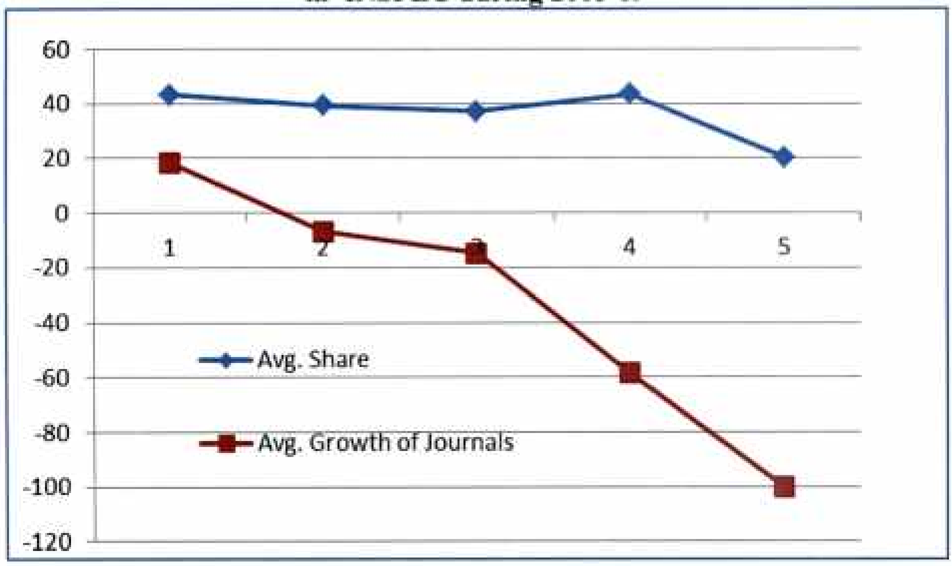
There were total 72 Journals (publishing Indian papers) covered by INSPEC during 2005-09. The year wise coverage of the Journals has been depicted in the above Fig. In 2005-06 there was maximum growth of journals (7%) with 23% annual growth in Publication. The year wise coverage of the Journals was 50, 59, 54, 46 and 21 during the period of 2005-09 respectively.

***Fig. 17:* Top 20 Journals of INSPEC during 2005-09**



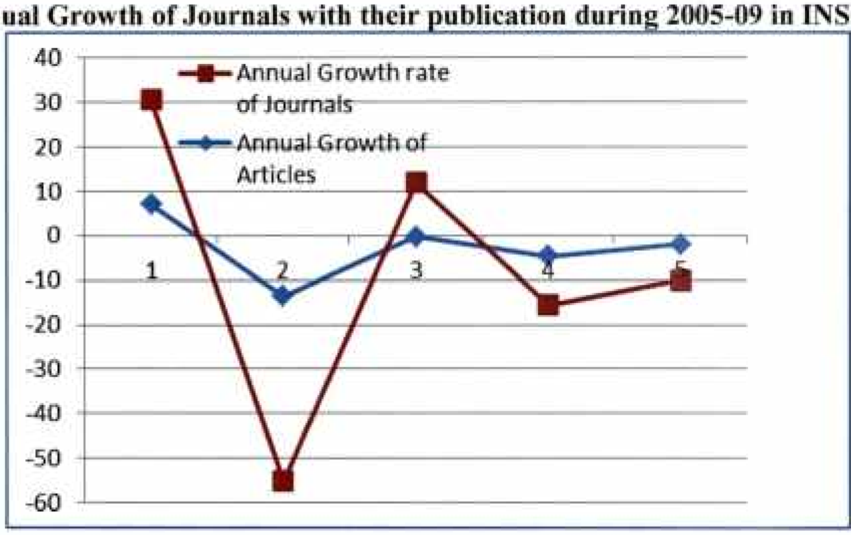
Curr Sci was top most journal during study period followed by *Pramana J Phys, Indian J Pure Appl Phys* was at third position.

Average Growth Rate of Journals covered in INSPEC during 2005-09



Average growth rates of journals with papers was maximum during 2005, which dipped during successive years continuously *i.e.* 2006- 2009. This is of concern for the policy makers. The growth of papers also indicated the same pattern except the year of 2008 when there was an increase in the average paper.

Annual Growth of Journals with their publication during 2005-09 in INSPEC



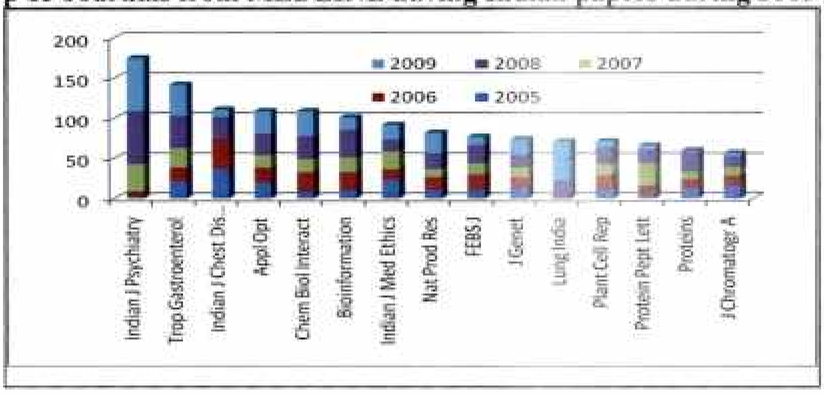
The annual growth of journals as well as paper have similar papern over the years of 2005-09. During the period of 2005-6, it has decreased, but again picked up during the period of 2006-7. The pattern is showing a zig-zac movement. During the period of 2007-8 there was a dip again but next period has shown an increasing pattern.

MEDLINE:

Medline Plus is a free Database that provides consumer health information for patients, families, and health care providers. Medline brings together information from the United States National Library of Medicine, the National Institutes of Health (NIH), other U.S. government agencies, and health-related organizations. Medline Plus contains Health topics covering hundreds of diseases, conditions, and wellness issues. Drug information for both generic and brand-name prescription and over-the-counter medications.

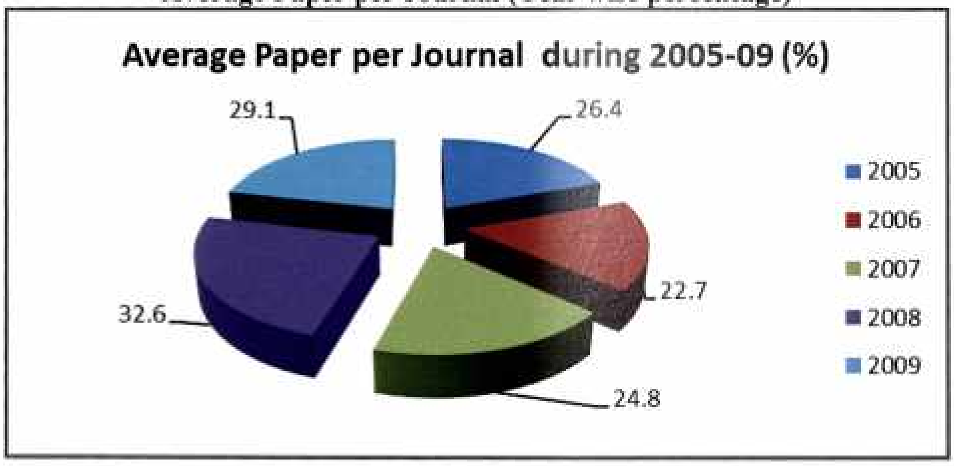
Output Analysis: There were total 3145 Journals covered by MEDLINE during 2005-09 having 50,577 Indian Papers with an average of 16.64 papers per year. In the year of 2008, maximum (14,750) indian papers were covered in MEDLINE and the Number of Journals having Indian papers was also maximum during this period . The Top 15 Journals indexed in MEDLINE having maximum share of Indian papers during 2005-09 are *Indian J Psychiatry* (175), *Trop Gastroenterol* (142), *Indian J Chest Dis Allied Sci* (111), *Appl Opt* (109), *Chem Biol Interact* (109), *Bioinformation* (101), *Indian J Med Ethics*, (92), *Nat* Prod Res (82), FEBS J (77), J Genet (74), Lung India (71), Plant Cell Rep (71), Protein Pept Lett (66), *Proteins* (60) and 57 in *J Chromatogr A*.

Top 15 Journals from MEDLINE having Indian papers during 2005-09



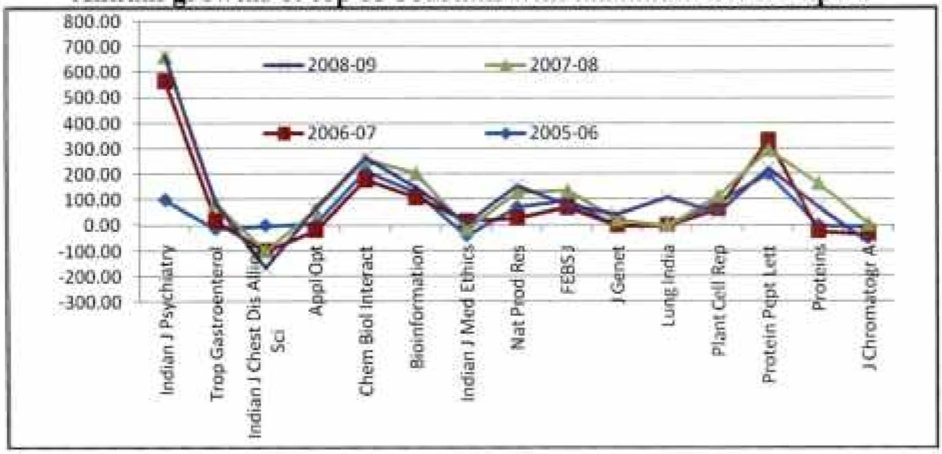
The average Indian Papers per Journal was maximum during the year of 2005. The average of papers *vis a vis* journals, during the succeeding years were 14% (2006), 12% (2007), 11% (2008) and 12% during the year of 2009.

Average Paper per Journal (Year wise percentage)



During the period of study annual growth of top 15 Journals with Indian papers in MEDLINE was at its maximum during 2005-06 followed by 2006-07 and 2007-08.Whereas during 2008-09, the annual growth dipped to minimum.

Annual growths of top 15 Journals with maximum no. of Papers



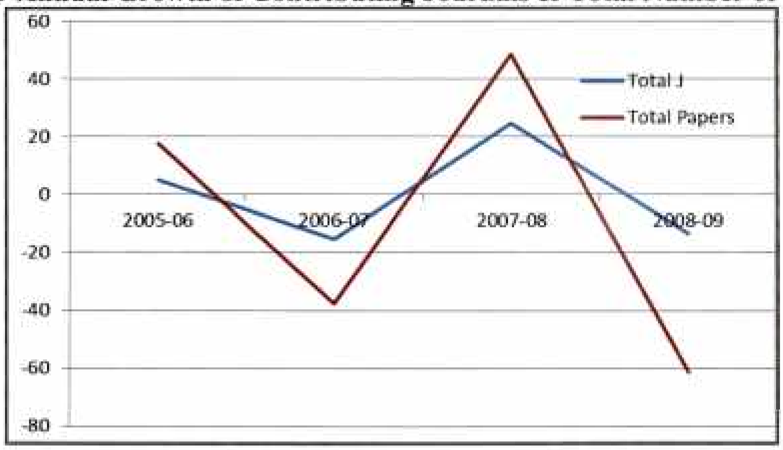
The data was analyzed to compute the ratio between publishing journals and the Indian papers published in, during the period of study. This was maximum in the year of 2008 followed by 2006, 2005, 2009 and 2007 in the decreasing order of the ratio of journals and papers.

Ratio of Papers *vis-a-vis* Journals

Year	2005	2006	2007	2008	2009
Total J	702	739	640	848	747
Total Papers	8623	10460	7598	14750	9146
Ratio of Papers/Journal	12.28	14.15	11.87	17.39	12.24

During the period of study annual growth of journals having Indian papers was maximum during 2007-08 followed by 2005-06, 2006-07 and 2008-09 in decreasing order.

Fig.: 23 **Annual Growth of Contributing Journals & Total Number of Papers**



Research Findings:

The coverage of the major 'Global Secondary Services' indicates that over the years the coverage of the Indian Papers have decreased. When an Indian author writes a qualitative scientific paper, he/she likes to publish the paper in an international reviewed journal. The simple reason is that barring a very few, most of the Indian S & T journals lack perceived quality and the reception to them at the international level is very poor. Various studies have already indicated that the number of Indian journals covered in the international databases such as ISI and Scopus is very less. Our study based on three databases namely CABI, COMPENDEX and INSPEC also confirm this assumption. Hence, we have carried out an exercise of identifying and documenting the Indian S & T journals with the important data, 'extent of peer reviews'.

Peer Review: The most important measure to ensure quality of a journal is the peer review system. It has been criticized that many Indian journals do not have peer review system. Therefore, in the current initiative, the peer review system followed by Indian journals is being investigated. To understand the peer review system, the following practice is followed.

1. Whether the Indian journals are listed in peer reviewed databases such as web of science, SCOPUS *etc.*?
2. Whether the journals clearly specify the peer review system?

3. Whether the papers in the journals mention the date of receipt, review including revision and acceptance details of papers?
4. Whether the journals receive reasonable citations from international journals?

It should be noted that peer review systems enable the authors to enhance the quality of papers and experiments/investigations are put in the right direction by experts. In the absence of peer review mechanisms, journals are likely to publish trivial content. Encouraging young researchers and motivating them still challenges S and T research, despite many avenues to do. Peer reviewed journals enable young researchers to access to authoritative content. We are concerned with poor peer reviewing practice of Indian journals. Unless the institutions insist their scientists to opt for publications in the peer reviewed journals, the situation may not improve and the Indian journals will continue to be in the vicious circle.

Indian Science Abstracts: An analysis (2005-2009)

We analyzed Indian science abstract, which is major indexing service for scientific publication in India and is the only secondary service available in the field till now, for the years of 2005-09. Only recently a private publisher has launched "Indian Citation Index", which is available to users on subscription basis. Indian Science Abstracts (ISA) is a semi-monthly abstracting service which has been reporting scientific work done in India since 1965. Original research papers short communications, review papers, and informative papers published in current scientific and technical periodicals, as well as Indian standards and thesis are reported in ISA. It is a leading abstracting service in India covering entire spectrum of Science and Technology including Intellectual Property Rights, Management and Library & Information Science. Now, ISA is available On-line also, with the following search options:

- Document type
- Title
- Journal Abbreviation
- Subject Category
- Author name
- Keyword
- GeoFig.ic term
- Generic term
- ISA volume
- ISA issue

The abstracts in ISA are broadly classified according to Universal Decimal Classification (UDC) scheme and arranged under UDC number (along with subject headings) in the following order of category of entry:

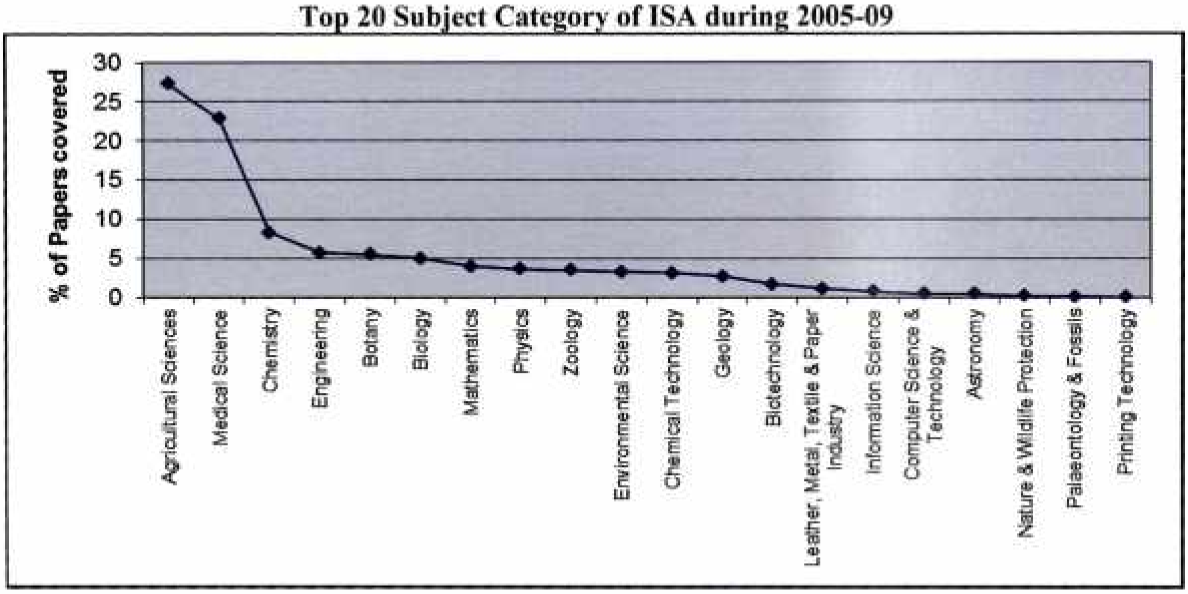
- Journal article
- Standard
- Thesis.

The documents are grouped under 26 broad classes which includes Agricultural Sciences, Medical Science, Chemistry, Engineering, Botany, Biology, Mathematics, Physics, Zoology, Environmental Science, Chemical Technology, Geology, Biotechnology, Leather Metal Textile & Paper Industry, Information Science, Computer Science & Technology, Nature & Wildlife Protection, Palaeontology & Fossils, Printing Technology, Astronomy, Building Industry, Business Management, Home Science, Management and Intellectual Property. In each category the entries are arranged alphabetically by the surname of the first author and then by the journal, title and the year of publication. Entries are serially numbered. The keyword index terms are free-text terms rather than standard terms. A list of periodicals covered in the issue is provided, containing full name of journal along with the abbreviated title as used in the entries in parenthesis

In the present study, the papers have been extracted from Indian Science Abstracts to cull out the papers being published by Indian authors in Indian & foreign journals for the period of 2005-2009. To cover all the papers published during this period, we have downloaded papers from 2005 issues of ISA to 2011 issues of ISA, as some of the journals are published late and the coverage gets delayed in ISA. The data have been analyzed for computing trend of papers and journals being covered by ISA along with the trend of papers from different geographicalareas of the country over the years (2005-2009). For this, an analysis has been done to compute total publications during the period of the study which are coming out from different cities and states of India.

Subject Category Analysis:

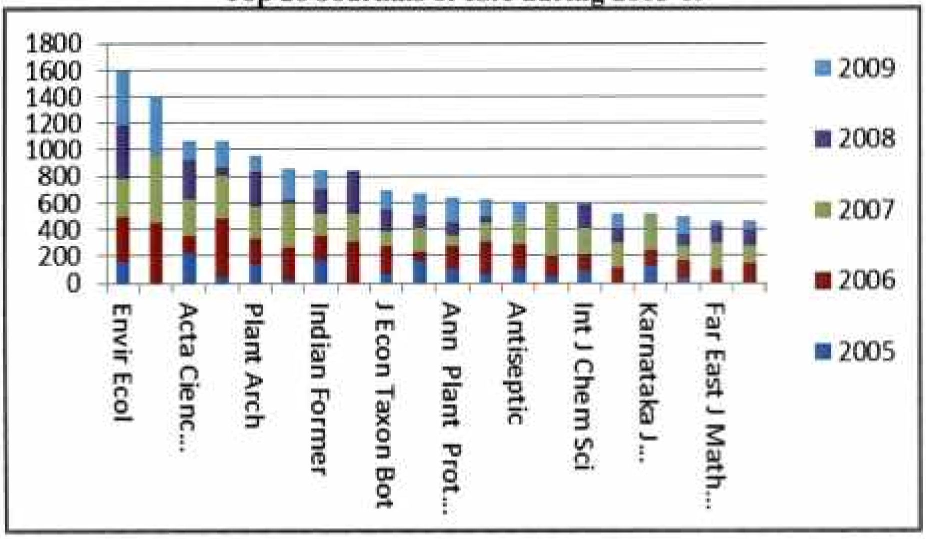
In the present study, all papers are grouped under 26 Subject Category. The most prolific Subject Area was Agricultural Science (27.29%), followed by Medical Science (22.83%), Chemistry (8.31%), Engineering (5.76) and Botany (5.52).



Journal Analysis:

There were a total of 844 Journals covered by ISA during the period of 2005-09 having 73,241 Indian Papers with an average of 83.89 papers per year. The Top 20 Journals indexed in ISA having maximum share of Indian papers during 2005-09 are as follows:

Top 20 Journals of ISA during 2005-09



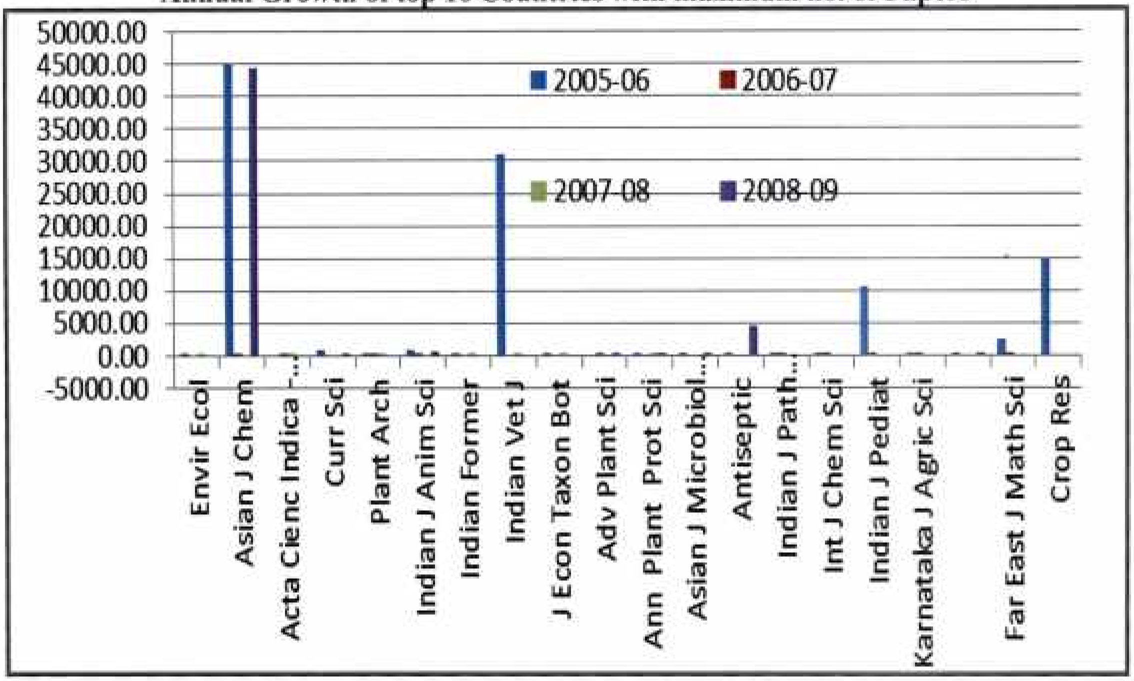
Out of these total 73,241 papers, indexed in ISA, 80% papers appeared in Indian journals, rest 20% papers appeared in journals being published from other countries *e.g.* USA, Australia, UK, Nepal and Bangladesh etc. The year wise distribution of top 15 countries is presented in the following table.

Publishing Countries of Journals of Papers indexed in ISA

Country	2005	2006	2007	2008	2009	Total Papers
India	15170	12060	12253	10632	7873	57988
UK	960	1288	765	724	1388	5125
USA	466	803	529	677	964	3439
Netherlands	484	973	519	482	974	3432
Germany	188	240	186	188	305	1107
Pakistan	38	169	167	168	122	664
Australia	70	116	74	44	96	400
Japan	47	101	29	81	61	319
China	6	32	6	30	58	132
Iran		16	32	27	57	132
Belgium	33	30	8	13	47	131
Canada	16	35	5	32	33	121
Bangladesh	10	10	13	23	22	78
Nigeria	4	13	25	9	25	76
Nepal		2	7	11	8	28
Chile			5	7	7	19

During the period of study, annual growth rate of top 10 publishing countries having papers in ISA was maximum during the period of 2005-06, followed by 2007-08 and 2008-09. During the period of 2006-07 the annual growth rate have decreased as presented in the figure.

Annual Growth of top 10 Countries with maximum no. of Papers



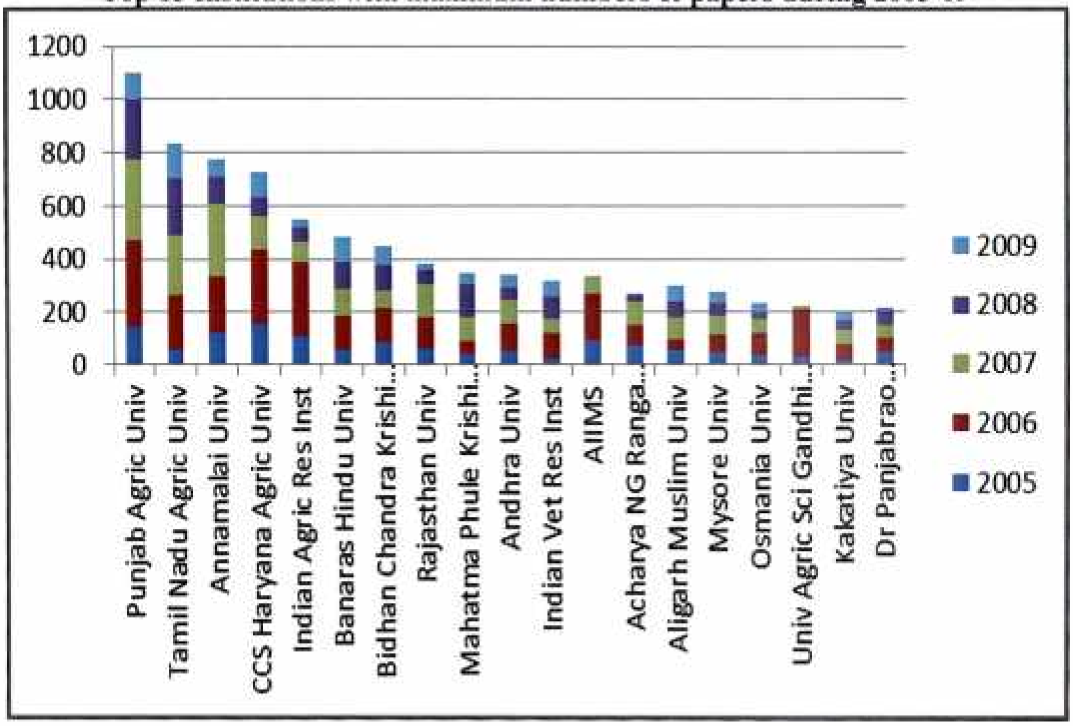
Institutional Analysis: There was a total of 18480 Institutes contributing 73,241 papers. The number of institution (5619) contributing papers in the year of 2006 was maximum, however, the average paper contributed by an institution was maximum (6.43) during the year of 2007.

Total Number of Contributing Institutes and Average Publication per Institute

Year	Total Institute	Total Papers	Average Publication
2005	4629	12275	5.26
2006	5619	19359	3.23
2007	5381	17325	6.43
2008	4781	12829	5.78
2009	4043	11453	2.52

During the study period (2005-09), most prolific institute was *Punjab Agricultural Univ.* followed by *Tamilnadu Agricultural Univ., Annamalai Univ, CCS Haryana Agriculture Univ., Indian Agricultural Research Inst* and *Banaras Hindu Univ.*

Top 15 Institutions with maximum numbers of papers during 2005-09



Geographical Analysis:

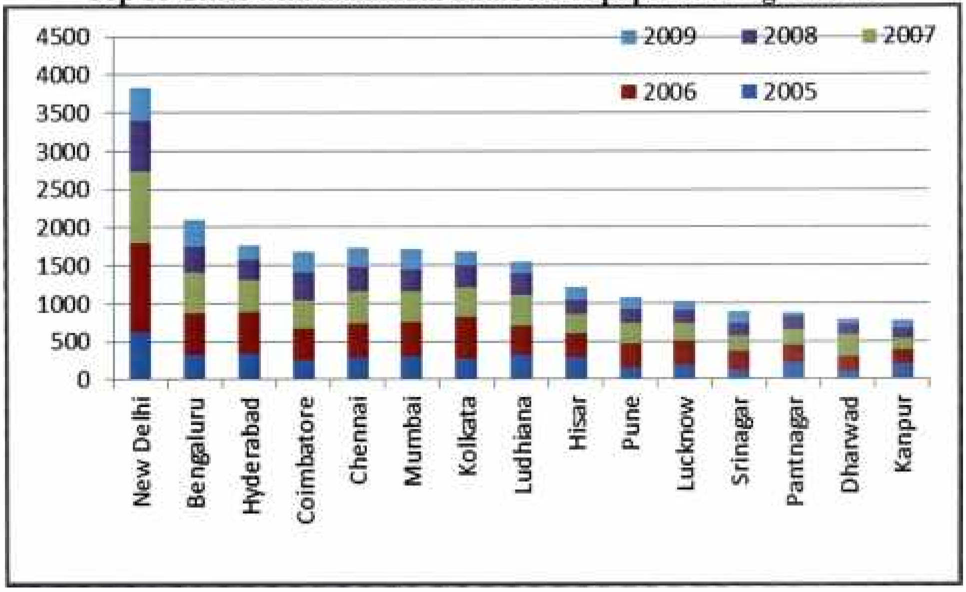
During the year of 2005-2009, a total of 828 cities contributed 73,241 papers indexed in ISA. During the period of 2007 maximum Cities (553) contributed papers in ISA. The average paper per City was maximum (38.03) during the year of 2006.

Total Number of Contributing Cities and Average Publication per City

Year	Total Cities	Papers	Avg. Papers
2005	513	12275	23.93
2006	509	19359	38.03
2007	553	17325	31.33
2008	514	12829	24.96
2009	512	11453	22.37

New Delhi was the most the prolific city with 3195 papers followed by Bengaluru, Hyderabad, Coimbatore, Chennai, Mumbai, Kolkata, Ludhiana, Hissar, Pune and Lucknow .

Top 10 Cities with maximum numbers of papers during 2005-09

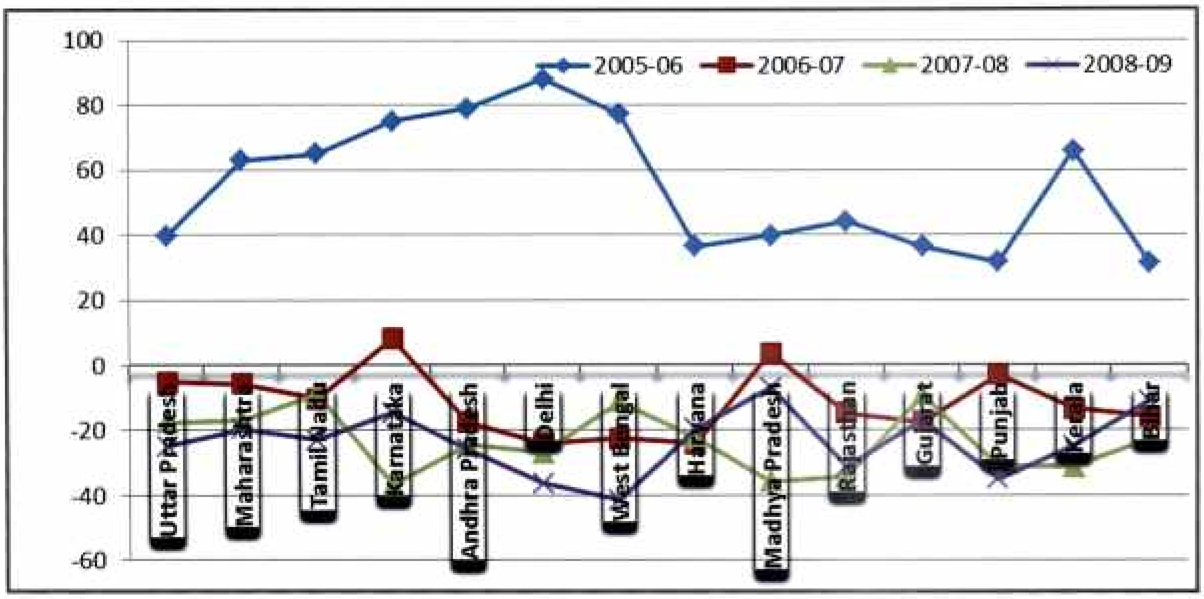


An analysis was also done to compute state wise contribution in ISA. During the year of 2005-2009, maximum 37 states contributed all the papers appearing in ISA. Most prolific State was Uttar Pradesh followed by Maharashtra, Tamil Nadu, Karnataka, Andhra Pradesh, Delhi, West Bengal, Haryana, Madhya Pradesh and Rajasthan.

State	2005	2006	2007	2008	2009	Total
Uttar Pradesh	1359	1895	1798	1483	1113	7648
Maharashtra	1091	1778	1677	1396	1124	7066
Tamil Nadu	941	1551	1394	1271	979	6136
Karnataka	759	1328	1438	910	778	5213
Andhra Pradesh	634	1135	935	706	523	3933
Delhi	627	1177	937	653	440	3834
West Bengal	478	847	656	583	341	2905
Haryana	477	650	494	383	308	2312
Madhya Pradesh	411	574	595	382	355	2317
Rajasthan	457	658	561	368	253	2297
Gujarat	411	560	462	419	348	2200
Punjab	434	571	554	382	248	2189
Kerala	301	499	432	297	223	1752
Bihar	286	376	317	245	218	1442

The further analysis of top 10 contributing states, indicated that the "Annual Growth rate" was maximum in 2005-06. During the period of 2006-07 the growth rate decreased but again during the years of 2007-08, the growth rate picked up and increased slightly. The growth rate again fell down during 2008-09.

Annual Growth Rate of Most Productive States During 2005-09



In this study we have highlighted quantitatively the contribution made by the Indian scientists during 2005-09 as reflected in Indian Science Abstracts. Indian publication productivity 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.

Salient Finding of the Study and Lead for the Future

- 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 6^{th} position by 2018, as compared to 2005-09 (10^{th} position) in terms of total papers published in a journal, China is expected to occupy top position followed by USA (Source database-SCOPUS).

- 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.

- 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.

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

- In areas constituting earth & environmental sciences, increase in publications activity was reported in water resources and environmental engineering during 2005-09. Substantial increase was also reported in chemical engineering, telecommunications, and artificial intelligence.

- Engineering & Technology, Chemical Sciences, Biological sciences and Medicine, have been the leading broad areas of research in India and have shown consistent rising trend in publications output.

- 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.

- Some of the least and low productivity areas of Indian S&T are 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.

- India's publications in medium and high quality journals in science and technology have increased over the years along with its distribution in different journals, indicating a trend towards more interdisciplinary research.

- Total 34 states contributed papers in all the areas of S&T. The country needs a balanced approach in regional distribution of its resources. Maharashtra, Tamil Nadu, Uttar Pradesh, Delhi, Karnataka, Andhra Pradesh, West Bengal are the leading states in Productivity of research papers, accounting together for three - fourth of the publications output in S&T during 2005-09. Rajasthan, Kerala, Gujarat, Madhya Pradesh, Chandigarh, and Haryana together contributed only 15% share in country publications output during the corresponding period. Other states, such as Punjab, Bihar, Orissa, Uttarakhand, Assam, Himachal Pradesh, and J&K are considered as Low productivity states and together contributed only 10.5% publications share during 2005-09.

- 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.

- **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.

- 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%).

- 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.

- Research in S&T in India is an institutional activity. 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 ≥600 papers each during 2005-09.

- 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.*

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

- 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. Some of the other countries are** Germany, United Kingdom, Japan, France, South Korea, Canada, Australia, China, Italy, Taiwan, Switzerland, Russian Federation, Spain, Netherlands, Malaysia, Brazil, Sweden, Poland and Singapore.

- Physical Sciences have been the most preferred subject area for collaborative research. We have also found significant differences in collaboration patterns across fields, 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.

- 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.

- India published a total of 16 highly-cited papers (total 290- 700 Citations to each paper) 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 $\geq$ 100 co-authors from around the world, indicating that the papers were the out- come of a metacentric study.

- 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.

Lead for the Future:

World over, gradually all the countries are carrying out scientometrcics & bibliometric analyses to provide 'Evidence Based' information for various decision making processes and policy makers. 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.

An analysis carried out by 'Evidence' a constituent of Thomson Reuter's for UK Research Council, presents a bibliometric study of India's research output and international collaboration. The report offers a comparison of India's publication and citation impacts over a 27 year period (1981 to 2008) to those of the UK, USA, Germany, China, Japan, South Korea, France, Brazil and Australia. The report presents :A summary about the importance of bibliometrics and what they can indicate. An indication of the number of papers published by Indian researchers over a 27 year period (1981 to 2008), A comparison of Indian publications and citations against specific countries, A comparison of the citation impact of Indian papers against specific countries, A comparison of the papers produced and citation impact of Indian papers.

In the United States, S&T indicators are referred to as 'science and engineering indicators', or similar variants such as 'science and technology competitiveness indicators'. High quality indicators are essential for good science and technology policymaking. The report comes out every alternate years.

Main Science and Technology Indicators, published twice yearly by OECD, provides a set of indicators that reflect the level and structure of the efforts undertaken by OECD member countries and nine non-member economies (Argentina, China, Israel, Romania, Russian Federation, Singapore, Slovenia, South Africa, Chinese Taipei) in the field of science and technology. This publication is prepared by the Economic Analysis and Statistics (EAS) Division of the OECD Secretariat in collaboration with the Working Party of National Experts on Science and Technology Indicators (NESTI). It contains the main data series selected from the OECD Scientific and Technological Indicators database. The indicators cover the resources devoted to research and development, patent families, technology balance of payments and international trade in highly R&D-intensive industries. Also presented are the underlying economic series (a reference year and for the last six years) used to calculate these indicators. Series are presented for the last six years for which data are available.

Some of the other countries are also bringing out S&T Indicators Reports. The abridged English version of the Report on Science & Technology Indicators for Norway is published biannually. The purpose of the report is to present an overall description for non-Norwegian readers of the status of Norwegian activity in research and experimental development, higher education, science and technology. The report describes and documents the Norwegian research and innovation system. It is based upon the results from the national R&D and Innovation surveys as well as other statistics and studies. Time series and international data are also included. The report also serves as a reference work and includes time series and international comparisons.

In China, the WIS Lab, located at Daliyan is continuously carryinh out studies on different aspects of S&T indicators, which are submitted to their S&T Ministry, as an information background. A report titled 'Knowledge, Innovation and Agglomeration: regionalized multiple indicators and evidence from Brazil' discusses about the status of S&T at Brazil. There are institutions in Germany, Belgium, Netherlands Korea engaged exclusively working for S&T Indicators.

In Sri Lanka also National Science Foundation is active for selecting priority areas for funding R&D, human resource development, facilitating Industry Institute partnership (IIP) and technology transfer activities etc. S&T Policy Planning activities and formulating ,S&T strategic plan by the Ministry of Research and Technology. The findings are to be used by Ministry of Finance & Planning for devoting funds for S&T activities and human resource development; Use by higher education sector for human resource training; Use for academic purposes.

Science, technology and innovation (STI) indicators are crucial for monitoring scientific and technological development. They are useful for formulating, adjusting and implementing STI policies. Indicators can be used to monitor global technological trends, conduct foresight exercises, and determine specific areas of investment. It becomes immediately evident that indicators of the number of people engaged in research at the present time are needed, to suggest how many will be required if the target is to be achieved. That raises questions about the development & training of researchers by universities, and their mobility within the system and across its boundaries through immigration and emigration. Again more indicators are needed if the picture is to be understood. As part of gathering the data to construct the indicators, best practices may be found in the organizations being surveyed which can be shared across the system. At the end of the day, the target may not be achieved, but the functioning of the system may have been improved. This is an important outcome of a benchmarking exercise.

Currently, there is a critical need to extend the production and availability of high-quality S&T statistics to as many countries as possible. There is unanimous agreement that the less developed countries are significantly under-represented in international S&T statistics and there is an urgent need to fill this information gap. Many of the less developed countries have identified the procurement and organization of reliable human and financial resources

For indicators to be used effectively, they must be embedded in the policy process, and that requires interaction between policy makers and 'data analysts'. Policy makers must be able to formulate objectives and programs to move the economy and the society towards the objectives. For example, Nanotechnology is supposed to become one of the key enabling technologies of the 21st century. Its economic potential is forecasted to be a market of several hundred billion Euros in the next decade. Therefore, nanotechnology has attracted the interest of many industry sectors and many companies redirecting internal activities to prepare themselves for this new challenge. At the same time governmental R&D decision makers all over the world are setting up new nanotechnology-specific research programs aiming at putting their respective countries in a favorable position for the future, or these could include genetic research leading to more robust breeds of plants and animals, or new breeds, the development of vaccines and of better diagnostic tests for health care. For the process to work there has to be discussion of the policy questions to be illuminated, leading to the formulation of survey questions, which, if answered well, will provide the information needed. The process of interaction and co-operation allows each group to do what it does best, policy analysis and development on one hand, and survey question and questionnaire development, data collection on the other. These are quite different skills, but they must be brought together if the resources available for indicator production are to be used effectively and efficiently.

In both cases, there may be need for capacity building which can be addressed by the NSTMIS (DST) through the provision of practical advice on the development of country profiles, indicator reports and the use of indicators in evidence-based policy. With this background, it is also suggested that NSTMIS can take up the responsibility for bringing out a regular publication on various aspect of S&T indicators, may be on alternate years.

References

1. [Anonymous]. (2005). Quantitative Indicators for Research Assessment - A Literature Review (Review No. 05/1). Canberra: Research Evaluation and Policy Project, Research School of 10, 112-27.433-41.
2. Aled ab Iorwerth. (2006) How to Measure Government Productivity: A Review Article on 'Measurement of Government Output and Productivity for the National Accounts' (The Atkinson Report). International Productivity Monitor (13), 57
3. Arunachalam S, (2002). Is Science in India on the decline?,Current Science, 83,107-108.
4. ASEAN (Association of Southeast Asian Nations): http://www.aseansec.org/ Accessed on 15th Nov. 2012.
5. Balasubramani R (2011). Plasmodium Falciparum Research Publication in India: A Scientometric Analysis" European Journal of Scientific Research, 56(3), 294-300.
6. Balasubramani R, Parameshwaran & Raja S (2009). Scientometic Dimension on Osteoporosis in India. Journal of the Young Librarians Association 2(1) 72-82.
7. Balasubramani R, Surulinathi M & Raja S. (2012). An Evaluative study of Wi-Fi Communication Research Publications: A Scientometric Study. SALIS Journal of Information Management Technology, 1(1) 32- 40.
8. Basu Aparana & Nagpaul P.S. (2000). National mapping of science-India: Multidisciplines, InformationToday& Tomorrow, 19(3), 3-7.
9. Basu Aparna & Aggarwal Ritu (2001). Indian scientific literature in Science Citation Index: A report. Information Today & Tomorrow, 20(4), 3-8.
10. BatageljV. & Mrvar A. (2007) Pajek.Program for Large Network Analysis.Retrieved on October 4, 2007 from, http://vlado.fmf.uni-lj.si/pub/networks/pajek/ .
11. Bensman S. J. (2001). Bradford's law and fuzzy sets: Statistical implications for library analyses. IFLA Journal, 27, 238-246.
12. Bibliometric study of India's Scientific Publication outputs during 2001-10: Evidence for Changing Trends by Department of Science and Technology Government of India New Delhi July 2012. Available at http://www.nstmis-dst.org
13. Bibliometric Study of India's Research Output and International Collaboration. A report, undertaken by Evidence, a Thomson Reuters business, on behalf of Research Councils UK (2011) Source: http://www.nature.com/news/2009/090708/full/news.2009.652.html and http://www.dst.gov.in/about_us/ar07?08/ar07?08index.htm
14. Bordons M., Morillo F. & Gómez I. (2004).Analysis of cross-disciplinary research through bibliometric tools. In H. F. Moed, W. Glänzel& U. Schmoch (Eds.), Handbook of quantitative science and technology research (pp. 437-456). Dordrecht: Kluwer.
15. Boyack K., Börner K. & Klavans R. (2007). Mapping the Structure and Evolution of Chemistry Research. In D. Torres-Salinas & H. Moed (Eds.), Proceedings of the 11th International Conference of Scientometrics and Informetrics, 1, 112-123, CSIC, Madrid, 21-25 June 2007.
16. Buchandiran G. (2011).An Exploratory Study of Indian Science and Technology Publication Output. Library Philosophy and Practice 2011 available on http://unllib.unl.edu/LPP/ .
17. Callon M: Four models for Dynamics of Science IN Theory and Methods pp 29-34; available on http://siba.unipv.it/fisica/articoli/H/Handbook%20sci.%20techn_pp.29-63.pdf
18. Caplan, David (1998) "Measuring the output of Non-Market Services," Economic Trends 539, October, pp. 45-49.

19. Coordination and Collaboration in European Research towards Healthy and Safe Nanomaterials. (2011) J. Phys.: Conf. Ser. 304; 012001, (http://iopscience.iop.org/1742-6596/304/1/012001)
20. Dilrukshi P.R.M.P. : Science and Technology Indicators of Sri Lanka ; Science and Technology Policy Research Division (National Science Foundation) www.nsf.ac.lk
21. Dutta S. & Mia I. (2011).Global Information Technology Report 2010-1011: Transformations 2.0. World Economic Forum, 2011. Retrieved June 2, 2012, from http://www3.weforum.org/docs/WEF_GITR_Report_2011.pdf
22. Elsevier Integrates New Collaboration Analysis Capabilities into Sci Val Strata to Further Enhance Research Evaluation: Research Trends (SCOPUS) September, 2011
23. Ergazakis K., Metaxiotis K. & Psarras J. (2004): Towards knowledge cities: Conceptual analysis and success stories. Journal of Knowledge Management, 8(5), 5-15.
24. Evidence from the latest BIS report indicates that international collaboration on articles boosts impact through citations and adds to the UK's position as a 'world-class' research nation. blogs.lse.ac.uk/impactofsocialsciences/2011/11/14/evidence-from-the-latest-bis-report/ Accessed on 20th Nov. 2012
25. Garfield Eugene (1983). Mapping science in the third world, Part 1. Science & Public Policy,
26. Garg K C (2003). An overview of cross-national, national, and institutional assessment as reflected in the international journal of Scientometrics,.Scientometrics ,56, 169-199.
27. Garg K.C; et al (2006). Scientometric profile of Indian science as seen through Science Citation Index. Annals of Library and Information Studies, 53, 114-25.
28. Garg KC & Kumar Suresh (2010) Analysis of Citation Pattern of Indian Science Journals Indexed by SCIE. Annals of Library and Information Studies Vol. 57, 365-372
29. Glanzel W. (2002). Co-authorship patterns and trends in the sciences (1980-1998): A bibliometric study with implications for database indexing and search strategies. Library Trends, 50(3), 461-73.
30. Glänzel W. (2003). Bibliometrics as a research field: Exploring and combining bibliometric tools in search of scientific excellence. Scientometrics, 57(2), 257-280.
31. Gupta B M & Garg K C (2002), Is science in India on decline? A rejoinder, Current Science, 83, 1431-32.
32. Gupta B. M. & Bala Adarsh: (2011)Ascientometric analysis of Indian research output in medicine during 1999-2008. J Nat SciBiol Med. 2(1): 87-100. doi: 10.4103/0976-9668.82313
33. Gupta B.M. & Dhawan S.M. (2008). A Scientometric Analysis of S&T Publications Output by India during 1985-2002. DESIDOC Journal of Library &Information Technology, 28(2): 73-85
34. Gupta B.M., Dhawan S.M. & Osareh, F. (2004). India-Middle-East Collaboration in S&T: an analysis through co-authored publication, Library Herald, 42 (4): 309-323.
35. Gupta BM & Bala Adarsh: Indian S&T during last Fifteen Years (1996-2010): A Quantitative Assessment using Publications Data. publications.drdo.gov.in/ojs/index.php/djlit/article/view/
36. Haustein S., Tunger D., Heinrichs G. & Baelz G. (2010). Reasons for and developments in international scientific collaboration: does an Asia-Pacific research area exist from a bibliometric point of view? Scientometrics, 86(3), 727-746.
37. Hullmann Angela, European Commission, Meyer Martin & Leuven K.U.; (2003) Publications and Patents in Nanotechnology: An overview of previous studies and the state of the art. Scientometrics, Volume 58, Number 3, 507-527.
38. International comparative performance of India's scientific research. by Department of Science and Technology Government of India New Delhi November 2012. available at http://www.nstmis-dst.org
39. Kaliyaperumal K & Natarajan K (2009). Scientometric Analysis of Literature Output on Retina. DESIDOC Journal of Library & Information Technology, 29(4) 33-36.
40. Karkil M. M. S., Garg K. C. & Sharma Praveen (2000). Activity and growth of organic chemistry research in India during 1971-1989. Scientometrics 49(2) : 9

41. King David (2004). The scientific impact of Nations .Nature, 430, 311-16.
42. Klavans R. & Boyack K. (2007). Is there a Convergent Structure of Science? A Comparison of Maps using the ISI and Scopus Databases. In D. Torres-Salinas & H. Moed (Eds.), Proceedings of the 11th International Conference of Scientometrics and Informetrics, 1, 437-448, CSIC, Madrid, 21-25 June 2007.
43. Kushwah A S, Srivastava D, Gupta M: An analytical study of Indian S&T Journals. In: Proc. of COLLNET and WIS (Webometrics, Informetrics, Scientometrics) 2013 Ed. Hildrun Kretchmer; (Estonian Research Council, 2013Tartu, Estonia). Available at http://www.etag.ee/
44. Leydesdorff L. (2007a). Visualization of the Citation Impact Environments of Scientific Journals: An online mapping exercise. Journal of the American Society of Information Science and Technology, 58(1), 207-222.
45. M Callon, JP Courtial & F Laville (1991). Co-word analysis as a tool for describing the network of interactions between basic and technological research: The case of polymer chemistry, 22(1), 155-205
46. Mattsson P, Laget P, Nilsson A, Sundberg CJ. (2008). Intra-EU vs. extra-EU scientific co-publication patterns in EU. Scientometrics, 2008, Vol. 75, No. 3, 555-574
47. Ming-Yueh Tsay & Yi-Jen Lin (2009). Scientometric analysis of transport phenomenon literature, 1900-2007. Malaysian Journal of Library & Information Science, 14(3) 35-58.
48. Moed H.F, Debruin R. E. & Vanleeuwen T. N. (1995). New Bibliometric Tools for the Assessment of National Research Performance - Database Description, Overview of Indicators. Scientometrics, 33(3), 381-422.
49. Moed H.F. (2005). Citation analysis in research evaluation. Dordrecht: Springer.
50. OECD (2012), Main Science and Technology Indicators, Vol. 2011/2, OECD Publishing. doi: 10.1787/msti-v2011-2-en-fr
51. OECD (Organisation for Economic Co-operation and Development): http://www.oecd.org
52. Osareh F.; McCain KW. (2008). Visualizing the structure of Iranian chemistry in Sci Search using author co-citation technique, Collnet Journal of Scientometrics and Information Managemnt, Vol 2(1):37-43.
53. Osareh, F. & McCain KW. (2008).The structure of Iranian chemistry research, 1990-2006: An author co-citation analysis. Journal for Society of Information Science & Technology, 59 (13): 2146-2155.
54. Pichaan P., & Buchandiran G. (2006). Peer reviewing in Indian S&T Journals. Current Science, 90(5): 615.
55. Raja Gopal Y & Kumar M P R (2005). Standard of scientific research publications, Current Science, 88, 207-208
56. Raja S & Balasubramani R (2011). Scientometric Study of the Research Publication on Malaria 2003-2007: A Global Perspective. International Research Journal of Library, Information and Archival Studies, 1(1) 114-125. R
57. Raja S & P Ram Kumar (2012). Scientometric Study of Nuclear Crisis (1970 - 2011). Indian Journal of Information Sources and Services, 2(1) 10-15.
58. Raja S, Ramkumar P & Viji P (2011).Scientometric dimension on gender in worldwide thyroid cancer: A study based on web of science database": Indian Journal of Science and Technology 4(4) 425-
59. Ramón Compañó & Angela Hullmann : Forecasting the development of nanotechnology with the help of science and technology indicators. Nanotechnology, 13, (3), June 2002, 243-247.
60. Rana Shushan (2012).Bibliometric analysis of output and visibility of science and technology in Singapore during 2000-2009
61. Rao I K & SahooBibhutiBhusan (2008). Distributions of Multiple Authors: A Case Study of two Journals (JASIST and Scientometrics). Collnet Journal of Scientometrics& Information Management, 2(1) 27-36

62. Research Council of Norwey: Science and Technology Indicators for Norway (INDIKATORRAPPORTEN).http://www.forskningsradet.no/prognett-indikatorrapporten/Home_page/1224698172612
63. Sagar Anil, Kademani BS, Garg RG & Kumar Vijai (2010). Scientometric mapping of Tsunami publications: a citation based study. Malaysian Journal of Library & Information Science, 15(1), 23-40
64. Sangam SL, Meera & Megeri MN (2008). Growth pattern of Indian Chemical Science literature: A Scientometric analysis. Collnet Journal of Scientometrics & Information Management, 2(1), 99-110
65. Satyanarayana K & Jain N C: (2002) Coverage of Indian S&T Journals in SCI/JCR.Current Science, 83 (8) 928
66. Schubert A & Braun T (1986). Relative indicators and relational charts for comparative assessment Of publication output and citation impact, Scientometrics ,9, 281-291.
67. Science and Technology Indicators for the European Research Area : (STI-ERA). http://www.cordis.europa.eu/indicators/publications.htm
68. Shanghai Jiaotong University: http://ed.sjtu.edu.cn/ranking.htm
69. Stagnation of R&D intensity a major threat to the European knowledge-based economy, European Commission Press release, 19th July 2005
70. Tsutomu, H. (2003). Three steps in knowledge communication: The emergence of knowledge transformers. Research Policy, 32, 1737-1751.
71. UIS (UNESCO Institute for Statistics): http://www.uis.unesco.org
72. Ulrich Periodical Directory . available at http://www.ulrichsweb.com/ulrichsweb/Search/advancedSearch.asp ? Accessed 8th October, 2011
73. UNESCO (United Nations Educational, Scientific and Cultural Organization): http://www.unesco.org
74. Using Science and Technology Indicators to support knowledge-based economies. Policy Briefs (2006), II
75. Van Raan, A.F.J. & Van Leeuwen, T.N. (2002), Assessment of the scientific basis of interdisciplinary, allied research: Publication of bibliometric methods in nutrition and food research. Research Policy, 31, 611-632.
76. Van Raan, A.F.J.(2005). Fatal attraction: Conceptual and methodological problems in the ranking of universities by bibliometric methods. Scientometrics, 62(1), 133-143.
77. Verma RK. (2009). Bibliometric Study of Indian S&T Publication as reflected in Indian Science Abstracts. Collnet Journal of Scientometrics& Information Management, 3 (2) 19-28
78. Vonortas N.S. (1997). Cooperation in Research and Development. Boston: Kluwer Academic Press.
79. Woolf S. (1989). Statistics and the modern state. Comparative Studies in Society and History, 31, 588-603
80. World Bank Knowledge Assessment Methodology (KAM): http://info.worldbank.org/etools/
81. Zitt M. (2005).Facing Diversity of Science: A Challenge for Bibliometric Indicators.Measurement: Interdisciplinary Research and Perspectives, 3(1), 38-49.