REMOTE SENSING LITERATURE IN SCOPUS DATABASE: A BIBLIOMETRIC ANALYSIS

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ABSTRACT

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. For this purpose, Scopus database has been taken for the study. Under the search term "Remote Sensing, irrespective of the field, the SCOPUS database provided more than 1,31,883 records covering a period of forty two years from 1971 to 2012. These records were further analysed using Excel and SPSS software. This paper attempt to provide the growth of literature using bibliometric tools in field of Remote Sensing over the period of 42 years ie. 1970-2012.

Keywords: Bibliometrics, Remote Sensing, Relative Growth Rate, Doubling Time.

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. From a general perspectives, remote sensing is the science of acquiring and analyzing information about objects or phenomena from a distance (Jensen, 2000, Lillesand 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.

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 scientometric 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

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

Remote sensing, as a practical and advanced space exploration technology, offered a lot of valuable data about the earth surface for global analysis, detailed assessment, environmental monitoring, mapping, change detection, disaster management, and civil and military intelligence(Benz et al, 2004; Hijmans et al. 2005; Song et al. 2001; Jackson et al. 1999; Tralli et al.2005). However, a comprehensive comment of the global remote sensing research has never been applied. Accordingly, the comprehensively and systematically global research trends in remote sensing have been taken up for the study.

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:

The major objectives of the study are

1. To examine the growth of remote sensing research for the period of 42 years from 1971-2012
2. To identify the Annual distribution and growth of Remote Sensing during the period 1971-2012.
3. To identify the type of documents in the field of Remote Sensing.
4. To identify and analyse the country-wise contribution of research output in the field of Remote Sensing.
5. To identify the languages of the output of publications.

6. To identify the authorship pattern of the major countries.
7. To identify the Cumulative Index , Relative Growth Rate and Doubling Time for the remote sensing literature publication output.

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. The search term "Remote sensing" (not remotesensing or remote sensing) is used to search all the publications which contained this word in "Title, abstract and Key word". One lakh thirty one thousand eight hundred and eighty three (1,31,883) documents have been published in Remote Sensing during the 42 years of study period from 1971-2012.

METHODOLOGY

One lakh thirty one thousand eight hundred and eighty three (1,31,883) were identified in the field of "remote sensing" during the 42 years of study period from 1971-2012. 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:

Bibliographic distribution of Remote sensing literature in SCOPUS Database for the period 1971-2012 has been shown in the Table 1.

Table 1: Bibliographic Distribution of Remote Sensing Literature

S.No	Document type	TP	%
1	Conference Paper	57838	43.86
2	Article	56105	42.54
3	Review	2437	1.85
4	Conference Review	1403	1.06
5	Editorial	299	0.23
6	Short Survey	253	0.19
7	Book	186	0.14
8	Report	107	0.08
9	Letter	84	0.06
10	Others	13171	9.99
	Total	**131883**	**100.00**

TP- Total Publications

From the above mentioned biblographic distribution , Conference paper have 43.86% and Article have 42.54% during the study period. Other document types like Review,Conference Review and others have less than 2% in total publications. This shows more number of remote sensing literature have been published in conference paper and articles.

Table 2 shows the Year wise distribution of Remote Sensing literature for the period 1971-2012 in SCOPUS Database .

Table 2: Year wise Distribution of Remote Sensing Literature

S.No	YEAR	TP	%	CUM TP	%
1	1971	65	0.05	65	0.05
2	1972	67	0.05	132	0.10
3	1973	224	0.17	356	0.27
4	1974	363	0.28	719	0.55
5	1975	466	0.35	1185	0.90
6	1976	305	0.23	1490	1.13
7	1977	439	0.33	1929	1.46
8	1978	552	0.42	2481	1.88
9	1979	751	0.57	3232	2.45
10	1980	1015	0.77	4247	3.22
11	1981	1198	0.91	5445	4.13
12	1982	1353	1.03	6798	5.15
13	1983	1510	1.14	8308	6.30
14	1984	1829	1.39	10137	7.69
15	1985	1450	1.10	11587	8.79
16	1986	1421	1.08	13008	9.86
17	1987	1122	0.85	14130	10.71
18	1988	1331	1.01	15461	11.72
19	1989	1619	1.23	17080	12.95
20	1990	1659	1.26	18739	14.21
21	1991	1826	1.38	20565	15.59
22	1992	1356	1.03	21921	16.62
23	1993	1982	1.50	23903	18.12
24	1994	2215	1.68	26118	19.80
25	1995	2071	1.57	28189	21.37
26	1996	2453	1.86	30642	23.23
27	1997	3160	2.40	33802	25.63
28	1998	3329	2.52	37131	28.15
29	1999	3071	2.33	40202	30.48
30	2000	3526	2.67	43728	33.16
31	2001	3499	2.65	47227	35.81
32	2002	4526	3.43	51753	39.24
33	2003	4793	3.63	56546	42.88
34	2004	6319	4.79	62865	47.67
35	2005	6607	5.01	69472	52.68
36	2006	5960	4.52	75432	57.20
37	2007	6596	5.00	82028	62.20

38	2008	8306	6.30	90334	68.50
39	2009	9477	7.19	99811	75.68
40	2010	9369	7.10	109180	82.79
41	2011	12296	9.32	121476	92.11
42	2012	10407	7.89	131883	100.00
		131883	**100.00**		

TP- Total Publications; CUM TP- Cumulative total publications

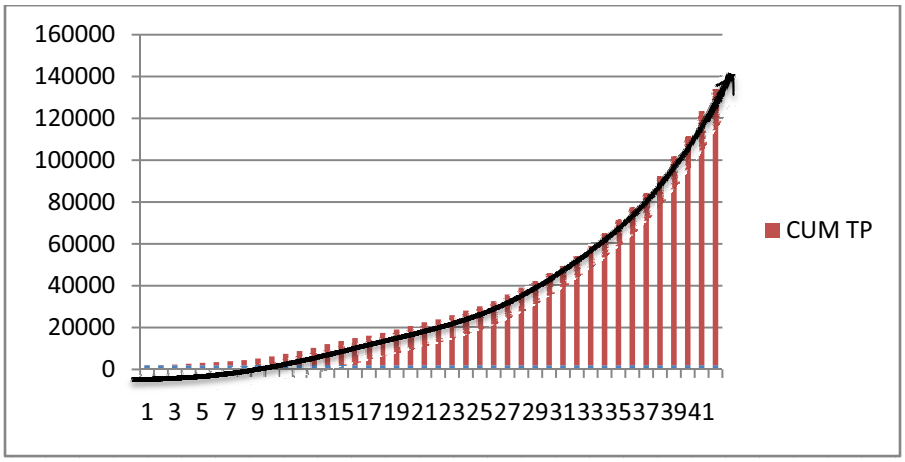

Figure 2: Cumulative Total Publications

From table 2, there is a gradual increase during the period of 1971-2012. From 1971-1979, the literature output are in hundreds (<0.3%), from 1980-2001, it was in thousands (0.46% to 2.78%) and from 2002-2012, the output is in ten thousands.(3.36% to 10.56%).This shows a stable growth in the said discipline. From 1987- 1988, the growth is slightly lower than the previous year. Again 1992, there is a small decrease in the growth. After that the growth is gradually increasing. Year wise distribution shows a parabolic increase in publications.

Table 3 shows a Relational Growth Rate (RGR) and Doubling Time (Dt) of the remote sensing literature in SCOPUS Database during the 42 years of study period from 1971-2012.

Table 3: RGR and Doubling time

S.No.	YEAR	CUM TP	%	w1	w2	RGR	Dt
1	1971	65	0.05		4.174387	4.174387	0.166012
2	1972	132	0.10	4.174387	4.882802	0.708415	0.978241
3	1973	356	0.27	4.882802	5.874931	0.992129	0.698498
4	1974	719	0.55	5.874931	6.577861	0.702931	0.985873
5	1975	1185	0.90	6.577861	7.077498	0.499637	1.387008
6	1976	1490	1.13	7.077498	7.306531	0.229033	3.02576
7	1977	1929	1.46	7.306531	7.564757	0.258226	2.6837
8	1978	2481	1.88	7.564757	7.816417	0.25166	2.753716
9	1979	3232	2.45	7.816417	8.080856	0.264439	2.620638
10	1980	4247	3.22	8.080856	8.353968	0.273112	2.537423
11	1981	5445	4.13	8.353968	8.602453	0.248485	2.788902

12	1982	6798	5.15	8.602453	8.824384	0.221931	3.122596
13	1983	8308	6.30	8.824384	9.024974	0.20059	3.4548
14	1984	10137	7.69	9.024974	9.223947	0.198973	3.482881
15	1985	11587	8.79	9.223947	9.357639	0.133692	5.183569
16	1986	13008	9.86	9.357639	9.47332	0.115681	5.990624
17	1987	14130	10.71	9.47332	9.556055	0.082736	8.376076
18	1988	15461	11.72	9.556055	9.646076	0.090021	7.698244
19	1989	17080	12.95	9.646076	9.745663	0.099587	6.958707
20	1990	18739	14.21	9.745663	9.838362	0.092699	7.475831
21	1991	20565	15.59	9.838362	9.931346	0.092984	7.45292
22	1992	21921	16.62	9.931346	9.9952	0.063854	10.8528
23	1993	23903	18.12	9.9952	10.08176	0.086559	8.00611
24	1994	26118	19.80	10.08176	10.17038	0.088621	7.819838
25	1995	28189	21.37	10.17038	10.24669	0.076307	9.081724
26	1996	30642	23.23	10.24669	10.33013	0.08344	8.30539
27	1997	33802	25.63	10.33013	10.42828	0.098148	7.06074
28	1998	37131	28.15	10.42828	10.52221	0.093932	7.37766
29	1999	40202	30.48	10.52221	10.60167	0.079465	8.72087
30	2000	43728	33.16	10.60167	10.68574	0.084072	8.242946
31	2001	47227	35.81	10.68574	10.76272	0.076977	9.002673
32	2002	51753	39.24	10.76272	10.85424	0.091517	7.572394
33	2003	56546	42.88	10.85424	10.94281	0.088572	7.824137
34	2004	62865	47.67	10.94281	11.04874	0.105935	6.541741
35	2005	69472	52.68	11.04874	11.14868	0.099934	6.934561
36	2006	75432	57.20	11.14868	11.23099	0.082308	8.419616
37	2007	82028	62.20	11.23099	11.31482	0.083829	8.266823
38	2008	90334	68.50	11.31482	11.41127	0.096453	7.184827
39	2009	99811	75.68	11.41127	11.51103	0.099764	6.94636
40	2010	109180	82.79	11.51103	11.60075	0.089719	7.724073
41	2011	121476	92.11	11.60075	11.70747	0.106719	6.4937
42	2012	131883	100.00	11.70747	11.78967	0.082198	8.430816

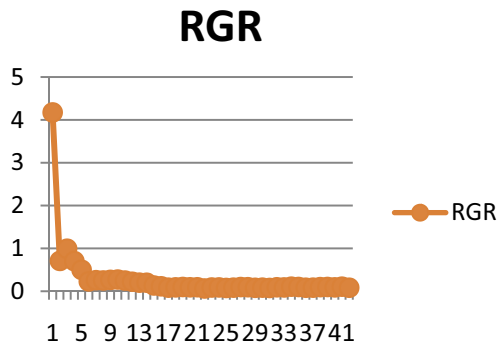

Figure 3 (Relative Growth Rate(RGR)

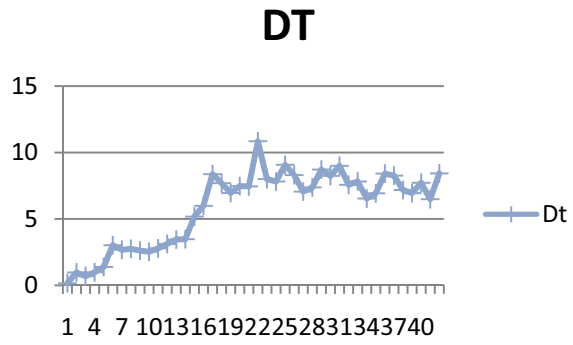

Figure 4 Doubling Time(Dt)

In table 3**,** Relative growth rate of contributions, a comparative study of pervious year cumulative growth, in the initial period seems to be high and slowly reduces. RGR ranges from 4.174387 to 0.082198. The doubling time(Dt) ranges from 0.166012 to 4.44 over the period. From 1987, the range of Doubling time increases above 5.

Table 4 shows the country wise distribution of Remote Sensing literature for the period 1971-2012 in SCOPUS Database .

Table 4: country wise distribution of Remote Sensing literature

S.No	COUNTRY	TP	%
1	United States	34342	26.04
2	China	22393	16.98
3	Germany	6930	5.25
4	France	6162	4.67
5	Italy	6126	4.65
6	United Kingdom	5689	4.31
7	Canada	5167	3.92
8	Japan	4750	3.60
9	India	3770	2.86
10	Spain	2796	2.12
11	Netherlands	2659	2.02
12	Australia	2604	1.97
13	Russian Federation	2292	1.74
14	Brazil	1615	1.22
15	Taiwan	1608	1.22
16	Switzerland	1303	0.99
17	South Korea	1249	0.95
18	Belgium	1167	0.88
19	Finland	1045	0.79
20	Sweden	975	0.74
21	Other countries	17241	13.08
	Total	**131883**	**100**

The table 4 and figure 5 shows that the United States have 26.04% in remote sensing publications and stands first. China follows it with 16.98% and occupies the second place. This indicates that these countries are more concentrated in the remote sensing research. Even though India have 2.86% in publications output, it stands in the 9th position all over the world. Other countries which publishing below 975 remote sensing documents have 13.08% in total publications. Germany (5.25%), France (4.67%) and Italy 4.65%) occupies the 3rd, 4th and 5th place respectively

Language wise distribution of Remote Sensing literature for the period 1971-2012 from the SCOPUS Database is shown in the table 5..

Table 5: Language wise distribution of Remote Sensing literature

S.No	LANGUAGE	TP	%
1	English	119015	90.24
2	Chinese	6279	4.76
3	French	882	0.67
4	Russian	617	0.47
5	German	579	0.44
6	Portuguese	376	0.29
7	Spanish	218	0.17
8	Japanese	184	0.14
9	Italian	91	0.07
10	Hungarian	60	0.05
11	Polish	46	0.03
12	Czech	39	0.03
13	Turkish	37	0.03
14	Dutch	35	0.03
15	Slovene	32	0.02
16	Korean	27	0.02
17	Croatian	21	0.02
18	Persian	18	0.01
19	Arabic	11	0.01
20	Swedish	11	0.01
21	Others	3305	2.49
	Total	**131883**	**100.00**

* TP- Total Publications

The publications of remote sensing literature in English language 90.24% have been shown in the table 5 and occupy the first place in total output. The Chinese language have 4.76% and stands in the second place in publication. Languages like French (0.67%), Russian (0.47%) and German (0.44%) occupies the 3rd, 4th and 5th places respectively in remote sensing literature publication. Other languages have 2.49% in total publication. The fig. 6 shows the details.

Degree of Collaboration : Subramaniyam (1983)[20] proposed a mathematical formula for calculating author's degree of collaboration in a discipline. The degree of collaboration among authors is the ratio of the number of collaborative publications in the total number of publications published in a discipline during certain period of time. The values of degree of collaboration can be calculated both for publications and citations. It is expressed mathematically as:

$$G = \frac{N_m}{N_m + N_s}$$

Where g = Group Coefficient of a discipline

N_m = Number of multiple authors during a specific period in a discipline

Ns = Number of single authored works in a discipline during a given period of time. "Degree of Collaboration" has been calculated and the same is shown in table 6

Table 6: Year Vs Authorship Pattern

S.No.	Year	Single Author	Collaborative Author	TP	Degree of Collaboration
1	1971	24	41	65	0.63
2	1972	30	37	67	0.55
3	1973	84	140	224	0.63
4	1974	119	244	363	0.67
5	1975	167	299	466	0.64
6	1976	111	194	305	0.64
7	1977	174	265	439	0.60
8	1978	260	292	552	0.53
9	1979	299	452	751	0.60
10	1980	423	592	1015	0.58
11	1981	526	672	1198	0.56
12	1982	532	821	1353	0.61
13	1983	651	859	1510	0.57
14	1984	706	1123	1829	0.61
15	1985	575	875	1450	0.60
16	1986	540	881	1421	0.62
17	1987	405	717	1122	0.64
18	1988	460	871	1331	0.65
19	1989	534	1085	1619	0.67
20	1990	511	1148	1659	0.69
21	1991	508	1318	1826	0.72
22	1992	406	950	1356	0.70
23	1993	470	1512	1982	0.76
24	1994	498	1717	2215	0.78
25	1995	476	1595	2071	0.77
26	1996	547	1906	2453	0.78
27	1997	628	2532	3160	0.80
28	1998	586	2738	3329	0.82
29	1999	514	2557	3071	0.83
30	2000	542	2984	3526	0.85
31	2001	527	2972	3499	0.85
32	2002	550	3976	4526	0.88
33	2003	579	4214	4793	0.88
34	2004	688	5631	6319	0.89
35	2005	681	5926	6607	0.90
36	2006	600	5360	5960	0.90
37	2007	590	6006	6596	0.91
38	2008	696	7610	8306	0.92
39	2009	653	8824	9477	0.93
40	2010	673	8696	9369	0.93
41	2011	827	11469	12296	0.93
42	2012	582	9825	10407	0.94
	Total	19952	111931	131883	0.85

* **TP- Total Publications**

During the study period, collaborative author distribution is higher than the single author distribution. It indicates more number of collaborative work is done in the remote sensing research field. The degree of collaboration ranges from 0.53 to 0.94.

More than 100 publications per year started appearing from the year 1973 (224). Growth of literature during the study period and the comparative study of World publications output on Remote Sensing between the year 1973 and 2012 has been made for the top 10 countries that has contributed on Remote Sensing and the same is shown in Table 7

Table 7: Top 10 Countries Research Output Of Remote Sensing Publications

S.No.	Country	Total Publications			% share of papers		
		1973	2012	1973-2012	1973	2012	1973-2012
1	United States	38	2408	34314	16.96	23.14	26.04
2	China	-	3182	22393	-	30.58	17.00
3	Germany	1	710	6930	0.45	6.82	5.26
4	France	-	543	6162	-	5.22	4.68
5	Italy	-	704	6126	-	6.76	4.65
6	United Kingdom	1	436	5689	0.45	4.19	4.32
7	Canada	2	415	5161	0.89	3.99	3.92
8	Japan	-	458	4749	-	4.40	3.60
9	India	-	388	3770	-	3.73	2.86
10	Spain	-	366	2796	-	3.52	2.12
11	Other countries	182	797	33661	81.25	7.66	25.55
	Total	**224**	**10407**	**131751**	**100**	**100.00**	**100.00**

The table shows that India holds 9th rank among the ten countries of the world in Remote Sensing, with its global publications share of 2.86% as computed from cumulative 1973-2012. India has shown rise in its global publication share, rising from 0.00 to 3.73 from the year 1973 to 2012.

Table 8 shows the top 30 key words used in the search of remote sensing literature from the SCOPUS Database for the period 1971-2012.

Table 8: Top 30 Keywords used in the Remote Sensing Literature

S.No.	Keyword	Number
1	Remote sensing	111255
2	Algorithm	13092
3	Satellites	8065
4	Image analysis	7427
5	Satellite imagery	7344
6	Vegetation	7222
7	Synthetic aperture radar	6950
8	Mathematical models	6933
9	Geology	6560
10	Radiometers	6551
11	GIS	5510
12	Image processing	5212

13	Forestry	5088
14	Geographic information systems	5080
15	Computer simulation	5065
16	Mapping	4546
17	Image reconstruction	4251
18	Space optics	4211
19	Radar	4154
20	Data set	4081
21	Optical radar	3942
22	Land use	3933
23	Sensors	3853
24	Satellite data	3843
25	Oceanography	3747
26	Estimation	3693
27	Eurasia	3664
28	Classification	3526
29	Land cover	3456
30	Imaging systems	3363

Out of 140 keywords, the top 30 have been taken for the table 6. The keyword "Remote sensing" is used for 111255 times and "Algorithm" is used for 13092 times during the study period of 42 years from 1971-2012.

Table 9 shows the Subject Areas which covered the remote sensing literature during the period of 1971-2012 from the SCOPUS Database.

Table 9: Subject Areas which covered the remote sensing literature

S.No	SUBJECT AREA	TP	%	CUM	CUM %
1	Earth and Planetary Sciences	61710	26.179	61710	26.179
2	Engineering	45937	19.488	107647	45.67
3	Computer Science	39273	16.661	146920	62.33
4	Environmental Science	24573	10.425	171493	72.75
5	Physics and Astronomy	22843	9.691	194336	82.44
6	Agricultural and Biological Sciences	9318	3.953	203654	86.40
7	Social Sciences	8748	3.711	212402	90.11
8	Mathematics	6920	2.936	219322	93.04
9	Materials Science	6868	2.914	226190	95.96
10	Chemistry	1693	0.718	227883	96.67
11	Medicine	1421	0.603	229304	97.28
12	Energy	1358	0.576	230662	97.85
13	Biochemistry, Genetics and Molecular Biology	1175	0.498	231837	98.35
14	Multidisciplinary	1007	0.427	232844	98.78
15	Chemical Engineering	675	0.286	233519	99.07
16	Business, Management and Accounting	470	0.199	233989	99.26
17	Decision Sciences	456	0.193	234445	99.46

18	Immunology and Microbiology	272	0.115	234717	99.57
19	Arts and Humanities	236	0.100	234953	99.67
20	Economics, Econometrics and Finance	142	0.060	235095	99.73
21	Health Professions	136	0.058	235231	99.79
22	Undefined	109	0.046	235340	99.84
23	Neuroscience	104	0.044	235444	99.88
24	Veterinary	93	0.039	235537	99.92
25	Pharmacology, Toxicology and Pharmaceutics	84	0.036	235621	99.96
26	Nursing	47	0.020	235668	99.98
27	Psychology	42	0.018	235710	100.00
28	Dentistry	11	0.005	235721	100.00
	Total	**235721**	**100.00**		

The Subject Areas which covered the remote sensing literature during the period 1971-2012 from the SCOPUS Database is shown in the table 9. Earth and Planetary Sciences, Engineering, Computer Science, Environmental Science and Physics and Astronomy occupies the first five places in Subject Areas which covered the remote sensing literature during the study period. This shows that the remote sensing search term have been highly covered by the above subject areas. The search term 'remote sensing' is in multiple disciplines. So the total output 2,35,721 is higher than the original remote sensing literature publication(1,31,883)

List of institutions which publishes more than 500 publications in the remote sensing literature during the period of 1971-2012 in SCOPUS Database have been shown in the table 10.

Table 10: List of institutions which published more than 500 publications

S.No	AFFILIATION	TP	%
1	NASA Goddard Space Flight Center	3432	2.60
2	Chinese Academy of Sciences	2294	1.74
3	Jet Propulsion Laboratory, California Institute of Technology	1955	1.48
4	Deutsches Zentrum fur Luft- Und Raumfahrt	1823	1.38
5	Beijing Normal University	1496	1.13
6	Institute of Remote Sensing Application Chinese Academy of Sciences	1460	1.11
7	Wuhan University	1354	1.03
8	Graduate University of Chinese Academy of Sciences	1273	0.97
9	University of Maryland	1115	0.85
10	National Oceanic and Atmospheric Administration	1093	0.83
11	Consiglio Nazionale delle Ricerche	1046	0.79
12	European Commission Joint Research Centre, Ispra	918	0.70
13	University of Colorado at Boulder	905	0.69
14	Naval Research Laboratory	834	0.63
15	Indian Space Research Organization	830	0.63
16	NASA Langley Research Center	814	0.62
17	University of Arizona	785	0.60
18	Peking University	728	0.55
19	United States Geological Survey	659	0.50
20	IEEE	656	0.50

21	University of Tokyo	646	0.49
22	Canada Centre for Remote Sensing	645	0.49
23	Colorado State University	643	0.49
24	Institute of Geographical Sciences and Natural Resources Research Chinese Academy of Sciences	635	0.48
25	Nanjing University	628	0.48
26	Instituto Nacional de Pesquisas Espaciais	601	0.46
27	University of Washington Seattle	601	0.46
28	USDA ARS Beltsville Agricultural Research Center	596	0.45
29	CNRS Centre National de la Recherche Scientifique	589	0.45
30	University of Wisconsin Madison	578	0.44
31	Russian Academy of Sciences	542	0.41
32	University of California, Santa Barbara	537	0.41
33	ESTEC - European Space Research and Technology Centre	515	0.39
34	Others	98657	74.77
	Total	**131883**	**100**

Table 10 shows that the NASA Goddard Space Flight Center stands (2.60%) first in publishing remote sensing literature during the study period. It shows its active participation in publishing remote sensing literature. Chinese Academy of Sciences (1.74%) leads the second position. Indian Space Research Organization shows its effective participation by publishing 830 documents in total publication with 0.63% . Out of 34, it occupy the top 15th place in remote sensing literature publication all over the world.

Table 11 shows the Source Titles which have more than 500 remote sensing literature publication during the study period from the SCOPUS Database.

Table 11: Source Title for Remote Sensing Literature with more than 500 publication

S.No	SOURCE TITLE	TP	%
1	International Geoscience and Remote Sensing Symposium IGARSS	15019	11.39
2	Proceedings of SPIE the International Society for Optical Engineering	13491	10.23
3	International Journal of Remote Sensing	5508	4.18
4	Remote Sensing of Environment	3507	2.66
5	IEEE Transactions on Geoscience and Remote Sensing	3382	2.56
6	2011 International Conference on Remote Sensing Environment and Transportation Engineering Rsete 2011 Proceedings	2186	1.66
7	Digest International Geoscience and Remote Sensing Symposium IGARSS	2180	1.65
8	Photogrammetric Engineering and Remote Sensing	1991	1.51
9	European Space Agency Special Publication ESA SP	1500	1.14
10	Journal of Geophysical Research D Atmospheres	1159	0.88
11	Proceedings of the International Symposium on Remote Sensing of Environment	913	0.69
12	Geophysical Research Letters	890	0.67
13	Canadian Journal of Remote Sensing	738	0.56

14	Advances in Space Research	708	0.54
15	ISPRS Journal of Photogrammetry and Remote Sensing	676	0.51
16	Journal of the Indian Society of Remote Sensing	637	0.48
17	Applied Optics	623	0.47
18	32nd Asian Conference on Remote Sensing 2011 Acrs 2011	510	0.39
19	Others	76265	57.83
	Total	**131883**	**100.00**

The source title "International Geoscience and Remote Sensing Symposium IGARSS" have 11.39% and publishes 15019 remote sensing literature. "Proceedings of SPIE the International Society for Optical Engineering" publishes 10.23% of remote sensing literature and stands in the second place. "IEEE Transactions on Geoscience and Remote Sensing " publishes 2.56% and "Journal of the Indian Society of Remote Sensing" publishes 0.48% of remote sensing literature during the study period.

Table 12 shows the top authors with more than 100 publication in remote sensing literature during the study period of 1971-2012 from the SCOPUS Database.

Table 12: Top authors with more than 100 publications in Remote Sensing Literature

S.No	Author	TP
1	Bruzzone, L.	222
2	Jackson, T.J.	203
3	Hallikainen, M.	170
4	Benediktsson, J.A.	153
5	Tsang, L.	148
6	Camps, A.	146
7	Asner, G.P.	146
8	Plaza, A.	145
9	Gamba, P.	143
10	Li, X.	142
11	Long, D.G.	137
12	Kustas, W.P.	134
13	Huang, W.	130
14	Liang, S.	127
15	Gong, P.	127
16	Ustin, S.L.	126
17	Strahler, A.H.	125
18	Ulaby, F.T.	124
19	Foody, G.M.	123
20	Pulliainen, J.	122
21	Rango, A.	118
22	Wulder, M.A.	118
23	Kaufman, Y.J.	115
24	Smith, W.L.	115
25	Burrows, J.P.	114

26	Everitt, J.H.	114
27	Xue, Y.	112
28	Baret, F.	112
29	Coops, N.C.	111
30	Goodenough, D.G.	111
31	Zhang, B.	110
32	Johannessen, O.M.	110
33	Curran, P.J.	109
34	Lehner, S.	106
35	Franklin, S.E.	105
36	Wagner, W.	105
37	Jensen, J.R.	104
38	Datcu, M.	103
39	Shi, J.	103
40	Cihlar, J.	102
41	Du, Q.	102
42	Guo, H.	102
43	Pampaloni, P.	102
44	Tucker, C.J.	101
45	Anon	234

Table 12 shows that forty four authors publishes more than 100 publications in remote sensing literature during the study period. More than 150 publication have been written by the first four authors . ie 222, 203, 170 and 153 publications respectively. The unknown author(anon) provides 234 publications.

FINDINGS

Some of the findings are

- In Remote sensing literature 43.86% are Conference paper and 42.54% are journal article. Conference papers are predominant in remote sensing.
- Year wise distribution shows a gradual and parabolic increase in publications.
- Relative growth rate of contributions, in the initial period seems to be high and slowly reduces. RGR ranges from 4.174387 to 0.082198.
- The doubling time(Dt) ranges from 0.166012 to 4.44 over the period.
- 26.04% of the documents were contributed by USA. It is followed by China (16.98%) and Germany (5.25%). France, Italy and United Kingdom were published 4.67%, 4.65% and 4.31% respectively. The contribution of India comes to nearly 2.86% of World Output and occupies ninth position.
- 90.24% of publications were published in English. It is followed by Chinese and French.
- In Remote sensing, collaborative research (82.24%) is higher than solo research (17.76%). The degree of collaboration is 0.85. The degree of collaboration ranges from 0.53 to 0.94.
- The keyword “Remote sensing” is used for 111255 times and “Algorithm” is used for 13092 times in the study period.

- Earth and Planetary Sciences, Engineering, Computer Science, Environmental Science, Physics and Astronomy are the top five subject fields which contributes more number of remote sensing literature.
- The NASA Goddard Space Flight Center stands first in Remote sensing research. It is followed by Chinese Academy of Sciences, Jet Propulsion Laboratory, California Institute of Technology and Deutsches Zentrum fur Luft- Und Raumfahrt in overall research output. The Indian Space Research Organization stands in the 15th position of the world output.
- International Geoscience and Remote Sensing Symposium IGARSS, Proceedings of SPIE the International Society for Optical Engineering, International Journal of Remote Sensing, Remote Sensing of Environment, IEEE Transactions on Geoscience and Remote Sensing are the top five journals which contribute more number of remote sensing publications.
- Bruzzone, L., Hallikainen, M., Benediktsson, J.A. are the top four authors who contributed more than one hundred and fifty publications.

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 42 years of study period from 1971-2012. Total number of 1,31,883 documents are published in remote sensing research which shows that 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. The maximum number of documnents in the database are from the United States and majority of them 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.

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