

Research Output of Indian Institutes of Technology (IITs): A Scientometric Study

Nabi Hasan¹ & Mukhtiar Singh²

¹Indian Institute of Technology Delhi - 110016, India

²CSIR-Institute of Himalayan Bioresource Technology, Palampur (HP) - 176061, India

Abstract. The paper attempts to evaluate the trend of research output of five top ranked Indian Institutes of Technology (IITs) on the basis of research papers/articles indexed in Web of Science online database for the five years' period of 2009-13. A total of 215,019 records were retrieved for India which are 2.72% of the global records for the period 2009-13. The records of articles from top five IITs were scanned which accounted to 9.32% of total records of India. A maximum of 22.27% articles have been indexed in 2013 against 18.41% in 2009. A scientometric assessment of the trend of research papers has been presented in the study by way of analyzing; year-wise distribution of publications among IITs vs total Indian research output, Institutional distribution, degree of collaborations with other countries and with the institutions from India, etc. The results of the study would be useful to subject specialists, analysts, researchers, students and policy makers to look into the trends and to make effective policies on the basis of inferences drawn.

Keywords: Indian Institute of Technology; IITs; Web of Science; Research output; Scientometric analysis; Mapping research-IITs

1. Introduction

The Indian Institutes of Technology (IITs) is a group of autonomous engineering, technology and management institutes of India. The IITs are governed by the Institutes of Technology Act, 1961 of India. This act has declared them as "institutions of national importance", and lays down their powers, duties, framework for governance, etc. The Act lists sixteen institutes located at Bhubaneswar, Chennai, Delhi, Gandhinagar, Guwahati, Hyderabad, Indore, Jodhpur, Kanpur, Kharagpur, Mandi, Mumbai, Patna, Ropar, Roorkee and Varanasi. Each IIT is an autonomous institution, linked to the others through a common IIT Council, which oversees their administration. Apart, the Government of India has also announced 5 new IITs in July 2014 budget, to be set up at J&K, Goa, Kerala, Andhra and Chhattisgarh and 2 others in 2015

budget to be set up Karnataka and one ISM is to be upgraded to the IIT. The IITs award degrees ranging from B.Tech., M.S., M.Tech, MBA to Ph.D. (<https://www.iitsystem.ac.in/>)

2. Material, Methods and Limitations of the Study

The present study is a scientometric analysis of research articles of top five IITs that are IIT Bombay, IIT Delhi, IIT Kanpur, IIT Kharagpur and IIT Madras which are ranked under top 20 institutions of BRICS countries and also top ranked in the country. Keeping in view the significance of research articles; this form of publication was selected for study and analysis. The Web of Science (WOS) database of Thomson Reuter was selected for articles indexed during five years from 2009 to 2013. Data was identified for annual growth of IITs' research articles, collaboration amongst five IITs and with other institutions, prolific institutions collaborated, foreign collaborators, etc.

The international level productivity of IITs was selected as representation of the whole country for their better reliability and accessibility. The database was searched with 'India' as keyword in the address field in advance search. Individual IIT was then identified from the Organization field and concerned data of articles was retrieved for five IITs. The 215,019 records were retrieved for India which is 2.72% of total 7,894,639 records from the globe. The records on articles from five IITs from the total Indian records were scanned and found 20,046 records of articles which are 9.32% of total 215,019 records of India. Records of individual IITs have been identified and further analyzed for drawing the inferences.

3. Objectives

The objectives of the study aimed to evaluate the trend of research output of five top ranked IITs on the basis of research articles indexed in Web of Science by way of analyzing the following features of publications of the study period:

- i) Annual output of global vs Indian research articles.
- ii) Output and share of research articles from five IITs.
- iii) Average output of authors from five IITs.
- iv) Degree of collaborations among IITs and with other global institutions/countries.
- v) Collaboration study of each of the IIT.
- vi) Comparative citation data study of five IITs.
- vii) Prolific institutions for collaboration with top ranked IITs, etc.

4. Analysis and Discussion

4.1. Annual output of research papers

Search for keyword "India" in Address field of WOS Online database resulted in a total of 215019 (2.72%) records out of total 7894639 records of this form. The study was limited to the articles keeping in view the research value of this form of research publications. The average number of publications produced per

year was 43003.8 articles for India. The highest number (49406, 22.98%) of articles were reported in the year 2013. Table 1 depicts annual growth of articles from India. Continual upward growth trend was observed from 2009 to 2013. Articles of India were increased by 26.27% in 2013 against the year 2009. Figure 1 depicts the trend of research article output from India during 2009-13.

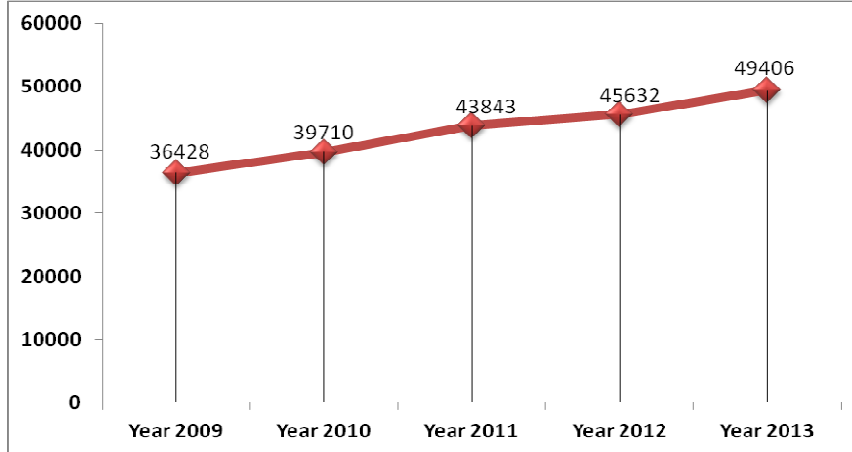


Table 1. Year-wise Indian research output

Year	Articles	Percentage
2013	49406	22.98
2012	45632	21.22
2011	43843	20.39
2010	39710	18.47
2009	36428	16.94
Total	215019	100.00
World output		7894639
Indian share in world		2.72

Figure 1. Trend of Indian article output during 2009-13

4.2. IITs’ share in research papers from India

Table 2 shows the share of five IITs in total article output from India. The IITs’ share was 9.32% out of a total of 215019 and the contribution was highest i.e. 10.13% in the year 2009. Decreasing trend observed from 2010 to 2012, but a slight increase of 0.10% was noticed in the year 2013. A continual increasing trend was observed in case of five IITs’ contribution of articles from 2009 to 2013. Share of five IITs in total Indian output is depicted in figure 2.

Year	IIT Articles	% IIT Articles	Share of IITs in India	Total Articles-India	% of India
2013	4465	22.27	9.04	49406	22.98
2012	4064	20.27	8.91	45632	21.22
2011	3925	19.58	8.95	43843	20.39
2010	3902	19.47	9.83	39710	18.47
2009	3690	18.41	10.13	36428	16.94
Total	20046	100.00	9.32	215019	100.00

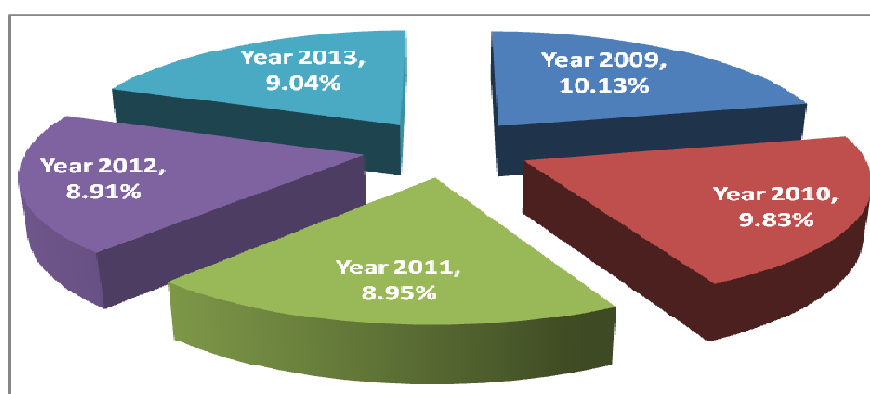


Figure 2. Percent share of five IITs in Indian article output during 2009-13

4.3. Individual Share of Five IIT's

Individual output of five IITs has been given in Table 3. Contribution of IIT Bombay increased by 6.93% followed by IIT Delhi with 5.61%, Kanpur with 2.68%, IIT Madras with 2.54% and IIT Kharagpur with 1.84% in the year 2013. The trend of article output from five IITs is given in figure 3 and yearly share in figure 4.

Year	IIT Bombay		IIT Delhi		IIT Kanpur		IIT Kharagpur		IIT Madras	
	Articles	%	Articles	%	Articles	%	Articles	%	Articles	%
2013	933	24.12	899	23.52	746	21.92	1142	21.67	815	20.46
2011	820	21.2	769	20.1	686	20.1	1041	19.7	797	20.0

2	0	2	5	5	1					
201	745	19.2	753	19.7	686	20.1	987	18.7	856	21.4
1	6	0	5	3	9					
201	705	18.2	717	18.7	631	18.5	1056	20.0	821	20.6
0	3	6	4	3	1					
200	665	17.1	684	17.9	655	19.2	1045	19.8	694	17.4
9	9	0	4	3	2					
Tot	386	100.	3822	100.	3404	100.	5271	100.	3983	100.
al	8	00	00	00	00	00	00	00	00	00

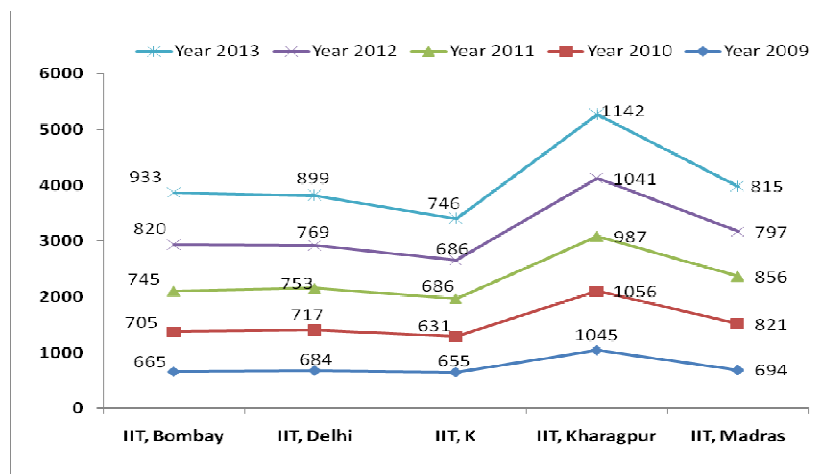
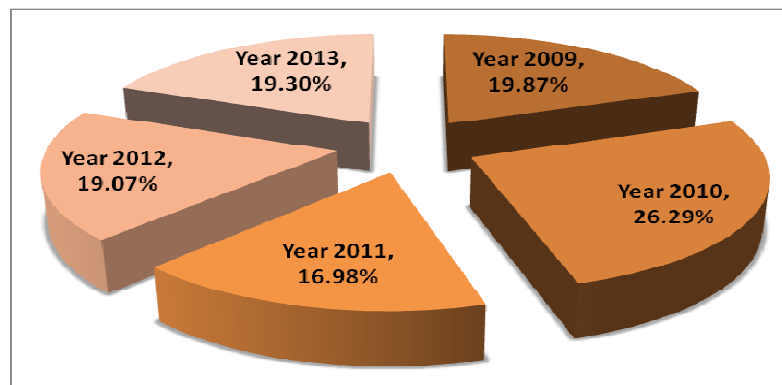


Figure 4. Trend of five IITs' article output during 2009-13

Figure 5. Year-wise share of article output from five IITs during 2009-13



4.4. Authorship pattern

Data was analyzed for authorship pattern and found that IIT Bombay have maximum authors during the period (8560) who contributed 3868 articles with an average of 2.2 authors per single article and an average of 0.5 articles by

single author. An average of 1.1 authors produced one article and 4311 authors produced 3822 articles. A total number of 3739 authors produced 3404 articles from IIT Kanpur with an average of 0.9 articles by a single author. In IIT Kharagpur, an average of 1.1 articles were produced by one author and in total, 4937 authors produced 5271 articles in five years. A total of 3983 articles were produced by 5601 authors with an average of 0.7 articles by one author.

Table 4. Authors per article and Article per author

IIT Name	Articles	Authors	Article/Author	Author/Article
IIT Bombay	3868	8560	0.5	2.2
IIT Delhi	3822	4311	0.9	1.1
IIT Kanpur	3404	3739	0.9	1.1
IIT Kharagpur	5271	4937	1.1	0.9
IIT Madras	3983	5601	0.7	1.4

4.5. Collaborations

Data was analysed to find out the collaboration among five IITs which has been depicted in table 5. Analysis shows maximum 4.04% collaborated articles by IIT Kanpur with other four IITs followed by IIT Madras with 3.50% articles in collaboration, IIT Delhi with 3.61% articles, IIT Bombay with 3.57% articles and IIT Kharagpur with 2.62% articles in collaboration.

Table 5. Collaboration among five IITs

IIT Name	IIT-M	IIT-Kh	IIT-K	IIT-D	IIT-B
IIT Madras	-	43	27	21	47
IIT Kharagpur	43	-	31	36	24
IIT Kanpur	27	31	-	25	37
IIT Delhi	21	36	25	-	18
IIT Bombay	47	24	37	14	-
Total	138	134	120	96	126
Collaboration in %	3.50	2.62	4.05	3.61	3.57

4.6. Citations/H-index

Comparative data of citations received by the articles published by five IITs was analyzed and presented in table 6. Results shows that IIT Bombay received maximum average number of 6.7 citations per article followed by IIT Kanpur with average 5.61 citations per article, IIT Kharagpur with 5.42 citations, IIT Madras with 5.40 citations and IIT Delhi positioned at fifth with 5.25 citations per article. IIT Bombay and IIT Madras secured H-Index of 45 followed by IIT Kharagpur with H-Index of 42, IIT Kanpur positioned at fifth with H-Index of 39.

Table 6. Comparative citation data of five IITs

	IIT M	IIT- Kh	IIT K	IIT D	IIT B
Number of articles	398 3	527 1	340 4	382 2	386 8
Number of citations received	214 90	285 81	190 81	200 72	238 80
Number of citations received without self-citations	188 25	240 55	155 10	173 55	207 03
Citing Articles	174 03	216 92	141 79	158 84	183 16
Citing Articles without self-citations	160 74	195 65	126 97	144 86	167 97
Average Citations per article	5.40	5.42	5.61	5.25	6.17
H-Index	45	42	39	40	45

4.7. Foreign collaborations

Data was analyzed to assess foreign collaboration which is depicted in table 7. It was found that India had collaborations with 177 countries of the world in 92706 (43.12%) out of total 215019 articles. USA topped the list of collaborations by collaborating in 14568 articles followed by Germany with 5740 articles. IITs as a whole collaborated with 96 countries in 9072 (45.71%) out of total 20046 articles and USA was again at top. The data in respect of all five IITs depicts that USA was highly preferred for collaboration.

Table 7. Comparison of collaboration with other countries in articles

Country	India	IITs (5)	IITM	IIT- Kh	IITK	IITD	IITB
USA	14568	1747	393	277	334	247	532
Germany	5740	797	171	179	103	99	256
South Korea	4383	388	131	59	52	23	131
China	2890	340	95			44	145
Japan	3448	301	92	53	28	40	
Australia	2512	292	89	46	44	37	
France	3961	471	75	51	82	80	181
Russia		227	73				138
Switzerland			66			22	
Canada	2710	326	62	92	40	80	
Taiwan			62				
England	4618	442		102	56	78	163

Poland								125
Czech Republic								127
Italy	2626						54	
Singapore							31	
Spain							47	
Brazil								120
South Africa							52	
India	177/927 06	96/90 72	59/19 40	61/13 92	59/11 33	60/10 39	76/36 97	

4.8. Collaborating institutions: Five IITs

Table 8 illustrates the data on top ten institutions collaborated with all the five IITs. IBM find place at top by collaborating in 1297 articles with all the five IITs followed by CSIR in 1005 articles, BARC in 372 articles and US DOE in 244 articles. There were 3915 institutions collaborated with IITs. Top ten institutions collaborated in 21.06% and remaining 3905 institutions in 78.94% articles.

Table 8. Top ten Institutions in Collaboration (other than IITs)

Institution	Number of articles
IBM	1297
CSIR	1005
BARC	372
US DOE	244
CNRS	238
IISc	237
University of California	226
Max Planck Society	215
TIFR	206
Purdue University	182
Articles of top ten institutions	4222
Share of top ten institutions in percentage	21.06
Share of remaining 3905 institutions in percentage	78.94

4.8.1 Collaborating institutions: IIT Bombay

Table 9 depicts the data on top ten institutions collaborated with IIT Bombay. BARC find place at top by collaborating in 243 articles followed by University of California in 135 articles, US DOE in 135 articles, Purdue University in 128 articles and Czeck Academy of Science positioned at fifth by collaborating in 121 articles. There were 1023 institutions collaborated with IIT Bombay, top ten institutions collaborated in 6.66% and 1013 institutions in 93.34% articles.

Table 9. Top institutions collaborated with IIT Bombay	
Institution	Number of papers
BARC	243
University of California	135
US DOE	135
Purdue University	128
Czech Academy of Sciences	121
Wayne State University	115
Yale University	114
University of Rajasthan	114
Ohio State University	114
Universidade Estadual De Campinas	113
Top ten Institutions' total	1332
Top ten Institutions' percentage	6.66
Remaining 1013's percentage	93.34

4.8.2 Collaborating institutions: IIT Delhi

Table 10 illustrates the data on top ten institutions collaborated with IIT Delhi. IBM find place at top by collaborating in 1281 articles followed by CSIR in 205 articles, University of Delhi in 80 articles, AIIMS in 67 articles and Jamila Millia Islamia in 55 articles. There were 1268 institutions collaborated with IIT Delhi, top ten institutions collaborated in 9.32% and remaining 1258 institutions in 90.68% articles.

Table 10. Top institutions collaborated with IIT Delhi	
Institution	Number of articles
IBM	1281
CSIR	205
University of Delhi	80
AIIMS	67
Jamia Millia Islamia	55
Inter University Accelerator Centre	48
Jawaharlal Nehru University	47
Ministry of Earth Sciences, India	33
CNRS	27
IISc	26
Top ten Institutions' total	1869
Top ten Institutions' Percentage	9.32
Remaining 1258's percentage	90.68

4.8.3 Collaborating institutions: IIT Kanpur

Table 11 depicts the data on top ten institutions collaborated with IIT Kanpur. CSIR find place at top by collaborating in 150 articles followed by IISc in 75 articles, CNRS in 58 articles, BARC in 41 articles and Sanjay Gandhi Postgraduate Institute of Medical Sciences in 37 articles. There were 1020 institutions collaborated with IIT Kanpur, top ten institutions collaborated in 1.96% and 1010 institutions in 98.04% articles.

Table 11. Top institutions collaborated with IIT Kanpur	
Institution	Number of articles
CSIR	150
IISc	75
CNRS	58
BARC	41
Sanjay Gandhi Postgraduate Institute of Medical Sciences	37
University of California	36
Yeungnam University	34
Max Planck Society	30
Bengal Engineering Science University	28
Pennsylvania Commonwealth System of Higher Education	27
Banaras Hindu University	27
Top ten institutions' total	393
Top ten institutions' percentage	1.96
Remaining 1010's percentage	98.04

4.8.4 Collaborating institutions: IIT Kharagpur

Table 12 shows the data on top ten institutions collaborated with IIT Kharagpur. CSIR find place at top by collaborating in 174 articles followed by Jadavpur University in 85 articles, BARC in 66 articles, Vidyasagar University in 63 articles and Sanjay Gandhi Postgraduate Institute of Medical Sciences in 37 articles. There were 1420 institutions collaborated with IIT Kharagpur, top ten institutions collaborated in 3.27% and remaining 1410 institutions in 96.73% articles.

Table 12. Top institutions collaborated with IIT Kharagpur	
Institution	Number of articles
CSIR	174
Jadavpur University	84

BARC	66
Vidyasagar University	63
Bengal Engineering Sciences University	57
Defence Metallurgical Research Laboratory	51
University of Calcutta	48
University of Kwazulu Natal	45
Indian Statistical Institute	42
University of Delhi	26
Top ten Institutions' total	656
Top ten Institutions' percentage	3.27
Remaining 1410's percentage	96.73

4.8.5 Collaborating institutions: IIT Madras

Table 13 depicts the data on top ten institutions collaborated with IIT Madras. CSIR find place at top by collaborating in 402 articles followed by US DOE in 73 articles, TIFR in 71 articles, IISc in 70 articles and Indira Gandhi Centre for Atomic Research in 66 articles. There were 1229 institutions collaborated with IIT Madras, top ten institutions collaborated in 3.09% and remaining 1219 institutions in 96.91% articles.

Institution	Number of articles
CSIR, India	402
US DOE	73
TIFR	71
IISc, Bangalore	70
Indira Gandhi Centre for Atomic Research	66
Max Planck Society	65
Karlsruhe Institute of Technology	62
Seoul National University	60
Pacific Northwest Laboratory	57
Wayne State University	56
Luther College	56
Anna University	56
Top ten Institutions' total	619
Top ten Institutions' percentage	3.09
Remaining 1219's percentage	96.91

5. Findings and Conclusions

During the 5 years' period under study, growth of research papers was found to be in increasing order. The paper helped in carrying out an evaluation of

publications of India vs world and with special emphasis on five top Indian institutions/universities. It comprehensively covered the different types of collaborations and citation data of five Indian institutions with national level institutions of India and those from abroad. The study may be useful to subject specialists, analysts, researchers, students, policy makers, institute administrators and faculty to look into the trends and make effective policies, think about the collaboration, see the citation pattern, etc. on the basis of inferences drawn in this paper. Important findings though have already been elaborated in the analysis and discussion part; some of them have been highlighted below as conclusions:

- i) The year 2013 accounted for highest number (49406/ 22.98%) of articles and a total of 215019 articles with an average of 43003.8 articles were contributed from India.
- ii) Share of India was only 215019 (2.72%) articles to global records (7,894,639) as indexed in database.
- iii) IITs' share to the total 215019 articles was 9.32% with highest contribution i.e. 10.13% in the year 2009. Decreasing trend was observed in respect of IITs share from 2010 to 2012, but a slight increase of 0.10% was noticed in the year 2013.
- iv) Highly productive institution from amongst IITs is the IIT Kharagpur with 5271 articles followed by IIT Madras with 3983, IIT Bombay with 3868, IIT Delhi with 3822 and IIT Kanpur with 3404.
- v) IIT Kanpur collaborated maximum with other four IITs which is 4.05% of its total articles followed by IIT Madras with 3.50% collaboration, IIT Delhi with 3.61%, IIT Bombay with 3.57% and IIT Kharagpur with 2.62% articles in collaboration.
- vi) IIT Bombay received maximum average number of 6.7 citations per article followed by IIT Kanpur and IIT Kharagpur.
- vii) IIT Bombay and IIT Madras secured H-Index of 45 followed by IIT Kharagpur with H-Index of 42.
- viii) It was found that India had collaborations with 177 countries of the world. USA topped the list of collaborations followed by Germany. IITs as a whole collaborated with 96 countries in 9072 (45.71%) out of total 20046 articles and USA was again at top.
- ix) IBM find place at top by collaborating in 1297 articles with all the five IITs followed by CSIR in 1005 articles, BARC in 372 articles and US DOE in 244 articles. There were 3915 institutions collaborated with IITs. Top ten institutions collaborated in 21.06% and remaining 3905 institutions in 78.94% articles.
- x) Amongst national collaborators; IIT Bombay has BARC at first place and CSIR for IIT Delhi, Kanpur, Kharagpur and Madras.
- xi) The study provides a base for researchers, institutions and policy makers to initiate new research projects or studies or collaborations in the area. It also makes researchers aware regarding the growth of quality research

literature, degree of collaborations, citation pattern and the H-Index of their institution.

References

Gupta, B.M. and Kaur, H., (2013). World glaucoma research: a quantitative analysis of research output during 2002-11. *Annals of Library and Information Studies*, Vol. 60, No. 2, 98-106.

Mahesh G. and Wadhwa, N.K., (2012). Web of Science based ranking of Indian library and information science journals. *Collnet Journal of Scientometrics and Information Management*, Online first, available at: http://www.tarupublications.com/journals/cjsim/FullText/new%20pdf/05_CJSIM6-2.pdf Indian Institute of Technology. Retrieved Sept. 14, 2014 from: http://en.wikipedia.org/wiki/Indian_Institutes_of_Technology

Singh, M. and Hasan, N., (2013). Intellectual Property: a scientometric study of scholarly output. *Journal of Knowledge and Communication Management*, Vol. 3, No. 1, 13-28.

Hasan, N. and Singh, M., (2014). Library and Information Science research output: a study based on Web of Science. Proceedings of the *10th International Conference on Webometrics, Informetrics and Scientometrics & 15th COLLNET Meeting*, 413-425.

Hasan, N. and Singh, S., (2007). Agricultural research in Himachal Pradesh: a profile based on AGRICOLA, AGRIS, CAB and FSTA CD-ROM databases. *SRELS Journal of Information Management*, Vol. 44, No. 3, 279-300.

Robertson, S., Jitan, S., and Reese, K., (1997). Web-based collaborative library research. Proceedings of the *2nd ACM International Conference on Digital Libraries*, 152-160.

Shri Ram, Kataria, S. and Ahmad, S., (2014). An assessment of the visibility of Indian journals in Social Science Citation Index–Journal Citation Report. *Journal of Information Management*, Vol. 1, No. 1, 1-17.

Web of Science database. Retrieved Sept. 6, 2014 from: <http://apps.webofknowledge.com>