Remote Sensing Research in India: An Analysis of Publications output during 2011-2015

Mr. Chaman Sab, M.
Research Scholar
Dept. of Studies in Library and Information Science
Kuvempu University, Shankarghatta, Shimoga
Email:chamansabm@gmail.com

Dr. P. Dharani Kumar
Asst. Professor
Dept. of Studies in Library and Information Science
Kuvempu University, Shankarghatta, Shimoga
Email dr.dharanikumarp@gmail.com

Dr. B. S. Biradar
Professor
Dept. of Studies in Library and Information Science
Kuvempu University, Shankarghatta, Shimoga
Email: bsbiradar53@rediffmail.com

Abstract - *The study examines growth and development of Indian remote sensing publications retrieved from web of science database for the period 2011 to 2015. Remote Sensing, irrespective of the field, the database provided 977 records and received 3,269 citations, with 3.35 an average citations per paper during the period. This paper attempt to provide the growth of literature using scientometric tools in field of Remote Sensing over the period of five years. The study uses different indicators, such as, total publications, citations, average citation per paper (ACP). International Collaborative papers, source preferred, the Relative Growth Rate (RGR), doubling time (Dt) and highly cited papers, to analyze the growth and development.*

Keywords: Growth, Scientometrics, Remote Sensing, Relative Growth Rate, Doubling Time, Collaboration

Introduction

The word 'growth' represents an increase in actual size, implying a 'change of state'. Change in size of literature over a specific period of time is termed as 'growth of literature'. A systematic study in the increase of scientific literature, scientific community and institutions, etc., facilitates quantitative and qualitative understanding of science and various scientific phenomena (Rao & Meera, 1992).

Science as such would not have existed if scientific results were not reported, and this fact leads scientists from all over the world to submit their work to national and international journals. The formal and informal channels for disseminating scientific information have become a privileged, although not the sole, medium for accessing the two main dimensions (social & conceptual) that seem to characterize all knowledge disciplines. The assessment of research performance of countries, regions, institutions and individuals based on counting of publications and citations are prominent in studies of science and in research policy for identification and evaluation of the strength and weakness in scientific achievements. As growth in Scientometric Indicators (SI) like publication profile of institutions, individuals,

countries, etc., are closely related to overall R & D development of a country (Sangam & Meera, 2011).

The generation of new scientific and technical knowledge/information has been accelerating over the past several years. In recent years an increasing attention has been paid to the social dimensions of scientific community that produces sciences. But this unprecedented growth in literature has become a major concern for the scientists, scholars, and library professionals as they try to keep themselves abreast with new advances in their subject, and information professionals try to organize this knowledge. The growth, origin and language of literature reflect in various national level activities in R & D is a matter of a great concern to the managers of the scientific activities in government industry and in academic community.

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 is a technique to observe the earth surface or the atmosphere from out of space using satellites (space borne) or from the air using aircrafts (airborne). Remote sensing uses a part or several parts of the electromagnetic spectrum. It records the electromagnetic energy reflected or emitted by the earth's surface. The amount of radiation from an object (called radiance) is influenced by both the properties of the object and the radiation hitting the object (irradiance). The human eyes register the solar light reflected by these objects and our brains interpret the colours, the grey tones and intensity variations. In remote sensing various kinds of tools and devices are used to make electromagnetic radiation outside this range from 400 to 700 nm visible to the human eye, especially the near infrared, middle-infrared, thermal-infrared and microwaves.

Remote sensing imagery has many applications in mapping land-use and cover, agriculture, soils mapping, forestry, city planning, archaeological investigations, military observation, and geomorphological surveying, land cover changes, deforestation, vegetation dynamics, water quality dynamics, urban growth, etc. This paper starts with a brief historic overview of remote sensing and then explains the various stages and the basic principles of remotely sensed data collection mechanism. 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, Lilles and 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.

Methods and Materials

This study uses Web of Science (www.isiknowledge.com) database to extract relevant publications data of Indian remote sensing research output for the period (2011 to 2015). For analyzing the data, Excel and SPSS- statistical software has been used.

Results and Discussion

Growth of Publications of Indian Remote Sensing research

Table 1 depicts the remote sensing research output of India, India has produced 977 papers, and received 3,269 citations during the period 2011 to 2015, Average Citations per Paper is 3.35. As per the web of science data, cumulative publications growth, the cumulative publications output of Indian remote sensing has increased in the year 2013 and 2015. The global publications share of India during 2011 to 2015 was 5.00%.

Table 1: Growth of Publications of Indian Remote Sensing research

Year	TP	TC	ACP	H-index
2011	193	992	5.14	16
2012	181	884	4.88	12
2013	197	695	3.53	11
2014	196	507	2.59	10
2015	210	191	0.91	6
	977	**3269**	**3.35**	

TP= Total Papers; TC= Total Citations; ACPP=Average Citations per Paper

Relative Growth Rate and Doubling Time

Table 2 represents the relative growth rate (RGR), doubling time (Dt), and mean of RGR and Dt of Indian publications in the field of remote sensing. From the Table 2 it is observed that the average RGR for the period is 0.38 and the Dt is 1.31. Dt is the period of time required for a quantity to double in size or value. When the RGR is constant, the quantity undergoes exponential growth and has a constant Dt or period which can be calculated directly from the growth rate. RGR decreased from 0.74 in 2011 to 0.29 in 2015. The corresponding Dt for different years gradually increased from 0.94 in 2011 to 2.40 in 2015. Thus the rate of growth of publication was decreased, the corresponding Dt was increased (Table 2).

Table 2: Relative Growth Rate and Doubling Time

Year	TP	Cum. Pubs.	RGR	Dt
2011	2940	2940		
2012	3218	6158	0.74	0.94
2013	3685	9843	0.47	1.48
2014	4780	14623	0.40	1.75
2015	4898	19521	0.29	2.40
	19521		**0.38**	**1.31**

RGR = Relative Growth Rate; Dt = Doubling Time

Highly Productive Indian Authors in the field of Remote Sensing

"Scientific productivity" is frequently measured in terms of the published output, mostly because the data on the n umber of publications by authors can be easily collected and are quite reliable. Lotka (1926) proposed his 'Inverse square law of scientific productivity' for measuring the scientific productivity of authors in a given discipline. It is one of the earliest studies in the direction of measuring scientific productivity using the number of publications of an author as a measure. Apart from studying the scientific productivity of authors, another

aspect of authorship which has gained importance is the study of collaborative trend of authors in a given discipline.

The table 3 shows the top highly productive authors based on the number of publications irrespective of their disciplines during 2011 to 2015 appeared in Web of Science. Dadhwal. V. K. is the highly productive author, he contributed 31 publications followed by Sharma. R. contributed 29 articles, Panigrahy, S., Kumar, R. and Kumar, A. contributed 28 articles, Joshi, P. K. and Basu, S. published each 20 articles, Parihar, J. S. and Ghosh, S. contributed 19 articles and Chauhan, P. contributed 18 articles.

Table 3: Highly Productive Indian Authors in the field of Remote Sensing

Sl. N.	Authors	Publications	% of 977
1	Dadhwal. V. K.	31	3.17
2	Sharma, R.	29	2.97
3	Panigrahy, S.	28	2.87
4	Kumar, R.	28	2.87
5	Kumar, A.	28	2.87
6	Joshi, P. K.	20	2.04
7	Basu, S.	20	2.04
8	Parihar, J. S.	19	1.95
9	Ghosh, S.	19	1.95
10	Chauhan, P.	18	1.84

Source wise Distribution articles

The sources of remote sensing research include articles published in the journals, conference and seminars proceedings, editorial materials, and corrections (Table 4). This study has observed a total of 977 publications in remote sensing from India over a period of five years from 2011 to 2015. Out of them, articles appeared in the journals have shown a predominant contribution (98.57%). The remote sensing research output appeared with proceedings papers ranks second in order (0.82%) in an overall output. The output from the reviews got the third place in an overall remote sensing research output from India.

Table 4: Source wise Distribution articles

Sl. No.	Sources	Publications	% of 977
1	Article	963	98.567
2	Proceedings Paper	8	0.819
3	Review	7	0.716
4	Editorial Material	4	0.409
5	Correction	3	0.307

Sub-fields of research priority in Remote Sensing research in India

Out of 10 sub-fields identified, only five sub-fields witnessed increase in their activities from 2011 to 2015. Out of 10 sub-fields of remote sensing only one domain published more than 500 publications, five domains published more than 100 and more articles and other subjects produced less than 100 publications (Table 5).
As per the sub-fields cumulative output in Indian remote sensing research, the maximum research priority (564 publications, 57.73% share) is assigned to Imaging Science

Photographic Technology in India during 2011 to 2015, followed by Environmental Sciences Ecology (377 publications, 38.59% share), Geochemistry Geophysics (173 publications, 17.71% share), Engineering (166 publications, 16.99% share), Physical Geography (112 publications, 11.46% share), Oceanography (57 publications, 5.83% share), Telecommunications, Meteorology Atmospheric Sciences and Astronomy Astrophysics (16 publications, 1.67% share).

Table 5: Sub-fields of research priority in Remote Sensing research in India

Sl. No.	Sub-fields	Publications	% of 977
1	Imaging Science Photographic Technology	564	57.728
2	Environmental Sciences Ecology	377	38.588
3	Geochemistry Geophysics	173	17.707
4	Engineering	166	16.991
5	Physical Geography	112	11.464
6	Geology	102	10.44
7	Oceanography	57	5.834
8	Telecommunications	16	1.638
9	Meteorology Atmospheric Sciences	16	1.638
10	Astronomy Astrophysics	16	1.638

Preferred journals for publishing by Indian Authors

One of the most important bibliometric techniques used in identifying core journals in a discipline has been Citation Analysis. "Citations are the formal explicit linkages between publications that have particular points in common (Garfield, 1979). The major leading journals preferred by the scientists are Journal of the Indian Society of Remote Sensing with 250 papers, International Journal of Remote Sensing with 209 papers, Geocarto International with 78 papers, IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing with 69 papers, Marine Geodesy with 57 papers, IEEE Geoscience and Remote Sensing Letters with 52 papers, International Journal of Applied Earth Observation and Geo-information with 45 papers, IEEE Transactions on Geoscience and Remote Sensing with 45 papers, Remote Sensing Letters with 38 papers, and Journal of Applied Remote Sensing with 33 papers.

Table 6: Preferred journals for publishing by Indian Authors

S. No.	Journal Titles	Publications	% of 977
1	Journal of the Indian Society of Remote Sensing	250	25.589
2	International Journal of Remote Sensing	209	21.392
3	Geocarto International	78	7.984
4	IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing	69	7.062
5	Marine Geodesy	57	5.834
6	IEEE Geoscience and Remote Sensing Letters	52	5.322
7	International Journal of Applied Earth Observation and Geo-information	45	4.606
8	IEEE Transactions on Geoscience and Remote Sensing	45	4.606
9	Remote Sensing Letters	38	3.889
10	Journal of Applied Remote Sensing	33	3.378

Indian organizations contribution in the field of Remote Sensing

Based on the publications output for India in remote sensing, total of 10 institutions were identified as high productive between 21 and 115 publications during 1999-2013. Indian Institute of Technology has published the highest number of publications i.e. 115 papers, followed by ISRO (110 papers), Indian Space Research Organisation (90 papers), Indian Institute of Tropical Meteorology (44 papers), Indian Institute of Remote Sensing (39 papers), National Remote Sensing Centre (30 papers), Anna University (27 papers), Space Applications Centre, ISRO (26 papers), TERI University (23 papers) and Indian Institute of Science (21 papers).

Table 7: Indian organizations contribution in the field of Remote Sensing

S No.	Organizations	Publications	% of 977
1	Indian Institute of Technology	115	11.771
2	ISRO	110	11.259
3	Indian Space Research Organisation	90	9.212
4	Indian Institute of Tropical Meteorology	44	4.504
5	Indian Institute of Remote Sensing	39	3.992
6	National Remote Sensing Centre	30	3.071
7	Anna University	27	2.764
8	Space Applications Centre ISRO	26	2.661
9	TERI University	23	2.354
10	Indian Institute of Science	21	2.149

International collaboration

Among these top international collaborating countries, India's collaborative linkages United States has contributed by 5.83%, followed by Germany (2.46%), France (2.46%), Netherlands (2.15%), England (1.84%), Canada (1.64%), Japan (1.55%), Italy (1.33%), Australia (1.22%) and Thailand (0.61%). (Table 8).

Table 8: International Collaboration

Sl. No.	Countries	Publications	% of 977
1	USA	57	5.834
2	Germany	24	2.456
3	France	24	2.456
4	Netherlands	21	2.149
5	England	18	1.842
6	Canada	16	1.638
7	Japan	15	1.535
8	Italy	13	1.331
9	Australia	12	1.228
10	Thailand	6	0.614

Conclusion

To evaluate the growth and quality of scientific production, the reliable tool is the scientometric analysis. In the study of remote sensing literature from the web of science database some significant findings were identified for the period from 2011 to 2015. Scientometric analysis is also extremely essential to plan appropriate measures to be taken to upgrade the research activities. A detail scientometric analysis of remote sensing research

performance of India and its comparison with other countries is very important to obtain a clear picture and to take necessary measures to upgrade the research performance. It is important to evaluate the research performance of major research institutes of the country and to compare their performance among themselves and similar institutes of other countries.

The maximum number of documents 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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