Growth of Remote Sensing Literature: A Bibliometric Analysis

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Abstract

This article aims to study a quantitative distribution of remote sensing literature from Scopus database using bibliometric analysis covering a period of five years from 2006 to 2010. The study focuses on the broader objectives, methodology, intricate analysis and findings. The study explains the concepts using various tables and figures for easy comprehension. Further, an attempt has been made to substantiate the fact of the importance of scientometric study in drawing valuable conclusions

Keywords

bibliometrics, Remote Sensing, Citation analysis.

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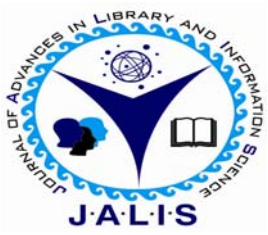

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INTRODUCTION

Remote sensing is a technique of obtaining information about objects through the analysis of data collected by special instruments that are not in physical contact with the objects of investigation. Remote sensing can be regarded as "reconnaissance from a distance", "teledetection" or a form of the common adage "look but don't touch". Remote sensing is the science of gathering data on an object or area from a considerable distance, as with radar or infrared photography, to observe the earth or a heavenly body. Thus Remote sensing means the sensing of the earth surface from space by making use of the properties of electromagnetic waves emitted, reflected or diffracted by the sensed objects, for the purpose of improving natural resources management, land use and the protection of the environment. This complex social, scientific and technological phenomenon of research is to be analyzed qualitatively and quantitatively. The quantitative study of science has been done by bibliometric analysis. The major indicator of scientific progress is the distribution of publication over the period, country wise contribution, collaboration pattern among the scientists, national and international collaborations etc.

REMOTE SENSING

From general perspectives, remote sensing is the science of acquiring and analyzing information about objects or phenomena from a distance (Jensen, 2000, Lille sand and Keifer, 1987). However, conventionally, remote sensing (RS) refers to the identification of earth features by detecting the characteristics electromagnetic radiation that is reflected/emitted by the earth surface. The sensors on-board various platforms detect the radiation received from the targets in different spectral regions. Compared to conventional monitoring from the ground, the advantages of satellite remote sensing are:

- Capacity to achieve a synoptic view
- Potential for fast survey
- Capability of repetition coverage to detect the changes
- Low cost involvement
- Higher accuracy
- Use of multispectral data for increased information
- Inaccessible area coverage
- All weathers/day and night capability

- Simultaneous observation/angles, spectral regions over land, atmosphere and oceans

BIBLIOMETRICS

A common research tool is a bibliometric method which has already been widely applied in scientific production and research-trend studies in many disciplines of science and engineering (Almind & Ingwersen, 1997; Cronin, 2001; Moed, Debruin, & Vanleeuwen, 1995). The popularity in the adaptation of bibliometric techniques in various disciplines stimulated stupendous growth of literature on bibliometrics and its related areas

REVIEW OF RELATED LITERATURE

Conventional bibliometric methods generally evaluate the research trend by investigating the publication outputs of different countries (Rahman, Haque, & Fukui, 2005), research institutes (Rajendram, Lewison, & Preedy, 2006), journals (Dannenberg, 1985), subjects (Rajendran , Ramesh Babu , & Gopalakrishnan , 2005) and research fields(Davis & Gonzalez, 2003 , Krishnamoorthy, Ramakrishnan, & Devi, 2009).

OBJECTIVES OF THE STUDY

The objectives of the study has been designed as follows:

- To examine the growth of journal articles in remote sensing research during the period 2006-2010.
- To analyze the country wise, language wise, year wise and author wise distribution of journal articles output in the field of remote sensing.
- To assess the extent of Indian publications and its collaboration pattern with in a country and with other countries in journal articles.
- To identify the average citations per contribution in journal articles

SCOPE AND COVERAGE

Based on an objectives mentioned above, the study aims to identify the growth of literature in "remote sensing" and its collaboration pattern among the authors across the world. To accomplish this objective, it is decided to analyze the remote sensing articles from SCOPUS Database which is the biggest database in science and technology. Thirty eight thousand eight hundred and eighty seven documents have been published in Remote Sensing during the study period from 2006-2010. Out of 38,887 , Journal articles 17,919 have been taken for analysis during the five years of study period from 2006-2010 .

METHODOLOGY

Out of 38,887 publications, 17919 journal articles were identified in the field of "remote sensing" during the period 2006-2010. It has been classified by using Microsoft Excel and the same has been loaded into Statistical Package for Social Sciences (SPSS) software for analysis.

ANALYSIS AND DISCUSSION

Bibliographic distribution of Remote sensing literature in SCOPUS Database for the period 2006-2010 has been shown in the Table 1.

Table 1: Bibliographic Distribution of Remote Sensing Literature

S.No.	Document Type	Total	%
1	Article	17919	46.2
2	Conference Paper	19514	50.3
3	Review	727	1.3
4	Conference Review	362	0.9
5	Editorial	128	0.4
6	Short Survey	77	0.3
7	Article in press	26	0.1
8	Letter	25	0.1
9	Others	109	0.4
	Total	**38887**	**100**

From the above mentioned biblographic distribution ,articles published in Journals alone have been taken for the study.

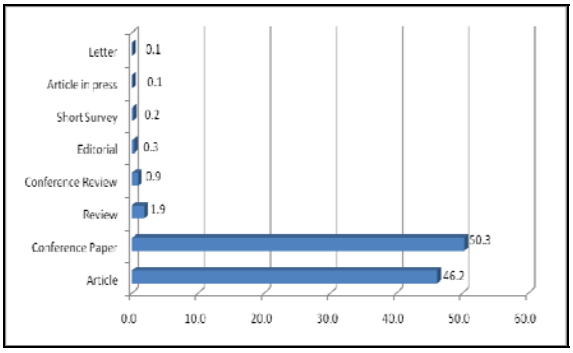

Figure 1: Bibliographic Distribution of Remote Sensing Literature

Table 2 shows the Year wise distribution of Journal articles in Remote Sensing literature for the period 2006-2010 in SCOPUS Database .

Table 2: Year wise Distribution of Remote Sensing Literature

S.No.	Year	Articles	%
1	2006	3006	16.9
2	2007	3250	18.1
3	2008	3713	20.7
4	2009	3931	21.9
5	2010	4019	22.4
	Total	17919	100

As per the table 2 shows gradual increase in publications shows the growth of remote sensing literature.

Author wise distribution of Journal articles in Remote Sensing literature for the period 2006-2010 in SCOPUS Database is shown in the Table3.

Table 3: Author wise Distribution of Remote Sensing Literature

S.No.	Authors	Total	Total%
1	Single	1368	7.6
2	Two	3445	19.2
3	Three	4092	22.8
4	Four	3519	19.6
5	Five	2167	12.1
6	Six	1296	7.2
7	Seven	755	4.2
8	Nine	402	2.2
9	9& above	830	4.6
10	Anon	45	0.3
	Total	**17919**	**100**

In table 3 , during the study period, three authors contributions is 22.8% in research publications output. Four authors is 19.6%, two authors (19.2%), and five authors (12.1%) respectively. Single author contribution is 7.6% in publications. This shows that the collaborative authors (two and more) contribution is more higher than the single author contribution. 0.3% of Anonymous authors (Anon) are in the period 2006-2010. More number (22.8%) of remote sensing articles in journals are published with three authors collaboration.

Year wise distribution of Authors from Journal articles in Remote Sensing literature for the period 2006-2010 in SCOPUS Database is shown in the table 4.

Table 4: Author Vs Year in Remote Sensing Literature

Author	2006	2007	2008	2009	2010	Total	Total %
Single	270	272	285	263	278	1368	7.6
Two	674	651	726	706	688	3445	19.2
Three	700	758	787	908	939	4092	22.8
Four	551	638	724	812	794	3519	19.6
Five	323	369	459	487	529	2167	12.1
Six	187	212	291	288	318	1296	7.2
Seven	108	124	178	172	173	755	4.2
Eight	68	62	90	80	102	402	2.2
Nine & above	125	164	173	215	198	875	4.9
Total	**3006**	**3250**	**3713**	**3931**	**4019**	**17919**	**100**

In this study period, three author contribution with 22.8% stands first in research publications output followed by four author articles (19.6%). Two authors (19.2%) research is in the 3rd place while that of five authors (12.1%) occupy the 4th place. Single author contribution is 7.6% and comes in the fifth place in publications. Publications of authors is increasing gradually for the five years from 2006-2010. The position of articles written by 3,4,2,5 and single author occupies the same place in each year and also during the period 2006-2010. Maximum number of remote sensing articles in journals are published with three authors collaboration.

Fifth place has been taken by single author with 7.6% of the total output. This indicate that in remote sensing literature, collaborative research is more when compared to single author contribution. It has been observed that the number of publications in remote sensing during the study period is found to increase gradually.

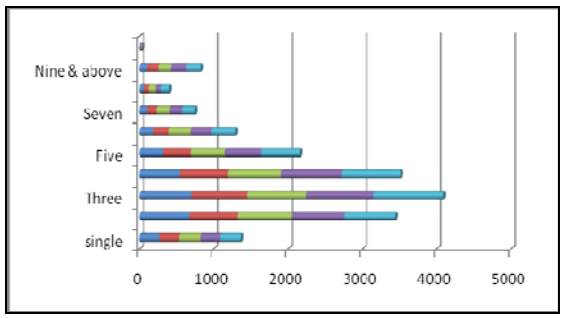

Figure 2: Author Vs Year in Remote Sensing Literature

Table 5: Distribution of Country Vs Year in Remote Sensing Literature

S.No.	Country	2006	2007	2008	2009	2010	Total	%
1	United States	849	905	979	932	889	4554	25.41
2	China	627	719	829	938	958	4071	22.72
3	India	127	135	175	175	213	825	4.60
4	Germany	136	124	162	191	188	801	4.47
5	Italy	137	123	144	158	141	703	3.92
6	Canada	105	143	151	119	153	671	3.74
7	France	95	116	143	138	153	645	3.59
8	United Kingdom	137	133	117	122	132	641	3.57
9	Japan	81	86	87	100	77	431	2.41
10	Spain	71	62	83	81	87	384	2.14
11	Australia	64	63	69	93	95	384	2.14
12	Brazil	51	59	65	78	111	364	2.03
13	Netherlands	44	53	64	56	57	274	1.53
14	Turkey	20	30	54	49	44	197	1.10
15	Taiwan	21	20	40	65	36	182	1.02
16	Russian Federation	34	19	27	46	28	154	0.85
17	Belgium	29	22	39	23	30	143	0.80
18	Switzerland	14	23	30	37	33	137	0.76
19	Finland	24	20	28	35	27	134	0.75
20	South Korea	21	20	26	22	38	127	0.71
21	Iran	11	11	35	33	33	123	0.68
22	Greece	24	20	25	25	23	117	0.65
23	Others	284	344	341	415	473	1857	10.36
	Total	**3006**	**3250**	**3713**	**3931**	**4019**	**17919**	**100**

In the entire study period, United States leads the first place in total publications (25.41%) while China occupies the second place (22.72%). India in the third place(4.6%) across the countries and Germany in the fourth place(4.47%). During this period, there is a gradual increase in the research publications output for each year. From 2006-2008, United States stands first in publications but from 2009-2010 it comes to the second level and China stands first. In 2009, the difference in publications output between United States and China is meager. But in 2010, publication output from China is slightly higher than United States. Country Vs Author from Journal articles in remote sensing literature for the period 2006-2010in SCOPUS Database is shown in the table 6

Table 6: Country Vs Author in Remote Sensing Literature

S.No.	Country	Single	Two	Three & above	Anon	Total	Total%
1	United States	423	1019	3079	23	4554	25.41
2	China	87	582	3402		4071	22.72
3	India	60	203	562		825	4.60
4	Germany	81	167	550	3	801	4.47
5	Italy	45	113	545		703	3.92
6	Canada	42	154	474	1	671	3.74
7	France	43	87	515		645	3.59
8	United kingdom	94	124	419	4	641	3.57
9	Japan	27	79	325		431	2.41

10	Australia	30	78	272	4	384	2.14
11	Spain	14	60	310		384	2.14
12	Brazil	12	57	295		364	2.03
13	Netherlands	22	43	204	5	274	1.53
14	Turkey	33	51	113		197	1.10
15	Taiwan	11	39	132		182	1.02
16	Russian Federation	29	30	95		154	0.85
17	Belgium	8	15	120		143	0.80
18	Switzerland	8	21	107	1	137	0.76
19	Finland	15	24	95		134	0.75
20	South Korea	14	26	87		127	0.71
21	Iran	17	27	79		123	0.68
22	Greece	8	23	86		117	0.65
23	Others	235	423	1195	4	1857	10.36
	Total	**1368**	**3445**	**13061**	**45**	**17919**	**100.0**

The United States has 25.41% and stands first place in total publications . China has 22.72% and it is in the 2nd place. Even though India's output is 4.6% , it occupies the 3rd place. In United States, two authors contribution are higher than the other authors . The publications output from China is higher in four authors contributions. The ascending order of publications are Three, four, two, five and single author's output in total. In India, three authors collaboration provides more number of publications. Single author publication is comparatively low in all the countries. This shows, in the modern technology world, collaborative authors gives the maximum number of research outputs rather than the single author's work.

The table 7 shows the Language Vs Year distribution from Journal articles in Remote Sensing literature for the period 2006-2010 in SCOPUS Database. During the study period, 82.4% of the publications are in English language. It is higher in each year and also in total. Chinese (14.2) occupies the 2nd place and Portuguese (0.9%) in the 3rd place. There is a gradual increase in research output for each year in all the Languages

Table 7: Language Vs Year in Remote Sensing Literature

S.No.	Language	2006	2007	2008	2009	2010	Total	Total %
1	English	2524	2712	3059	3189	3289	14773	82.4
2	Chinese	397	443	523	605	581	2549	14.2
3	Portuguese	20	27	28	46	48	169	0.9
4	French	7	22	11	19	16	75	0.4
5	German	6	11	20	12	11	60	0.3
6	Spanish	12	5	12	11	19	59	0.3
7	Japanese	11	4	6	9	7	37	0.2
8	Russian	6	3	5	5	3	22	0.1
9	Slovenian	2	4	2	1	4	13	0.1
10	Japanese; English	1	2	3	3	3	12	0.1
11	Hungarian	5	2	2	1	0	10	0.1
12	Turkish	2	2	4	0	2	10	0.1
13	Persian	0	1	5	3	1	10	0.1
14	Others (Languages which publishing below 10 articles in total)	13	12	33	27	35	120	0.7
	Total	**3006**	**3250**	**3713**	**3931**	**4019**	**17919**	**100.0**

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The table 8 shows the Language Vs Author distribution from Journal articles in Remote Sensing literature for the period 2006-2010 in SCOPUS Database.

Table 8: Language Vs Author in Remote Sensing Literature

S.No.	Authors	English	Chinese	German	Spanish	French	Japanese	Portuguese	Others	Total
1	1	1275	47	18	3	16	2	4	3	1368
2	2	2961	369	15	16	14	5	30	35	3445
3	3	3253	699	10	13	12	12	51	42	4092
4	4	2675	731	6	10	12	7	44	34	3519
5	5	1734	368	3	5	9	4	27	17	2167
6	6	1054	199	6	6	8	5	8	10	1296
7	7	664	78	1	3	0	0	5	4	755
8	8	359	34	0	1	2	1	2	3	402
9	9 &above	798	24	1	2	2	1	0	47	875
	Total	**14773**	**2549**	**60**	**59**	**75**	**37**	**171**	**195**	**17919**

In table 8, authors distribution among the languages have been shown. In English language, the ascending order of authors contribution as three, two, four, five and single authors respectively. In Chinese language also the order is four, three, two, five, six and single. But in German and French languages, only the single author contribution stands first in publications. German, Spanish, French and Japanese languages publishes below hundred of articles in remote sensing. Portuguese stands third place in overall publications. The English language stands first in all types of authors contributions.

Table 9: Year wise distribution of Citations in remote sensing literature

S.No.	Year	Number of Articles	Citation	%	Average %
1	2006	3006	32765	31.3	10.89
2	2007	3250	27665	26.4	8.51
3	2008	3713	22320	21.3	6.01
4	2009	3931	15163	14.5	3.85
5	2010	4019	6716	6.4	1.67
	Total	**17,919**	**1,04,629**	**100**	

The remote sensing literature cited by number of persons in the year 2006 is 31.3% and it is higher than the other study years. Average citations per contribution is higher In the year 2006.

The publications from United States is 25.41% and it occupies the first place during the study period 2006-2010. China (22.72%), stands 2nd and India (4.6%) in the 3rd place. Most of the countries publish the articles in english only. Difference between a number of journal articles from United states and China are meager. 82.4% of the publications are from the English language. There is a vast difference between english and other languages in publications output. Chinese language publications is 14.2% and Portuguese is 0.9% stands 2nd and 3rd place respectively. Research output in French, German, Spanish, Japanese and Russian languages are below 0.5%. Year wise Distribution of Citations and Average citations per contribution from Journal articles in Remote Sensing Literature for the period 2006-2010 in SCOPUS Database is shown in the table 9

Remote sensing literature Titles in Journal articles cited more than 100 times in SCOPUS Database for the period 2006-2010 is shown in the table 10. The article with the title "Uncertainty estimates in regional and global observed temperature changes: A new data set from 1850" in the journal "Journal of Geophysical research D: Atmospheres" is cited more number of times (447) during the study period.

Table 10: Remote sensing Literature Titles cited more than 100 times

S.No.	Title	Journal	Cited by
1	Uncertainty estimates in regional and global observed temperature changes: A new data set from 1850	Journal of Geophysical Research D:Atmospheres	447
2	The shuttle radar topography mission	Reviews of Geophysics	315
3	Initial performance assessment of CALIOP	Geophysical Research Letters	251
4	Application of spheroid models to account for aerosol particle non-Sphericity in remote sensing of desert dust	Journal of Geophysical Research D: Atmospheres	185
5	Contribution of anthropogenic and natural sources to atmospheric methane variability	Nature	177
6	Meep: A flexible free-software package for electromagnetic simulations by the FDTD method	Computer Physics Communications	163
7	Signal reconstruction from noisy random projections	IEEE Transactions on Information Theory	160
8	The evidence for shrub expansion in Northern Alaska and the Pan-Arctic	Global Change Biology	158
9	Cassini encounters Enceladus: Background and the discovery of a south polar hot spot	Science	145
10	Daily high-resolution-blended analyses for sea surface temperature	Journal of Climate	138
11	Onset of spring starting earlier across the Northern Hemisphere	Global Change Biology	135
12	Amazon rainforests green-up with sunlight in dry season	Geophysical Research Letters	135
13	Objectively analyzed air-sea heat fluxes for the global ice- free oceans (1981-2005)	Bulletin of the American Meteorological Society	131
14	Satellite-based energy balance for mapping evapotranspiration with internalized calibration (METRIC) – Model	Journal of Irrigation and Drainage Engineering	124
15	Reflectance quantities in optical remote sensing-definitions and case studies	Remote Sensing of Environment	122
16	Humid tropical forest clearing from 2000 to 2005 quantified by using multitemporal and multiresolution remotely sensed data	Proceedings of the National Academy of Sciences of the United States of America	116
17	Satellite gravity measurements confirm accelerated melting of Greenland ice sheet	Science	112
18	Distribution of aboveground live biomass in the Amazon basin	Global Change Biology	112
19	Gaussian decomposition and calibration of a novel small-footprint full-waveform 163igitizing airborne laser scanner	ISPRS Journal of Photogrammetry and Remote Sensing	110
20	Mexico City aerosol analysis during MILAGRO using high resolution aerosol mass spectrometry at the urban supersite (T0) – Part 1: Fine particle composition and organic sourceapportionment	Atmospheric Chemistry and Physics Discussions	108
21	A multi-sensor approach for the on-orbit validation of ocean color satellite data products	Remote Sensing of Environment	108
22	Overview of the EOS aura mission	IEEE Transactions on Geoscience and Remote Sensing	104
23	Farming the planet: 1. Geographic distribution of global agricultural lands in the year 2000	Global Biogeochemical Cycles	102

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Table 11: Authors Distribution of Remote Sensing Literature from India

S.No.	Authors	Total	Total %
1	Single	60	7.3
2	Two	203	24.6
3	Three	268	32.5
4	Four	153	18.5
5	Five	74	9.0
6	Six	36	4.4
7	Seven	14	1.7
8	Eight	9	1.1
9	Nine & above	8	1.0
	Total	**825**	**100.0**

Authors Distribution of Journal articles in remote sensing literature from India during 2006-2010 in SCOPUS Database is shown in the table 11. **I**n India, three authors contribution is 32.5% and stands 1st in publications. It is followed by the two (24.6%), four (18.5%) and five (9%) authors contribution. The single author contribution is 7.3% which is lower than the above collaborative authors contribution. Ultimately it indicates that the collaborative research is high. Distribution of Intra, Inter collaboration of authors in Journal articles in remote sensing literature from India is shown in the table 12. Intra collaboration implies collaboration of authors and publications with in a country. Inter collaboration shows the collaboration between one or more countries.

Table 12: Intra, Inter Collaborations of Authors Distribution in Remote Sensing Literature from India

S.No.	Authors	Collaboration with in a country	Collaboration with other country	Total	Total %
1	Single	60	0	60	7.3
2	Two	194	9	203	24.6
3	Three	246	22	268	32.5
4	Four	130	23	153	18.5
5	Five	64	10	74	9.0
6	Six	32	4	36	4.4
7	Seven	10	4	14	1.7
8	Eight	6	3	9	1.1
9	Nine & above	5	3	8	1.0
	Total	**747**	**78**	**825**	**100**

Intra collaboration is more in India rather than inter collaboration. In intra, three authors collaboration is higher than others. But in Inter, four authors collaboration stands first followed by the three authors. In overall , 90% of the publications are with intra collaborations and 10% with inter collaborations. Inter collaborations should be increased.

FINDINGS

Some of the findings are

- Year wise distribution shows a gradual increase in publications.
- Distribution of authors shows that the collaborative work is higher than the individual in research publications.

- Country wise and Language wise distributions shows that the United States and English language occupies the first place in publications
- Language Vs Year, Author and country shows that in which languages, in which years, which authors and in which countries, the publications of remote sensing articles are higher or lower.
- In the same way, Author Vs year, country Vs author and year shows the countries where the collaborative authorship is high or low in different years for the growth of remote sensing literature.
- India stands in the third place in publishing the remote sensing literature all over the world.
- Year wise distribution of citations and Average citations per contribution is found.

CONCLUSION

To evaluate the growth and quality of scientific production, the reliable tool is the bibliometric analysis. In the study of remote sensing literature from the SCOPUS Database some significant finding were identified for the period 2006-2010. Total number of 17,919 Journal articles were published in remote sensing research shows there was a significant research activity in the field of remote sensing during the study period. It also shows an increasing trend in this period. Indirectly shows that large number of research output from a country is correlated with the high activity and academic collaboration level of the country. A ranked list of articles shows that maximum number of articles in the database are from the United States and majority of the articles are published in english language. More efforts should be taken to further study in this field as remote sensing has always been thought to be widely useful in the advanced technological world.

REFERENCES

1. Jensen J.R.(2000) Remote Sensing of the Environment: An Earth Resource Perspective. Prentice Hall, New Jersey, p544

2. Lillesend, T and Kiefer, R.W.(1987) Remote Sensing and Image Interpretation, Wiley,p721.

3. Almind, T.C. & Ingwersen, P. (1997). Informatic analysis on the World Wide Web, Methodological approaches to "Webometrics". *Journal of Documentation*, 53(4), 404-426.

4. Cronin, B. (2001). Bibliometrics and beyond: some thoughts on web-based citation analysis, *Journal of Information Science*, 27(1), 1-7

5. 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 and first applications. *Scientometics*, 33(3), 381-422.

6. Hood, W.W., & Wilson C.S.(2001). The literature of bibliometrics, scientometrics and informatics, *Scientometrics*, 52(2), 291-314.

7. Rahman, M., Haque, T.L., & Fukui, T. (2005). Research articles published in clinical radiology journals: Trend of contribution from different countries, Academic Radiology, 12(7), 825-829.

8. Rajendram, R., Lewison, G., & Preedy, V. (2006). Worldwide alcohol-related research and the disease burden. *Alcohol and Alcoholism*, 41(1), 99-106.

9. Rajendran, P., Ramesh Babu, B , & Gopalakrishnan, S. (2005).Bibliometric analysis of "Fiber Optics" literature. *Annals of Library and Information Studies*, 52(3), 82-85

10. Davis, J.C., & Gonzalez, J.G.(2003). Scholarly journal articles about the Asian Tiger Economies: Authors, journals and research fields,1986-2001. *Asian-Pasific Economic Literature*, 17(2), 51-61

11. Krishnamoorthy G., Ramakrishnan, J., & Devi.(2009). Bibliometric analysis of literature on diabetes (1995-2004), *Annals of Library and Information Studies*, 56, 150-155