The Growth of GIS and Remote Sensing Research Publications of Indian Scientists during the period 1991 to 2014:

A Bibliometric Study

A Thesis Submitted to The Sardar Patel University For the Award of the Degree of

Doctor of Philosophy

in

Library and Information Science

Submitted by

Pragya Pandey

(Reg. No. 1564)

Under the Supervision of

Prof. Urmila A. Thaker

Former Professor and Head, DLIS, Sardar Patel University and Emeritus Professor, UGC, India

P.G. Department of Library and Information Science Sardar Patel University, Vallabh Vidyanagar – 388120, Gujarat, India March 2019

Certificate Of Originality

Certified that the work incorporated in this Thesis entitled "The Growth of GIS and Remote Sensing Research Publications of Indian Scientists during the period 1991 to 2014: A Bibliometric Study" submitted by me comprises the result of independent and original investigations that I carried out.

The materials obtained from other sources and used in the thesis have been acknowledged appropriately. The work contained in this thesis has not been submitted for the award of any other degree/diploma anywhere.

Name of the Research Scholar: Pragya Pandey Signature: Pragge landey

Place: Ahmedabad

Registration No: 1564

19.03.2019 Date:

Date of registration: 29.03.2012

Certified that the work mentioned above was carried out under my guidance.

19.03.2019 Prof. Urmila A. Thaker

Name and Signature of the Guide:

Place: Vallabh Vidyanagar

Former Professor and Head, DLIS, SP University and Emeritus Professor,

UGC, India

Institutional Address: Sardar Patel

University, Vallabh Vidyanagar.

Date:

Forwarded through the Head/ Chairperson DRACS

A8.00

I/C. Head Dept. of Library & Information Science Sardar Patel University Vallabh Vidyanagar-388 120

Acknowledgements

Writing acknowledgments for a Ph.D. Thesis, is an emotional flash-back into the past, remembering all those people who have been a part of this memorable journey. Before I put on record the names of people who have been a part of this most cherishing journey, I would like to pay my heartfelt gratitude to the almighty God, who blessed me with a beautiful life and family. I will remain eternally thankful to my parents for bringing up an-only "girl child' like a princess within their limited means. They taught me to be a self- respecting, confident, kind and successful person, I am a proud daughter of my parents and their upbringing has made what I cherish the most.

To commence with, I would like to place on record my heartfelt gratitude to my PhD supervisor Prof. Urmila Thaker, Former Professor and Head, Department of Library and Information Science, Sardar Patel University who guided me throughout, without even once doubting me, even in times when I was not sure of my capabilities. Her able supervision, continuous scholarly inputs, ever-approachable nature, and immense patience kept me going. I am thankful for all her inputs, suggestions and discussions. I will forever be indebted for her very kind support, it's because of her that I have been able to carry out this work successfully.

I am immensely thankful to the Head of the Department, Dr. Nimesh Oza, without whose support this thesis would have been a far-fetched dream. He went out of the way and provided all necessary help required for fulfillment of the requirements for this submission. I am also grateful to Dr. Shishir Mandalia, I/C Librarian, SPU, Dr. Lavji Zala, Assistant Professor, DLIS, SPU and Dr. Jignesh Makwana, Assistant Professor, DLIS, SPU for their inputs and support.

In addition, I am grateful to all the office bearers in the Dept. of Library & Information Science, Academic Section, library and other departments of the SPU whose prompt support and action helped me in the glitches during the course of study.

Coming to my host Institution - Physical Research Laboratory, Ahmedabad I am immensely thankful to Prof. J.N. Goswami, former Director, PRL who permitted me to follow my dreams by providing necessary administrative clearances for pursuing PhD at SPU. I am also thankful to Dr. Anil Bhardwaj, the present Director, PRL for his continuous motivational insights. I owe my heartfelt gratitude to Prof. Srubabati Goswami, who taught me how to pave path through difficult times, how to multi-task the many roles in my life and above all to always be upright and kind. Dr. Bhushit Vaishnav, Head, Academic Services, PRL needs special mention, as working with him nurtured some very fruitful skills on carrying out research in general, data collection and statistical analysis. I am also grateful for Mr. Dinesh Mehta's meaningful discussions on technical topics. I thank all the administrative sections at PRL for their support and especially the library and the computer center for its services and approachability.

On the professional front, I heartily thank Dr. Kruti Trivedi and Mr. Hitesh Solanki of the INFLIBNET Centre, Gandhinagar for their very insightful sessions on "Rstudio", which helped me to make some very interesting plots for my study.

ii

It's a saying that friends are the biggest assets in life and I am blessed to have a group of such proud relationships, it's hard to express in words my thankfulness to my dearest friends Alam, Sunita, Mukesh, Poonam (Deo and Gangani), Priyanka, Sneha and Surabhi whose presence make life worth living. I would also like to mention my gratitude for Tanmoy, Anjali, Dhara, Kamlesh, Salman, Harsh, Deepali, Bijal, Remya, Shahzuma, Nida, Jeel, Ashwini and Sweta. It is certainly my friends' blessings, affection and patience that even in my lowest times, I could never lose hope. Thank you all for being with me always, without fail.

And at last, but certainly not the least, as they say behind every successful man is a woman, I put on record that behind me it's my husband who has never failed me, never doubted my abilities and always stood by me in all ups and downs. His untiring efforts on the home front, with a young child to look after, without any complains, patiently handling all the stuff is praiseworthy. Also, academically, his time to time scholarly discussions are worth mentioning especially the pain he took to proofread my thesis. I sincerely thank him for all he has been doing for me all these years without once mentioning it.

And before signing off this section, I would like to mention my Nani and my son, both of them who are so close to my heart that words will never suffice to express my love for them.... so, here I dedicate this thesis to them.

Warm regards,

Pragya Pandey

Table of Contents

20-73

Certificate of Originality	i
Acknowledgement	ii
Table of Contents	v
List of Charts	viii
List of Graphs	ix
List of Tables	Х
List of Abbreviations and Acronyms	xi

Chapter I: Introduction 1-19

1.1	Concept of GIS and Remote Sensing	1
1.2	Bibliometrics	8
1.3	Statement of the Problem	9
1.4	Objectives of the Study	10
1.5	Significance of the Study	11
1.6	Scope and Limitations of the Study	12
1.7	Concepts used in the Study	12
1.8	Organisation of the Report	16
1.9	Summary	17
1.10	References	18

Chapter II: Literature Review

2.1	Introduction	20
2.2	Literature Reviews on Bibliometrics Studies	20
2.3	Summary	53
2.4	References	54

Chapte	r III: Research Methodology	74-79
3.1	Introduction	74
3.2	Research Method	74
3.3	Database and Scope	76
3.4	Search Strategy	76
3.5	Data Sorting Procedure	77
3.6	Data Analysis	78
3.7	Summary	78
3.8	References	79

Chapter	IV: Data Analysis and Interpretation	80-127
4.1	Introduction	80
4.2	Geographical Information System (GIS)	81
4.2.1	Publication Counts	81
4.2.2	Publication type	83
4.2.3	Publication Growth Pattern	83
4.2.4	Growth Trend	85
4.2.5	Scholarly Impact	86
4.2.6	Citation Impact of Source Documents	86
4.2.7	Publication Vs Citation Pattern	87
4.2.8	Subject wise distribution of publications	88
4.2.9	Top WoS Subject categories and their	89
	citation impact	
4.2.10	Top Institutions	90
4.2.11	Top Journals	91
4.2.12	Top Authors	92
4.2.13	Top Cited Publication	94
4.2.14	Collaboration and Network Mapping	95
4.1.15	Keyword Analysis	102

4.3	Remote Sensing (RS)	105
4.3.1	Publication Counts	105
4.3.2	Publication Type	107
4.3.3	Publication Growth Pattern	107
4.3.4	Growth Trend	109
4.3.5	Scholarly Impact	109
4.3.6	Citation Impact of Source Documents	110
4.3.7	Publication Vs Citation Pattern	111
4.3.8	Subject wise distribution of publications	111
4.3.9	Top WoS Subject categories and their	112
	citation impact	
4.3.10	Top Institutions	114
4.3.11	Top Journals	115
4.3.12	Top Authors	116
4.3.13	Top Cited Publication	117
4.3.14	Collaboration and Network Mapping	119
4.3.15	Keyword Analysis	123
4.4	Summary	126
4.5	References	127
Chapter ⁷	V: Findings and Suggestions	128-137
5.1	Introduction	128
5.2	Findings	128
5.3	Conclusion and Suggestions	134
5.4	Future Work	136
Bibliogra	phy	137

List of Charts

Chart No.	Chart Caption	Page No.
	Distribution of research among types of decuments	
4.2.2	in GIS	83
	Distribution of research among types of documents	
4.3.2	in RS	107
4.3.15	Top Author Keywords in RS	123

List of Graphs

Graph No.	Table Caption	Page No.
4.2.3	Growth of Publications in GIS	84
4.2.4	Growth trend of GIS research in India during 1991-2014	85
4.2.7	Publication vs Citations in GIS	87
4.2.8	Comparison of Growth trends of the top productive subject categories in GIS	88
4.2.14(a)	Reference Co-citation Network in GIS	98
4.2.14(b)	Country-wise Coupling in GIS	99
4.2.14(c)	Author collaboration Network in GIS	100
4.2.14(d)	Visualization of Institutional Collaboration in GIS	101
4.2.15(a)	Evolution of top author keywords in GIS Research	103
4.2.15(b)	Major Cluster of Keyword occurrence in GIS	104
4.3.3	Growth of Publications in RS	108
4.3.4	Growth trend of RS	109
4.3.7	Publication vs Citations Pattern of RS	111
4.3.8	Comparison of Growth trends of the top productive subject categories in RS	112
4.3.14(a)	Reference Co-citation Network in GIS	121
4.3.14(b)	Network of major institutional collaborations in RS	122
4.3.15(a)	Evolution of top author keyword in RS Research	124
4.3.15(b)	Conceptual Structural Map of RS	125

List of Tables

Table No.	Title	Page No.
4.2	Publication details of GIS	81
4.2.1	Publication counts per year in GIS	82
4.2.5	Scholarly impact of GIS	86
4.2.6	Citation rates across different document types in GIS	86
4.2.9	Top WoS Subject categories and their research impact in GIS	89
4.2.10	Top Institutions and their research impact in GIS	90
4.2.11	Top journals and their research impact in GIS	91
4.2.12(a)	Top authors and their research impact in GIS	92
4.2.12(b)	Authors listed in order of Dominance Factor in GIS	93
4.2.13	Top cited papers in GIS	94
4.2.14	Country wise collaboration of GIS	96
4.2.15(a)	Top Author Keywords	102
4.2. 15(b)	Top Keyword Plus as per WoS	103
4.3	Publication details of RS	105
4.3.1	Publication count per year in RS	106
4.3.5	Scholarly impact of RS	110
4.3.6	Citation rates across different document types in RS	110
4.3.9	Top WoS Subject categories and their research impact in RS	113
4.3.10	Top Institutions and their research impact in RS	114
4.3.11	Top journals and their research impact in RS	115
4.3.12(a)	Top authors and their research impact in RS	116
4.3.12(b)	Authors listed in order of Dominance Factor in RS	117
4.3.13	Top cited papers in RS	118
4.3.14	Country wise collaboration in RS	120
4.3.15	Top Keyword Plus as per WoS in RS	124

List of Abbreviations and Acronyms

Term	Full form
GIS	Geographical Information System
RS	Remote Sensing
ISRO	Indian Space Research Organization
DOS	Department of Space
CAGR	Compound Annual Growth Rate
AAGR	Average Annual Growth Rate

1.1 Concept of GIS and Remote Sensing:

Life on earth evolved from a single cell; magically we see a magnitude of flora and fauna in the universe today. It is also seen that during the evolution of mankind, innumerable transformations took place and we stand today as one of the most reformed versions of human beings not only physically but also in terms of intelligence and might. This evolution took billions of years, unmeasurable hard work, unquantifiable research and irreversible development. In totality it can be said that the knowledge which resides today in the minds of the human beings is a product of years of untiring research work. Continents and Countries which are able to achieve higher levels of societal and scientific independence and fulfillment are more advanced and developed today and those which are struggling with other socio-economic factors are in the developing state. Research is a field that itself has metamorphosed in the most complex manner and those countries which are developing need more research and development to cope up with the third world countries. In such a scenario, research is one of the important pillars for transforming Developing countries into the Developed ones.

India as a nation has seen a sea of change in its research activities since independence and today stands proudly with diverse areas of significant research activities going on in all the fields of science, technology, social science and humanities. With its maiden forays into the fields of space, medicine, technology etc., India has been continuously moving ahead on the path of development with the aid of its research and development activities. It is evident that all the areas of research are equally important for the whole nation to move, but it is also equally true that application-based research helps the countries to take giant leaps. Two such fields **Geographical Information System (GIS) and Remote Sensing (RS)** have brought about immense change in our nation's development and that too in a comparatively short span of time. Governments have invested funds and the crop of research in these fields is giving good fruits, but there is always a need for assessment of the yield, its quality, quantity, the efforts made, the time invested and the manpower involved. This study is one such attempt to assess the yield and growth of GIS and Remote Sensing research in India.

GIS:

GIS is a computerized Database system for capturing, storage, retrieval, analysis and display of spatial data, it can be understood as a component of Resource management system which requires to analyse phenomena processes and their interaction throughout space and time. Geographic Information System (GIS) offers capabilities which integrate multisector, multilevel and multiperiod database. GIS is a generalpurpose technology for handling geographic data in digital form, and satisfying the following specific needs, among others.

- The ability to pre-process data from large stores into a form suitable for analysis, including operations such as reformatting, change of projection, resampling and generalization.
- Direct support for analysis and modeling such that, form of analysis, calibrations of models, forecasting and prediction are all handled through instructions to the GIS.
- Post processing of results, including such operations as reformatting, tabulation report generation and mapping.

The key activities can be enhanced through the use of information systems technologies through the use of a GIS. Four M's describe the function of a GIS system: Measurement Mapping, Monitoring and Modelling.

GIS is a convergence of technological fields and traditional disciplines GIS has been called as "enabling technology" because of the potential it offers for the wide variety of disciplines which must deal with spatial data. Many related fields of study provide techniques which make up GIS. Many of these related fields emphasize on data collection and GIS brings them together by emphasizing on integration, modelling and analysis of this data. Thus, GIS often claims to be the science of spatial information. The fields primarily falling in this category are Geography, Cartography, Remote Sensing, Surveying and Photogrammetry, Computer Sciences, Mathematics and Statistics,

Geographic Information System (GIS Software) is designed to store, retrieve, manage, display and analyze different types of geographic and spatial data, which allows users to produce maps and other graphic displays of geographic information for analysis and presentation and thus serves as a valuable tool to visualize spatial data and/or to build decision support systems for further use in any organization or research bodies. GIS stores data in geographical features and their characteristics; these features are typically classified as points, lines or areas, or as raster images. GIS stores information using spatial indices that makes it possible to identify the features located in any arbitrary region of a map (Ministry of Electronic and Information Technology. Government of India, 2017).

GIS in Indian context:

India has long been a leader in using modern spatial technologies and started its tryst with satellite images and GIS in the 1980s by having its own Indian Remote Sensing satellites and image-based mapping and creating GIS databases and applications. In the early 2000s, it took steps toward designing a National Spatial Data Infrastructure. With a large talent pool and many veterans providing the vision, leadership, and drive, now a national movement has taken shape in India's next-generation GIS program-National GIS. Moving away from looking at GIS as just a mapping or database tool or as scientific software, India recognized that the true power of GIS can be realized only when it reaches the hands of the governed—those who can demand efficiency of governance/development and transparency in democratic action. "India is at the cusp of another technological and development curve, and in its drive for inclusive growth, social equity, and development, a major requirement would be to re-engineer many systems and processes. Information will be the fourth pillar of democracy, and GIS will be that important element of the fourth pillar—helping in the concept of unified information infrastructures. National GIS is envisaged not just to provide GIS data and GIS applications but serve as a platform for a host of e-services to every citizenbe they in urban or rural areas-and thereby leading India into inclusive growth and prosperity, expediting development, reducing disparity, and bringing rich Demographic dividends (ESRI, 2014).

Remote Sensing (RS) is defined as the science of techniques of getting about an object without coming in its physical contact. The basis of the remote sensing is the electromagnetic radiations or light which gives the information about the characteristics of the radiation and interaction with the object. Internal structure of the object and reflectance/emittance of the radiations induce a particular signature or characteristics of the object which helps in identifying the particular object. Every object has its own signature i.e. reflectance properties. Like different minerals, rock, soils, plant, etc. have their own reflectance which helps in identifying that particular

4

object. There are two types of satellites- remote sensing/sun-synchronous and geostationary satellites. The satellites which orbit from North Pole to South Pole are called remote sensing satellites and these satellites are used for mapping of natural resources and helps in other applications. As these satellites orbit from North Pole to South Pole, these view the whole earth and helps in monitoring the whole earth either for natural resources mapping or disaster monitoring. Remote Sensing can be understood as sensing of earth's surface from space by making use of the properties of electromagnetic wave emitted, reflected or diffracted by the sensed objects, for the purpose of improving natural resource management, land use and the protection of the environment.

Background:

Man has always tried to reach greater heights – treetops, mountains, platforms and so on-to observe phenomenon of interest, to decide habitable places, farming and such other day to day activities. This inquisitiveness to get a "bird's eye" view prompted man to take photographs of earth from elevated platforms. Balloons are the first elevated platforms used for photography in 1958 by the French Gaspard Felix Tournachon to photograph the village of Petil Bectre near Paris. Modern imaging concepts from up above mainly started as a military recognizance tool, during the American Civil war. Balloons are used to photograph enemy positions from the civil war until the 1st world war people experimented with other platforms such as kites and pigeons. The invention of the aeroplane in 1903 was a great step forward to having a stable platform for photography the 1st aerial photography from a plane was made by Wilbur Wright in Italy 1909. With the advent of the 2nd World War capabilities of Remote Sensing are pushed beyond visible Spectrum photography into infra and radar system.

The beginning of Space based Remote Sensing can be dated back to 1891 when Germans were developing Rocket propelled cameras system, and by 1907 Gyro stabilization had been added to improve picture quality in less than two years after the 1^{st} man made satellite SPUTNIK – 1 (4th October 1957) was launched. United States Explorer 6 in August 1959 transmitted the 1^{st} picture of earth to be ever taken from a satellite. However Systematic earth observation from the Space started with the launch of television infra-red observation satellite (TRIOS – 1) in April 1960, designed primarily for meteorological observations.

The term Remote Sensing was used by Evelyn L Pruitt, a geographer formerly with the office of Naval research to replace the more limiting term "aerial" and "photograph", In 1962, the Institute of Science & Technology, University of Michigan, organized the 1st symposium on Remote Sensing of the Environment, from that day civilian remote sensing of a discipline began to come up. The 1st multispectral photography from Space, from the Apollo 9 mission in 1968 using four Hassel bled cameras with different film filter combinations and bore sighted to see the same area.

A quantum jump, in the capability of imaging from Space was a launch IKONOS on Sept 24, 1999, which has a one-meter resolution pan chromatic and a four-meter m resolution in multi-spectral thus the spatial resolution capability of civilian satellite on approaching the needs of Military. The USA, France and India have planned a series of satellites with improved capability so that the users are assured continuity of data (Joseph, 2003).

Indian Remote Sensing Programme:

Indian Space effort had its modest beginning in 1962, with the establishment of rocket launching station at a place in the southern part of India through which the geo-

magnetic equator passes. Subsequently the Department of Space (DOS) was established by the Govt. of India in 1972 to promote the development and application of GIS and RS and Technology for identifying national socio-economic objectives the Space Commission which is the apex body of decision making on National Space Programs and Policies lays down the framework of important space activities and advises the Govt. on major policies and programs of Space activities. DOS functions directly under the Prime Minister of India. The Space Technology and Applications, activities are carried out through the constituent units of Indian Space Research Organization (ISRO) and the autonomous institutions established for specific programs. India's tryst with a remote sensing program started in 1972 when ISRO created the Space Applications Centre (SAC) that housed a Remote Sensing Meteorology Division (RSMD). In 1975, the National Remote Sensing Agency (NRSA) was established for operationalizing remote sensing activities (Dayasindhua and Chandrashekar, 2005)

Integration of Remote Sensing and GIS:

Remote Sensing can be readily merged with other sources of geocoded information in a GIS. This permits the overlapping of several layers of information with the remotely sensed data, and the application of a virtually unlimited number of forms of data analysis. On the one hand, the data in a GIS might be used to aid in image classification, on the other hand, the land cover data generated by a classification might be used in subsequent queries and manipulations of the GIS database. Remotely sensed data is almost always processed and stored in raster data structures. When working simultaneously with an image processing system and raster GIS, it is usually easy to move data between the two, Typically, a single theme of information is extracted from the remotely sensed data. The most common application of this combination is the landcover mapping. In addition to aerial photographs, it also provides a synoptic view of the surface features. Due to its repeatability and scope of Manipulation, it has an edge over the photographs.

Applications of GIS & RS:

It is seen that even after years of researches the practical use of GIS has become possible only a few years back due to the advances in the hardware and software faculties.

In general GIS and RS applications include:

- Street network-based applications: Vehicle Routing and Scheduling, Location Analysis-site Selection and evacuation plans.
- Natural resource-based applications: Management of wild and scenic rivers, recreation resources, flood plains, wet lands, agricultural lands, aquifers, forests, wild life etc. Environmental Impact Analysis. Viewshed Analysis, Hazardous or toxic facility sitting, Ground water modelling and contamination tracking, wildlife habitat analysis, migration routes planning.
- Land parcel-based applications: Zoning, sub-division plan review, environmental monitoring, modelling and assessment, settlement and infrastructure planning, soils, water resources, market analysis, geodemographics, landscape ecology, cartography, forestry and more. These methods are also used for disease studies by identifying areas of prevalence and rate of disease spread and for wildlife protection initiatives. (Cowen, n.d).

1.2 Bibliometrics:

Bibliometrics is the statistical Analysis of Bibliometric data, mainly in scientific and technical literatures. Pritchard in 1969, defined bibliometrics as "the application of

statistical and mathematical methods to books and other media of communication". In simple terms it can be said that it measures the amount of scientific activity in a subject category, journal, country, topic of other area of interest. Bibliometrics uses the main tool of science, quantitative analysis, on itself, there are various definitions used for "bibliometrics". Essentially, bibliometrics is the application of quantitative analysis and statistics to publications such as journal articles and their accompanying citation counts. The bibliometric tools provide a set of measurement tools to objectively analyse the growth of a discipline. There are two types of such techniques: publication analysis and citation analysis. Publication analysis focuses on the various aspects of creation and dissemination of the literature in a given field, whereas citation analysis focuses on the literature used by researchers in a given field. There are three basic techniques that are used for citation analysis: direct citation counts, bibliographical coupling and co-citation analysis. In this study, only direct citation counts have been used. It determines how many citations a certain document, author, journal, etc. has received over a period of time (Fayland, 2008; Olijnyk, 2014; Reid, 1983).

1.3 Statement of the Problem

It is seen the Government authorities or the Top-Level Management draw conclusion on their scientific priorities on the basis of the Scientific output of the Nation. Wealth creation in a nation and its dispersal depends upon the research capacity of that nation on whole. Determining the innovative activities in order to understand the role of scientists and researchers in the development of a country is a crucial aspect of the said wealth creation. They are the potential wealth creators in any organization or a country, thus giving rise to the need of evaluation of their research activities and their direction or trends. The scientific output indicates towards the innovation, inventions, technologies and research. The scientific output can be very well utilized to find out the diffusion of knowledge across the areas, countries, sectors and firms.

The fields of RS and GIS have evolved a great deal and have become independent fields of research in last two decades. Evaluation of these fields have become necessity of the hour, though there is a huge amount of literature in bibliometrics that has been published and there have been studies where evaluation has been undertaken at the global level, but there is no such study in Indian context that has identified how these areas of research have developed over the course of time and where does India stand in these fields of research..

In order to determine and illustrate the growth of the GIS and RS research in India this study has been carried out. It depicts the growth of GIS and RS literature in India written in English from 1991 to 2014. The study is entitled as "The Growth of GIS and Remote Sensing Research Publications of Indian Scientists during the period 1991 to 2014: A Bibliometric Study". Precisely the statement of the problem is to find out the yield of the GIS and Remote Sensing Research Publications of Indian Scientists during the period 1991 to 2014 by using bibliometric tools and techniques.

1.4 Objectives of the Study

- To measure the growth of GIS and Remote Sensing research during the period of study.
- To determine the Growth trend of research in these fields during the period of study.
- > To evaluate the research performance using citation data.
- \blacktriangleright To find out the core institutions devoted to the research.
- > To find out the core journals of the field.

- \blacktriangleright To determine top authors for the period of study
- > To find out top most cited publications of this period.
- > To find out the collaboration pattern with other countries
- To analyze the distribution of Author keywords and find out the major focused areas of research

1.5 Significance of the Study

The research activities generate revenues and revenues in-turn facilitate research. It is important for every country and the country men to understand that the research achievements are extremely vital in determining its development and influences the wealth creation and its distribution. India is a country of large population and limited finances, in such a scenario allocation of funds to the fittest, in the right proportion at the right time in the rightest way is of utmost importance. Hence, the science policy makers have a few questions before them like why the funds should be allocated to science, what are its benefits and how to select the fittest field for allocation of funds. In order to answer these questions, studies on bibliometrics and scientometrics come to aid. These studies evaluate the performance of scientists and researchers, institutions and countries to map the growth of the scientific output. Also, such studies are required to find out the gaps in research or the improvements needed in future for promotion of research activities and disbursement of funds to various projects. Owing to these reasons, the evaluation of Remote Sensing and GIS research in India needs to be evaluated. This study will enable the policy makers, researchers and library professionals us to get a better understanding of the characteristics of the literature on Remote Sensing and GIS research in India. It gives an indication of the kinds of resources used in the literature of Remote Sensing and GIS. This study reveals those aspects of RS and GIS which have never been investigated from the point of view of quantitative and qualitative assessment in Indian context.

1.6 Scope and Limitations of the study

The Web of Science (WoS) database has been chosen to carry out the study. This research work primarily focuses on research publications, published in English language (Scholarly Articles only) in the fields of GIS and Remote Sensing published by Indian Scientists during the period 1991 to 2014. Here, 2014 has been taken as the cutoff year considering the fact that almost all the papers published till 2014, would have been indexed in the WoS database by the time when the data got collected in 2015. This time constraint is imposed to make it sure that no article gets missed upon from inclusion in the data set. APA 6th edition for referencing style has been used in the study.

1.7 Concepts Used in the study:

Bibliometric indicators: "Indicator: Signal that reveals progress (or lack thereof) towards objectives; means of measuring what actually happens against what has been planned in terms of quantity, quality and timeliness. An indicator is a quantitative or qualitative variable that provides a simple and reliable basis for assessing achievement, change or performance.". Bibliometric indicators help us to understand the nuances of research performance in a given field. Bibliometric indicators are of three types viz. quantitative indicators, those which measure the productivity of a field, author, country or Institution in numerical quantities; qualitative indicators, which are used for measurement of the performance of a field, author, country or Institution for e.g. The citation counts; and structural indicators, which are useful in

identifying the relations and connections between the publications, authors, and areas of research. For e.g. The network relationships among the entities of research Many concepts and techniques have been used in the study to reach the final results. Such terms are explained in this section:

- **Publication Counts**: It is the number of publications to an author's/Institutions/Subject's credit. It is a crucial parameter which is used to assess the productivity of any author etc. This parameter is used to investigate the research output of various entities. Traditionally speaking, authors etc. with maximum number of papers to their credit will be regarded as researchers of high acclaim and more successful or experienced.
- **Citation Counts**: While the total number of publications metric may depict a researcher's efficiency or yield, it does not signify the actual influence or impact of those publications. The citation count metric represents the number of citations a publication has received and measures citations for either individual publications or sets of publications. Citation counts are regarded as an indicator of the global impact and influence of the author's research, i.e., the degree to which it has been useful to other researchers. The number of citations a scientific paper receives may depend on its subject and quality of research. Based on this assumption, citations have been used to measure and evaluate various aspects of scholarly work and research products. With the citation counts metric, the underlying assumption is that the number of times a publication has been cited by other researchers reflects the influence or impact of a specific publication on subsequent articles within the wider academic literature in a research area. Citation counts are widely used to evaluate and compare researchers, departments, and research institutions (Durieux and Gevenois, 2010).

• **Growth of Scientific publications**: Research publications are the most suitable sources to evaluate the growth rates of science. These publications contain the scientific explanations of the research being carried out and they are in turn used to carry out further research, this chain is never ending thus the growth rates facilitate the idea of finding of amount of growth of research in a given period.

• Annual Growth Rate:

Current Total - Previous Total

AGR = -----*100 / Number of Years

Previous Total

• Average Annual Growth Rate:

(Growth Rate in Period A + Growth Rate in Period B + Growth Rate in

Period C + ...Growth Rate in Period X)

AAGR = -----

Number of Periods

• Compound Annual Growth Rate (CAGR)

CAGR is frequently used in business presentations and reports to demonstrate how a particular part of the business has grown over time. CAGR takes growth rates from multiple periods and translates them into consistent growth rate which represents the same growth. This growth is measured for the publication as well (Defmacro Software, 2019).

• Average Citations Per Article (AvgCPA): The average number of citations per year is calculated by dividing the total number of citations by the number of years

the author or journal has been publishing papers. This can be a very useful metric to assess the yearly impact for a journal or author.

- h-index: It is a well understood fact that the citations are considered as the yardstick of measuring quality, with the presumption that researchers will certainly refer to an article if something important has been reported by an author in his published work. Here, a very important tool comes into play that is called the h-index, which is regarded as the measurement of an authors' work's quality or his performance. In simple words it is said that H-Index is a numerical indicator of how productive and influential a researcher is. It was invented by Jorge Hirsch in 2005, a physicist at the University of California. In mathematical expressions h-index of an author is 10 if, she has at least 10 publications, with 10 citations each. This means that the author has 10 papers which are so important in their findings that they have been referred by 10 more authors.
- Collaboration and network analysis: The collaborative research and resultant publications determine the amount of information and ideas exchange, the trends prevailing among the researchers while collaborating with any particular institution or country depict the research inclination and thereby quality as well (in case of collaborations with the developed countries etc.) Network analysis is the visual depiction of the various collaborative trends among the authors, institutions or countries. It can be defined as "a set of research procedures used to identify structures in social systems based on the relations among the system's components (nodes) rather than the attributes of individual cases" Barnett, 2001, p. 1640). It can be used to analyse the structure of communication in an organization, and the international monetary,

telecommunication and trade networks (Barnett and Danowski, 1992; Barnett and Salisbury, 1996).

• **Keywords Analysis:** The keywords assigned to the publications makes it possible to study the core areas of research and the gaps as well by locating the lesser used keywords. Such analysis is important in identifying the trend of research and growth of subjects.

1.8 Organization of the Report

Chapter I provides the background framework of this study. The chapter introduces the subjects of research i.e. GIS and Remote Sensing. The historical background of these fields is discussed on the global level and then in India. The chapter introduces Bibliometrics as a tool to analyse literature and science. It further declares the Statement of the Problem; the objectives of the study and its significance. It also briefly introduces the various terms which will be frequently dealt with in the study and the organization of the thesis followed by the summary of the chapter. Chapter II reviews the literature related to this study. The chapter presents a panorama of articles on diverse fields, topics and areas. The length and breadth of the works ranges from narrow subjects to broader topics, from colleges to universities and even international institutions, the chapter concludes with a summary of the reviewed literature.

Chapter III: discusses the research methodology used in this study. The chapter elaborates upon the steps involved in the research process undertaken for this study. This is followed by a description of the Database used for collection of data and the search strategy used therein. The chapter concludes with the description of data analysis and a summary of the chapter. Chapter IV consists of the data analysis and interpretation. Data analysis pertaining to growth model, growth pattern, publication counts, type of documents, top journals, institutions, authors, keywords, collaboration pattern, network visualization etc. have been discussed in detail for both the fields under study. It also portrays the data in form of tables, charts, figures and graphs with interpretations.

Chapter V is on findings and suggestions of the study. It summarizes all the findings of the study in accordance with the objectives narrated at the beginning of the study. It also gives an insight into the future work that can be carried out based on this study.

1.9 Summary:

This chapter is a stepping stone for this research work. It commences with the conceptual framework of the subjects under study i.e. GIS and Remote Sensing, followed by the background on the development of these fields at global and Indian levels respectively. The chapter also discusses about how these two fields are inter linked and dependent and yet aloof, their application to other fields and areas of science and technology. At a later stage the chapter also discusses about the Bibliometrics-the technique used to study the growth of GIS and Remote Sensing in India. Statement of the problem is discussed, followed by the significance, scope and limitations of the research work. The chapter ends with a section on report organization.

1.10 References

- Cowen, n.d. UNIT 1 WHAT IS GIS?. Retrieved from http://www.geo.upm.es/postgrado/CarlosLopez/materiales/cursos/NCGIA_cor e/u01.html
- Dayasindhua, N and Chandrashekar,S. (2005) Indian Remote sensing program: A national system for innovation? Technological Forecasting & Social Change, 72,pp. 287–299.
- Defmacro Software. (2019). Cleartax. Retrived from https://cleartax.in/s/what-is-cagrand-how-is-it-useful
- DefinitionofRSsystem,Retrievedfromhttps://www.researchgate.net/figure/226519231_fig1_Figure-1-Requirements-https://www.researchgate.net/figure/226519231_fig1_Figure-1-Requirements-
- Definition of GIS. Retrieved from https://www.gisresources.com/wpcontent/uploads/2013/09/BB1v1_ch1.pdf
- Durieux and Gevenois. (2010). Bibliometric indicators: quality measurements of scientific publication. Radiology. 255(2), pp.342-51. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/20413749.
- ESRI. (2014). India: A Vision for National GIS.Retrieved from https://www.esri.com/library/ebooks/india-a-vision-for-national-gis.pdf
- Fayland, M. J. (2008). Mapping the Literature: A Bibliometric Analysis of Evidence Based Practice Literature in English Language Nursing Journals (Doctoral dissertation).Retrieved from ProQuest Dissertations and Theses database.

- George, J. Fundamentals of Remote Sensing. (2003). University Press. India. PP. 102-145.
- Ministry of Electronic and Information Technology. Government of India. (2017). National Centre of Geo-Informatics. Retrieved from https://ncog.gov.in/
- Olijnyk, N. V. (2014). Information Security: A Scientometric Study of the Profile, Structure, and Dynamics of an Emerging Scholarly Specialty (Doctoral dissertation). Retrieved from ProQuest Dissertations and Theses database.
- Reid, E. F. 1983. An Analysis of Terrorism Literature: A Bibliometric and Content Analysis Study. Retrieved from http://digitallibrary.usc.edu/cdm/ref/collection/p15799coll30/id/364475
- VandenBos, G.R. (Ed). (2010). Publication manual of the American Psychological Association (6th ed.), Washington, DC:A American Psychological Association

2.1. Introduction:

Information explosion that started about half a century ago continues unabated. In most fields of science and technology, the literary output is doubling in less than ten years, in some fields even in less than five years. The literature in any field being produced is unfortunately scattered across the world in thousands of journals, conference documents, technical reports, theses and dissertations, and so on in more than sixty languages. Getting hold of the literature in any field has become an impossible task for an individual. To overcome this problem abstracting and indexing services have evolved. With these the problem of scatter has just reduced to a certain extent, but not eliminated. As an effective answer to the literature produced in the world on a narrow topic in various languages during a certain period and provide a summary of the same. In reality a review condenses, analyses, interprets, synthesizes, and evaluates, and thereby converts a huge mass of information into a usable piece of knowledge.

2.2 Literature Reviews on Bibliometrics Studies

The purpose of this review of literature is to offer an overview of the extent literature. The extent literature offers a variety of research productivity studies in all recognized disciplines that presents their findings in terms of four distinct categories or approaches, Discipline based studies, Institution based studies, Periodicals based studies and Author based studies This bibliometric investigation explores the phenomenon by drawing research output data from numerous outlets such as journals and conferences.

Discipline/Subject Based Studies:

Computer Science:

The field of computer science has almost changed manifolds over time, yet just one Bibliometric study has been recorded from India in this field. Kumar and Garg (2005) have analyzed 2058 papers published by Chinese authors and 2678 papers published by Indian authors in the field of computer science during 1971-2000 which indicates that India's output is significantly higher than the Chinese output. The study reveals the preference of Chinese researchers to publish their research results in domestic journals and that of Indian researchers to publish their research results in journals published in the advanced countries of the West. The authors have tried to analyze the share of papers in journals covered by SCI for India and China. However, the study also discusses that no significant difference has been observed in the impact of the research output of the two countries as seen by different impact indicators.

Library & Information Science:

Seven articles belonging to this field have been recorded. Dhiman (2011) has conducted a bibliometric study on the research output in LIS by taking into consideration the PhDs awarded in India during 2006–2010. This study discusses about the research in the field of LIS in India at the Doctoral level. This paper attempts to quantify the research contribution made by LIS students in the LIS research area based on the University News data. Pradhan and Chandrakar (2011) in their work have discussed about the Indian contribution in LIS in the International journals indexed in the SSCI database. The Social Science Citation Index in Web of

Science indexes 80 International LIS electronic journals published worldwide. This study shows a quantitative view of the growth of Indian scholarly literature in the field of Library and Information Science versus the world as a whole and their publishing trends by analyzing different aspects like authors, sources, references, and countries etc. for the period 2000-2009. The data used in this study has been collected from ISI-Web of Science and analyzed quantitatively in order to get an overview of the literature growth per year, the authorship pattern, and other related bibliometric phenomenon. Khan et.al (1998) in their work have presented the results of statistical and bibliometric analysis of the articles published on various aspects of Library and Information Science (LIS), emanating from Bangladesh during the period 1966 to 1997. The study calculated the number of articles, authorship pattern, country wise productivity etc. Mahapatra and Sahoo (2004) in their work studied the trends and areas of research, growth pattern and productivity of universities along with broad and narrow subject areas in the in Library and Information Science discipline during the period 1997-2003. They have presented the analysis of the study with the primary goal of appraising the perspective LIS research community to make them aware of the direction of research. Patra and Chand (2006) have presented a Bibliometric portrait of Library and Information Science research literature emerging from India based on the data abstracted in Library and Information Science Abstracts (LISA). Bradford's law of scattering and Lotka's Law have been applied. Authors have deduced that the productivity pattern is in conformity to Lotka's law. Mittal et.al (2006) analysed 536 papers published on Library and Information Science education during the period 1995 to 2004. The productivity of authors and core periodicals has been determined using Lotka's and Bradford's law. Literature growth, country-wise distribution of papers and language pattern has also been studied. Literature growth in this area of LIS has been found to be negative. Most of the papers have been contributed by single

authors (72.8%) and two authors (20.69%) and 72 % of literature is published in 72 journals. Rajyalakshmi and Deshpande (1997) have conducted a study of 65 dissertations in library and information science, submitted to Nagpur University during the period 1990 to 1994. The study revealed the trends in various aspects of library and information science. In the paper Citation analyses have been carried out to find the types of cited source materials, subject distribution, authorship pattern and chronological distribution of cited references.

Social sciences:

Studies in this field are rare to find, only one such work has been found on social science research. Goel (2008) has examined the social science research in India during the period 1998-2007 using the bibliometric parameters. The CSA database has been used to collect data on randomly selected organizations. This study examines organizations' performance on various measures as publications share in the world research output, research in core Indian and international journals and geographical distribution etc. Economics: Three important studies in this category have been undertaken. Mulla and Chandrashekara (2011) have conducted a bibliometric analysis of the 2253 articles on industry and trade published during 2005. The online database of the Indian science abstracts website is the main source for this study. The study finds out that the average number of Authors conclude that the authorship trend shows that the maximum number of papers have been contributed by the corporate bodies. The degree of collaboration industrial and trade literature has been recorded. India's share has been analyzed. Kannappanavar and Vijaykumar (2001) have reported results of a bibliometric study of investigation of the author patterns involved in the International Monetary Fund (IMF) literature. Authorship data were collected from research activities of the IMF from January 1991 to December 1998, prepared by the

Inter departmental working group of fund policy Advice of the IMF. Sesovan (2008) in his work has analysed the data on Indian patent applications obtained from the annual reports of the Controller General of Patents, Designs and Trademarks.

Basic Sciences:

Mahapatra and Jena (2006) describe the growth of scientific research literature on Orissa published during 1985-2004. The study includes 875 research papers from forty different journals. The paper analyses the data by their authorship pattern, year wise growth, and subject wise break up of papers, category of journals, place of origin, length of papers, and productivity of journals. Arunachalam and Garg (1986) have studied the papers published over a two-year period from the five ASEAN Countries, viz. Indonesia (182), Malaysia (452), the Philippines (241), Singapore (258) and Thailand (447), and covered in Science Citation Index 1979 and 1980; and citations to them in the international literature of science as seen from SCI 1979-1983. The study reveals that despite the relative economic affluence, science in these countries is still on the periphery. Most productive institutions, authors, areas have been identified and the impact analysed. Arunachalam and Garg (1985) have analysed the 258 papers published from Singapore and covered in Science Citation Index (SCI) during 1979 and 1980. They have determined the status of science in Singapore, most prolific area, language used for publication, top institutions etc. Mathematics is one of the most ancient science subjects, the basis of many other disciplines yet this field has not been explored much. Only one study has been found in the current review. Baskaran (2012) has taken up the graph theory from mathematics for analyzing its research growth during 2004–2011. He has used data from web of science and applied bibliometric techniques to examine the relative growth rate and doubling time of publications, institution wise and ranking of authors. In Physics, Girap et.al (2011)
have studied the scientometric dimensions of fuel cell research as reflected in INIS database. They have highlighted the quantitative growth and development of world literature on Fuel Cell publication output as per INIS database from 1970–2008. The study reflects that a great deal of work has been done in the field. The average number of articles, highest number of articles in a year, spurt in literature output, number of countries involved in the research, highest contributing country, all these have been reported in the study. BARC has been reported as the most productive Institution within India. Rajendran et.al (2005) have undertaken a study to analyse the global output of 'Fiber Optics' research. Articles covered in the Ei-Tech Index database covering the period 1999-2003 have been considered for the study. Growth of literature year wise, country wise, authorship pattern, bibliographic forms, ranking of core journals and nature of research has been analyzed. Arunachalam and Singh (1985), in their work have highlighted the prolific institutions and authors in the field of superconductivity in Israel. They have identified the journals most often used, and highly cited papers. Six articles in this field have been found. Maharana et.al. (2011) have conducted a citation analysis of top research papers in chemistry with specific reference to India. They have tried to determine India's position in publishing top research papers in chemistry as reflected in the Science Direct database. The paper describes application of citation analysis methods to study citations of 450 research papers in chemistry taken from the listing of top 25 papers in Science Direct database. Lalitha Kumari (2009) in her work has used scientometric indicators to analyze the organic chemistry research during 1998-2004. She has made a cross national comparison, calculated the absolute citation impact and relative citation impact, concluded that G7 nations are the leaders for the volume of literature published and citations attracted are showing a decreasing trend over the years probably due to shifting and diversification of their research efforts to other emerging research fronts.

Country wise ranking has been identified in her study based on the impact factors. Barooah et.al (1999) in their work conducted a bibliometric analysis on 4253 citations collected from doctoral dissertations submitted to various universities by the S & t workers worked in the area of Organic chemistry during 1977 to 1997. They have found the percentage of citations and the sources thereof and have also calculated the half life of the organic chemistry literature field, which is found to be 27 years. Biradar and Sampath Kumar (2003), in their work have established the obsolescence of literature, Annual Ageing Factor (AAF), Mean Life (ML) and Utility Factor (UF) of periodicals in the field of chemistry. They have conducted this study based on the references appended to the articles published in Indian Journal of Chemical Technology during the year 1994, 1997 and 1999. Kannappanavar et.al (2004) in their study highlight the authorship trend and collaborative research in chemistry in India during 1996-2000. Trends of authorship, degree of collaboration have been calculated. Karki and Garg (1999) have studied the performance of Indian organic chemistry research during the 70s and 80s. The study reveals the significant work and its impact using mainstream connectivity, surrogate measures of quality and relative impact indicators.

Earth Sciences & Geology: Geo-science is one of the important fields for research, five such works have been found. Mahapatra and Das (2000) have studied the nature of growth of literature on geology between 1987-1996. They have examined the type of collaboration among authors and the trend of growth, the degree of collaboration among various categories of authors, correlation of the growth of various categories of authors and the impact of collaboration on the growth of literature. Zhuang et al. (2013) have conducted a Bibliometric analysis of articles related to remote sensing of SCI and SSCI databases during 1991–2010, this study evaluated the geographical

influence of authors by the new index (geographical impact factor), and revealed the auctorial, institutional, national, and spatiotemporal patterns in remote sensing research. Another work on remote sensing has been done by Chhinaraj and Balasubramani (2013). This paper presents a quantitative analysis of remote sensing, in terms of research output throughout the world during 1975 – February' 2010. Tian et al. (2008) have used Bibliometric techniques to find out the global scientific production on GIS research by from 1997 to 2006. The published output analysis showed that GIS research steadily increased over the past 10 years and the annual paper production in 2006 is about three times 1997s paper production. Vijailakshmi and Ambuja have aimed 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.

Life Science/Biology:

Five papers have been noticed on the subject. Garg et.al. (2010) have studied the scientometric profile of Genetics and Heredity Research in India using the data from Science Citation Index during the period 1991-2008. This study shows the peak year of research output, subfield of highest output, most productive countries, lowest impact institution and the highest one too. Sudhier and Dileep (2010) have studied the Doctoral Dissertations in Biochemistry in the University of Kerala, India. In this study they have tried to determine the bibliometric characteristics of the biochemistry research in the University of Kerala, India including subject distribution, bibliographic forms of cited documents, most cited journals and collaboration in authorship, etc. Bala and Gupta (2010) have analyzed the research activities in the fields of Biochemistry, Genetics and Molecular Biology in India for the period 1998-

2007. The study analyses the share of international collaborative papers in India's research output, the characteristics of research output of major Indian institutions, authors, and highly-cited papers. It reveals the country's performance based on its research output, its publication shares and rank in global context, and annual publication growth rate. Mukherjee et.al. (2010) in their work have reviewed the posttsunami ecological research in India and its implications for policy making. ISI database has been used to retrieve data. The study reveals the major areas of research interests. This work points to the gap areas in ecological research in India and highlights the lessons learnt from research in other tsunami-affected countries. It also provides guidance on the links between science and policy that are required for effective coastal zone management. Thanuskodi (2010) in his Bibliometric study has analyzed the research output performance of scientists on Ecology. This study attempted to analyse the performance of scientists working in various institutions in terms of growth rate, areas of research concentration, author productivity and authorship pattern. Botanical sciences /Plant Science has seen six papers Singh et.al (2008) have conducted a bibliometric study of publications on Embelia ribes, a medicinal plant. He has used databases like Pub Med and Medicinal and Aromatic Plants Abstract etc for extraction of papers on the subject. The publications have been analyzed from various point of views like author productivity, core journals etc using bibliometric tools. Balasubramani and Murugan (2011) have studied the publication output on Tapioca, a plant in India using bibliometric techniques. An analysis has been done in terms of publication output as per science citation index database between 1978 and 2010. A quantitative analysis on the countries and organizations that contribute in the field of sago is presented. Similar research has been conducted by Garg et.al. (2011) where they have studied the research in plant genetics and breeding with special reference to India. The study reveals important data on the

institutions involved in research, the highest impact, the trend of author collaborations. Shri Ram (2011) has taken up an important plant herb Artemisia (Artemisia annua) used for curing Malaria and tried to find out the research output in the field. The study reveals that China has produced many papers on the subject and in India, CIMAP is the leading contributor. Another study in botanical sciences has been conducted by Joshi et.al (2010) for studying the scientometric profile of global forest mycology research. The study examines the R&D efforts in the field of forest mycology (study of fungi) with a primary focus on the global trends of publication output and its citation impact for the papers published during 1987-2008. The results indicate the growth of publications during the period of study, top producing countries, etc. Anilkumar and Rani (2005) have discussed about the Indian Botanist's contribution for the period of 1997 – 2001 based upon the data as reflected in the Journal of Indian Botanical society.

Technology:

Garg and Padhi (2000) have undertaken the study of 766 publications of prolific authors in scientific journals indicates that prolific authors produce about 25% of the total scientific output in periodical literature in Laser Science and Technology. The average productivity per author is about 2. Prolific authors from most of the countries belonging to either academic or research institutions except in USA and Japan. Prolific authors on average made more impact than non- prolific authors. However, the situation varied from country to country. Garg (2002) in his study has analyzed 1223 papers published by India (347papers) and China (876papers) at conferences and in journals during 1993 and 1997 in the field of laser S&T. The study reveals the fact that China's output is twice to that of India. However, Activity Indices for both the countries in 1993 and 1997 were almost the same. Surwase et.al (2008) have attempted to highlight quantitatively the growth and development of world literature in the field of pulsed laser deposition in terms of publication output as per Science Citation Index (1982-2006). Thirumagal (2012) In his paper deals with the Bibliometrics of publications on Nanotechnology in India in the Web of Science database. The analysis period taken is from 2001 to September 2011. This paper finds out the individual author's contribution, geographical distribution and year-wise research in nanotechnology in India. Citation of articles, ranking of Journals, h-index, g-index and gh-index. Histcite and Bibexcel tools have been used for data analysis. Bhattacharya et.al. (2012) have discussed about the status of nanotechnology in China and India and used bibliometric tools to analyze the comparative research trends in both the countries. Karpagam et.al.(2011) have studied the mapping of Nanoscience and Nanotechnology research in India by using bibliometric parameters. The paper analyses the growth pattern of Nanoscience and Nanotechnology literature in India during 1990–2009. The Scopus international multidisciplinary bibliographical database has been used to identify the Indian contributions on the field of Nanoscience and nanotechnology. The study measures the performance based on several parameters, country annual growth rate, authorship pattern, collaborative index, collaborative coefficient, modified collaborative coefficient, subject profile, etc. Further the study examines national publication output and impact in terms of average citations per paper, international collaboration output and share, contribution and impact of Indian Institutions and impact of Indian journals. Karpagam et.al (2011) have again taken up the subject from another view point and tried to reveal the publication trend on nanotechnology among G15 countries through a bibliometric approach. The study attempts to identify the publication trend on Nanoscience and Nanotechnology among G-15 countries using the Scopus database. There are 7,55,656 bibliographic records in nanotechnology on Scopus database over the period of 18

30

years (i.e.) 1992-2009. The publication progress on Nanotechnology is measured using scientometric tools such as Relative Growth Rate, Doubling Time, Activity Index, and Growth Rate. Further this study examines the Indian Institutional performance by ranking. Nazim and Moin(2008) have studied the nanotechnology research using the bibliometric parameters. This work examines the scientific output in the field of 'nanotechnology', the aim being to offer an overview of research trends in this field and characterize its most important aspects such as growth of literature, authorship pattern, most productive journals, authors, countries, etc. Health / Medical Science:

Medical sciences have evolved in the recent times and many bibliometricians are drawn towards the field. Twenty one papers on various sub-disciplines of medical sciences have been found. Such large number of articles show the extent to which the research is going on in this field and the attention it is gaining. Mahapatra and Panda(2004) have described the growth trend in health science literature on Orissa published from 1993-2002. This paper includes 118 research papers on 'health literature' from 59 Indian and foreign journals. It analyses the authorship pattern, year wise growth subject wise break up of papers, category of journals, country of origin, length of papers, and ranking of journals. Neelameghan and Rao (2012) in this paper have described a general model for analyzing the patterns of incidence of events using, as a case study, the incidence of certain communicable diseases in India in the 19th century. Bibliometrics are applied for data analysis. A similar study has been conducted by Prem Kumar and Krishnamachari (2011) on the non-communicable disease research in India. At the same time other aspect of Medical sciences has been analyzed by Rivera et.al (2010) They have taken medicinal chemistry publications into consideration and have used citation counts of journals to evaluate the status of research in three countries i.e. Latin America, the People's Republic of China, and India. In another study Gupta et.al (2011) have mapped the research publications output for Diabetes in India for the period 1998-2008. This paper showcases the research output from India in the field of Diabetes, India's rank and global publications share, citation impact, overall share of international collaborative papers, and share of major collaborative partners. It also analyses the characteristics of most productive institutions, authors, and highly-cited papers. The publications output, impact and collaborative publication share of India is also compared with China, South Korea and Brazil. Krishnamoorthy et.al (2009) have also taken Diabetes as subject for bibliometric analysis; their concentration is on overall analysis of the literature published on diabetes during 1995-2004. The data have been collected from the diabetes literature indexed the MEDLINE database. Relative Growth Rate, Doubling Time have been calculated and it is found that while RGR is decreasing the doubling time keeps increasing every year. Conformity of research productivity with the Brdaford's law has been established in this study. Gupta and Bala (2011) have taken another disease i.e. Malaria and its research in India during 1998 -2009 in their paper and conducted a bibliometric study. This study analyses the research output of India in malaria research in national and global context. SCOPUS Citation database has been used to retrieve the publication data, which has been further analyzed on several parameters including its growth, rank and global publications share, citation impact, overall share of international collaborative papers and share of major collaborative partners and patterns of research communication in most productive journals. The publications output, impact and collaborative publication share of India is also compared with South Africa, Brazil and China. Raja et.al(2011) have analyzed the scientometric dimension on gender in worldwide thyroid cancer based on web of science database. This study has been carried out to analyze the research field of Gender in thyroid cancer in terms of publication output as per science citation index (1991- Mar 2010). The study reveals interesting facts on the research in the field. Top countries, average number of articles per country, authorship and collaborations and several other parameters have been studied. Kaur and Gupta (2010) have mapped the research in Dental Science in India using scientometric tools for the period 1999-2008. The study examines India's performance based on its publication output in dental sciences during 1999-2008, based on several parameters, including the country annual average growth rate, global publication share & rank, national publication output and impact in terms of average citations per paper, international collaboration output and share and contribution of major collaborative partners, etc. The study uses 10 years (1999-2008) publications data in dental sciences of India and other countries drawn from Scopus International multidisciplinary bibliographical database. Kumaragurupari et.al (2010) in their research have analyzed the peer reviewed publications by Indian ophthalmologists and vision researchers for the period 2001-06. The study analyses the productivity, trends in journal choice, publication types, research funding, and collaborative research PubMed has been used for data collection. The results show that the total number of published articles were 2163. During the six-year period studied, the annual output of research articles has nearly doubled. Fifty percent of the publications have come from nine major eye hospitals. Gaps in the field of research have been identified and the research productivity shows an increase during the period of study. Kaliyaperumal and Natarajan (2009) have taken up another aspect of research related to the eyes. They have conducted a scientometric analysis of literature output on retina published during 2002-2007. The study focuses on the growth pattern as well as overall trend in literature output on retina. MEDLINE has been used for data collection. The results indicate variability in the authorship pattern, English language as the major medium in literature output for

retina. The contribution of the USA is higher in this subject also in comparison of other countries of the world. Saravanan et.al (2010) have assessed the trends in Indian conservative dentists and endodontists' publications in PubMed-Medline database during 1996–2009. In this study the articles with the words Dental AND India have been taken into consideration. Using this data the year of publication, number of authors, name of the journal, reach of the journal, status of the journal, specialty of the first, state of origin, and type of research and performance of department of conservative dentistry and endodontics have been identified. Dutt et.al. (2010) have studied the profile of global dengue research using scientometric techniques during the period 1987-2008 as per the data from SCI – Expanded database. The areas of maximum and minimum concentration have been identified. Country wise and Institution wise rankings have been identified and growth trends have also been indicated. Bala and Gupta (2010) have undertaken the study of the Indian neuroscience research output during 1999-2008. This study analyses the research output, its growth, rank, global publications' share, citation impact, share of international collaborative papers and major collaborative partner countries and patterns of research communication in most productive journals. It also analyses the characteristics of most productive institutions, authors and high-cited papers. The publication output and impact of India is also compared with China, Brazil and South Korea.Kaur and Gupta (2009) have also conducted a similar study for the fields of Immunology and Microbiology in India for the period 1999-2008. The study examines India's performance based on its publication output in immunology and microbiology using similar parameters as above. The database used here for data collection is SCOPUS.Krishnamoorthy and Amudhavalli (2008) in their work have conducted a scientometric study of the health sciences in India. This paper attempts to assess the R&D activity and its output in Health Sciences in India for about three

decades, 1970 to 2000. Statistical analysis has been carried out using SPSS and other relevant measures. Core subjects and sub-disciplines, in which maximum research is going on, have been identified. Kaur and Gupta (2009) in their work have examined the Indian contribution in Pharmacology, Toxicology & Pharmaceutics during 1998-2007 using the scientometric tools and techniques. Several parameters like country's annual average growth rate, global publication share and rank, institutional profile of select top institutions, international collaboration profile and major collaborative partners, patterns of communication in national and international journals and characteristics of its top high productive authors have been kept into consideration. Kumbar and Akhtary(1998) analyzed 7451 citations appended to 322 articles published in the American Journal of Ophthalmology Vol.117-120 during the years 1994-1995. They calculated the average number of citations per article, types of literature authorship pattern, obsolescence of literature, and a ranked list of cited periodicals. Mela et.al (2003) have evaluated the number and scientific "weight" of papers written by European radiologists during the period 1995-2000 and compared with other countries. Their work shows that European Radiological Research is responsible for 40% of the world scientific production and Germany, UK and France are the leading publishers in Europe. Biradar and Tippeswamy (2004) have studied 3401 references appended to the 61 M.D. Pediatrician Dissertations. They have attempted to determine the average number of references per dissertation, forms of documents, authorship pattern and obsolescence of literature and percentage of cited periodicals. Garg et.al (2006) have analyzed 2275 papers on malaria research published in journals and indexed by Commonwealth Agricultural Bureaux International (CABI) CD-ROM incorporating Tropical Diseases Bulletin (TDB), and Pub Med Medline (web edition) in 1990 and 2000. The study finds out the malarial

research output, most productive journals, countries and institutions along with the explored areas etc.

Engineering: Two studies have been found in this discipline. Ganguli (2008) in his work has investigated the aerospace research from scientometric point of view. Aerospace science and technology is a major research area for nations because of its economic and strategic importance. An attempt has been made to find out the most productive countries, institutions, authors. Indian scenario has also been examined in this work and top Indian institutions in the field have been identified. Modak and Madras (2008) have done a scientometric analysis of chemical engineering publications. The work compares the number of journal publications and citations by various countries and institutions. The study indicates towards an exponential increase in the publication records of China in terms of quantitative aspects while the citation analysis shows the USA continues to maintain its leadership position with regard to impact in the field. Analysis of the output of selected Indian universities/organizations against that of the top universities in the world indicated that the records of top institutions from India are not comparable to the best universities in USA, but are comparable to the best in Asia and are significantly better than the best universities in China.

Agriculture: Krishna and Kumar (2004) have analyzed the citations of 68 doctoral thesis on Agriculture and Veterinary Sciences during 1996 to 2000. The subject wise authorship pattern and trend graph for books and journals have been observed. Damodharan (2011) in his Bibliometric study has analysed the doctoral thesis on the growing and use of Groundnuts in India, which aimed to find out the year wise, crop wise and discipline wise growth during the period 1948-1996. Major areas of research have also found. Vijay (2005) in his work on food science has revealed that

collaborative research is preferred to solo research in the area. The publication pattern from different institutions had also been studied to determine the pattern of contributions from the different organizations and institutions.

Literature: Studies related to literary works are rare to find. One such work has been noticed during the period. Ray and Sen (2012) have tried to view Gitanjali, a song compilation by Rabindranath Tagore, from the angle of Bibliometrics and have studied the growth of poems of Gitanjali, their lengths, places and dates of writings, use of words and rank frequency of different words. They have tried to find out whether Gitanjali follows any bibliometric law. The study also tries to find justification of the title Gitanjali with the help of bibliometric techniques

Science and technology: Kademani et al (2007) have attempted to analyze the growth and development of science and technology (S&T) activities in India, as reflected in publication output covered by Science Citation Index (SCI) during 1990-2004. The study analyses the broad features of Indian S&T by focusing on its publication growth characteristics, language, format and media of communication, research quality, institutional productivity, patterns of research collaboration, and broad and narrow subject areas of interests of Indian institutions and scientists. A broad comparison of India's research output with select countries, particularly with China, has also been made.Sagar et.al (2009) have taken up scientometric study of the review articles on science and technology indexed in SCI and having India in the affiliation of authors for the period 2000-2005. Collaboration patterns of Indian reviewers, areas of expertise, average yearly growth rate, etc have been identified and inter-quartile mean of the number of synchronous references of the 2042 review articles has been calculated.

Bio-Energy:

One study in this field has been found. Shukla et.al (2001) have taken Bio-Energy literature and applied Bradford's Law of Scattering and Lotak's Law of Productivity to verify if the law holds good for ten Abstracting services in the field. Results of linear regression showed that Lotka's distribution holds good for bio-energy literature and the value of n ranged between 205 and 4.5.

Author / Scientists-based studies: There are many authors whose contributions stand aloof in the crowd tall and radiating. These scientists are renowned for their work. Bibliometricians have many times tried to assess their productivity using bibliometric tools and techniques. Thirteen studies related to such scientists have been noticed. Munnolli et.al (2011) have conducted a scientometric analyses of the Nobel laureate Harald Zur Hausen in their work. This paper highlights quantitatively the publication productivity of Harald zur Hausen a renowned scientist and Nobel Laureate in Physiology who was honoured with Nobel Prize for the discovery of human papilloma viruses causing cervical cancer. A similar effort as above has been made by Kalaiappan et.al (2010) in their scientometric study of the literature output of Prof. G.N. Ramachandran, an eminent biophysicst and crystallographer, in the Subjects of Biophysics and Crystallography. The paper examines the contributions of Prof. Ramachandran, magnitude of his collaborations, and year-wise distribution of his productivity. Hazarika et.al (2010) have carried out a scientometric analysis of a famous biometeorologist Nayana Nanda Borthakur for his papers published during 1963-2005. His collaborative authorship pattern, top collaborators, frequently preferred journals, fifty percentile age, publication concentration and core areas of research have been identified in this study. Keshava et.al (2010) have studied the scientometric portrait of Prof. S.S. Kubakaddi, a famous scientist in physics. His

papers during 1974 -2008 have been analyzed and collaborative patterns, highest productive year, collaboration coefficient, h-index have been identified and calculated. Deverai et.al (1998) have analyzed the productivity of M.V.Srinivas's research. Publications by year, domain, authorship pattern, channels of communications have been revealed in the study.Kademani et.al (2000) have analyzed the citations to the publications of eminent Indian scientist and visionary Vikram Sarabhai, using Science citation Index 1944-1991. The extent of citations received, in terms of the number of citations per paper and the categories of citing documents and the distribution of citations among them have been determined. Kademani et.al (1994) have analyzed the citations to the publications of eminent Indian scientist and nobel laurete Sir C.V. Raman. The contributions made by him have been analysed by year, domain name etc. Sinha and Dhiman (2001) have observed the research articles published in Indian and Foreign journals by Dr. R.C. Sinha. His total output in Indian as well as foreign journals and authorship pattern etc have been analyzed in the study. Munnolli and Kalyane (2003) have analyzed 312 papers of Ram Gopal Rastogi published during 1954 to 1992 in various domains. Highest collaborating authors, most productive years, most preferable journals and most prolific keywords have been found in the study.Kalyane and Sen (2003) have analyzed the publications of eminent scientist Tiber Braun. Productivity coefficient has been found to be 0.78. Most active collaborators have been identified. Author productivity in the research group of Tiber Braun follows the trend of Lotka's Law. Most preferred journal and his core area of work have also been revealed in the study. Kalyane and Kademani (2005) have conducted a study of R.Chidambaram's publications. These are analyzed by year, domain, collaboration pattern, channels of communication used, keywords etc. the results indicated that the temporal variation of his productivity and of the types of papers published by him was eminently qualified to be taken as a 'role model' for the

younger generation to emulate. Angadi et.al (2006), in their work have attempted to analyse the publication productivity of Anthony J. Leggett, the 2003 Nobel Prize winner in physics. The peak years of his productivity, most prolific areas of research, most active collaborators are identified. His productivity coefficient turned out to be 0.60, which clearly indicates that his productivity increased after 50-percentile age. The highest degree of collaboration, most preferred channel of communication and publication density and publication concentration are also found. Sangam et.al. (2007) have studied the scientific contributions of Sivaraj Ramaseshan in various journals and some classic papers. His collaborations, fields of work, most productive years etc have been identified in the study.

Institution based studies: Sixteen bibliometric and scientometric studies have been found on the research outputs of various Institutions, Universities, Colleges and Organizations etc. These studies generally try to evaluate the research output of these institutions over a period of time, on any particular topic or any division. Nishy et.al (2012) have undertaken an impact-citations-exergy (iCX) trajectory analysis of leading research institutions in India. They have taken factors like impact, citations and number of papers into account for carrying out the study. Savanur and Konnur(2012) in their paper have studied the growth and Impact of research output of Bangalore University for the period 1971-2010. This scientometric study makes an attempt to highlight the quantitative growth and development of the Bangalore University (BU) in Science and Technology in terms of publication output as per Science Citation Index from 1970 to 2010. Kaur et.al. (2011) have conducted a scientometric analysis of the research output of the Government Medical College & Hospital (GMCH) in Chandigarh, India. The paper attempts to analyze the research profile of the Institution based on several parameters including its status, growth rate,

impact, international collaborative research patterns, media of communication, disease and organ related patterns of research output. Sarkhel and Choudhari(2010) have analyzed the research output in the field of agriculture from Bidhan Chandra Krishi Viswavidyalaya (BCKV), Mohanpur, West Bengal using bibliometric techniques. Database used for the study is CAB Abstracts and a period of 15 years i.e. from 1993-2007 has been taken into consideration. The results show that there has been a topsy-turvy growth in the research publication during the period. Journals in which papers have been published by BCKV have been ranked on the basis of number of papers with their NAAS rating. The authorship pattern shows the trends towards collaborative research. Raghuraman et.al (2010) have taken up the scientometric analysis of some disciplines to compare the research outputs of Indian institutions with other international institutions. They have used the h-index and the P-index to determine the ranks of each selected Institutions in India. The study reveals the rankings of the Indian Institutions, their publications profiles and their status in comparison to the International Institutions of same cadre. Upadhye et.al(2010) have analyzed the scientometric dimensions of the nuclear physics division at Bhabha Atomic Research Centre. 257 research papers are published during 2003–2008 in diverse domains of nuclear physics. The study indicates towards the average number of publications, the most prolific authors, the leading journals preferred by the scientists and the collaboration trend among the authors of the division. Manjula and Chudamani (2010) have studied the contributions of scientometric ranking algorithms of universities in Karnataka. They have used techniques to evaluate the output in terms of organizational structure and resources inputs, the quality of the information sources, information for decision making in science and appropriate data aggregation methods. Bhatia (2010) in her study has analyzed the publications productivity of National Institute of Occupational Health during 2000 – 2006. The results reveal the

41

prolific areas of research, the collaboration trends and the journals most commonly preferred for publication by the scientists of NIOH. Maheswaranan (2009) has studied the area-wise publications of Structural Engineering taking the case of Structural Engineering Research Centre (SERC) during the years 2002-2006. The data used in the study has been taken from the annual reports of SERC and has been analyzed based on Impact Factor (IF) provided by Journal Citation Report (JCR). The study highlights the yearly output, publications in national and international journals, number of papers in SCI and non-SCI journals, Normalized Impact Factor (NIF) per paper, number of papers in the proceedings of national and international conferences / workshops / seminars / symposia etc., category-wise distribution of papers in different NIF ranges, the proportion of high NIF papers and papers above the average NIF. This study reveals the area-wise impact of the research conducted by the Centre in particular.

Sharma (2009) has taken up the research publications of Central Potato Research Institute for a bibliometric analysis to find out the trends of research going on in the institution during 1991-2007. Analysis shows the preferable mode of collaborations among the scientists; the degree of collaboration is found to be 0.82. Study further examines the factors which have or do not have impact over the scientific productivity of the scientists during the period under review.Husain and Mushtaq (2010) have conducted a scientometric study of the academic ranking of Indian central universities in science and technology as per their representation in science citation indexexpanded during the year 2005-2009. In this study the Universities have been searched individually and the data have been recorded using the distinct limiting options of the. The data so obtained have been worked out and interpreted in accordance with the Scientometric methods. The results show the ranking of various Universities in India, the growth pattern of the publications, The most frequently used language, the subjects and their rankings and the journals' rankings based on the number of publications in that field. Sevukan and Sharma (2008) have presented a detailed bibliometric analysis of research performance of biotechnology faculties in central universities of India from 1997-2006. The data used for the study have been retrieved from two database sources- PubMed and Science Citation Index Expanded (SCIE). The study examines the growth in literature, collaboration pattern among authors, etc. Lotka's law has been has been found to be applicable to the study while the study does not conform to the Bradford's law. Furqan Ullah et.al(2004) in their work have observed that quantitative analysis of citations has immense value in library management, specially in selection of periodicals for subscription. In this study, an analysis has been made of 20,046 citations mentioned in 777 scientific and technical reports published by National Institute of Hydrology, Roorkee, since its inception i.e., December 1978. Kademani et.al(2005) in their study have analyzed 475 papers published by the Bio-organic Division of Bhaba Atomic Research Center during 1972-2002. The highest numbers of publications per year, average number of publications, the most prolific authors and the core journals preferred by the scientists are found out. Barooah and Sharma(2001) have conducted a Bibliometric study to analyze the journal collection of the library of Regional Research Laboratory Jorhat (RRLJ) through a study of use of journal titles or publication of research by the scientific community of the laboratory. Mohammed Furqan Ullah et.al.(2004) have taken up the quantitative analysis of citations in 777 scientific and technical reports published by National Institute of Hydrology, Roorkee, since its inception i.e., December 1978. The paper gives an account of year-wise break-up of different categories of reports. Different bibliographic forms of literature cited in the reports such as journals, books, conference proceedings, technical reports, IAHS publications

and other documents like Ph.D. Thesis, M.E./M.Tech dissertation, bulletins, standards etc. have been analyzed and presented.

Periodical based studies: Some journals are considered as the core journals of a field. The papers published in these journals are highly cited and have high impact factors. Aswathy and Gopikuttan(2012) have made an attempt to analyze the Journal of spacecraft and rockets, one of the premier journals in the field of Space technology. This paper presents a scientometric analysis of the journal during 2006–2010. The analysis covers various parameters like growth pattern, authorship patterns, and distributions with regard to subject, year, institution and geographical area. The study reveals the degree of collaboration among the authors and Lotka's law is also applied to find the author productivity. Nishy et.al(2012) have studied the visibility and impact of the Indian journal of chemistry, section B, a leading journal in organic and medicinal chemistry. They have used scientometric parameters like geographical distribution, citations received each year, authorship patterns, etc to evaluate the articles published during 2005-2009. Kannappanavar and Roopashree (2011) have discussed about the information use pattern of Indian Geneticists using the Journal of genetics. The study shows that the journals are heavily cited as compared to other forms of documents and that the trend is towards team research. Multi authors lead over single author. Around 48% of the journals cited are from United States. The study reveals important facts about the trend of research and It is observed from the study that 'Genetics' is the most heavily cited journal followed by 'Science', both are from United States. The Indian journal, Journal of Genetics is in the 14th place. Literature as old as 174 years has also been cited. Kumar and Moorthy (2011) have performed a bibliometric analysis of DESIDOC Journal of Library and Information Technology, a leading journal in the field of LIS in India. The analysis covers various

parameters like growth pattern, content coverage, authorship patterns, subject-wise distribution of articles, etc. of this journal for the period 2001-2010.

Similar study has been conducted by Singh et.al(2011) for the journal DESIDOC bulletin of information technology for the period 1992 -2002. Research publications over a ten-year period are analyzed to assess the trends in the publication patterns in this journal by library and information professionals. This study reveals the total number of articles published in the 60 issues. Author collaboration, country wise distribution, etc have been analyzed by the authors. Patil(2010) has conducted a bibliometric study of the journal Herald of library science. This paper examines the articles published for determining the authorship pattern, degree of collaboration and geographical distribution of papers. The study reveals that the majority of papers are single authored. The degree of collaboration has been identified. Andhra Pradesh has produced the highest number of articles from India and Nigeria is at the top among Foreign Countries.Narang(2005) has done a bibliometric analysis of the Journal of Pure and Applied Mathematics for the period 2003-2007 by taking into consideration the number of contributions and their distribution in different volumes, authorship pattern, foreign and Indian author contributions, citation analysis and number of pages used in each volume. The results indicate a decrease in the number of contributions in successive volumes; the most cited documents are articles from research journals. The number of foreign contributors is more than Indian contributors. Growth and popularity of the journal is showing mixed trends i.e. upward and downward progress. Kaushik et.al(2010) have analyzed the Pantnagar journal of research using bibliometric techniques. This paper examines the articles published in the Journal, during 2003-2008. This paper analyses the year-wise distribution of articles, physical growth of volumes, references cited total, national and international, average length of papers, authorship pattern, degree of collaboration, illustrations and tables included, articles with/without abstracts, college & department-wise contributions of the university, and other states and countries. Thanuskodi(2010) aims to analyze the publication output of Indian social scientists using the journal of social sciences. It covers the number of articles, authorship pattern, subject wise distribution of articles, average number of references per article, forms of documents cited, year wise distribution of cited journals etc. Mukherjee(2009) has conducted a bibliometric study of selected open-access journals using Google Scholar to analyze the scholarly impact of open access journals in library and information science during 2000-2004. This study investigates the impact of these open-access journals in terms of quantity of articles published, subjects covered etc. Hadagali et.al(2009) have analyzed the journal Current science from bibliometric point of view. This paper analyses the citation pattern for the years 2005 and 2006. Authorship pattern, types of publications, language-wise distribution, highly productive institutions, and periodicals preferred by cited scientists are examined Kulkarni et.al (2009) have analyzed the papers of Indian journal of pharmaceutical education and research published during 1996-2006 using bibliometric techniques. The study reveals that journals are the predominant citation source followed by books. Analysis shows that majority of the scientists preferred to publish research papers in multiple authorships and there is considerable time lag in publication of articles from the date of receipt of the papers. Zafrunnisha and Reddy(2009) have analyzed the Indian journal of marketing using bibliometric parameters. The work gives us a clear picture of the authorship pattern, Bibliographic form, Subject, Language, Country and rank wise distribution of citations of articles appeared in IJM XXX VI published in the year 2006 i.e., January to December 2006. Halder and Chandra (2009) have taken up the IASLIC Bulletin for a bibliometric study of Published Literature in Library and Information Science during the year 2003

-2007". This paper highlights the growth patterns of Library and Information Science literature on the basis of bibliometric study. The investigation focuses on distribution of contributions, authorship pattern of contributions, distribution of references, analysis of length of literature, distribution of illustrations used, state wise distribution of contributions and subject trends of the articles, etc. Garg et.al(2008) has conducted a scientometric study of the journal Mausam for the period 2003-2006. Role of IMD has been identified based on number of contributions. Time lag between receipt, acceptance and publication of papers has been identified. The journal has been examined from various point of views like age of citations, journals cited, impact factors and their variations in different years. Kumar et.al (2008) have carried out the scientometric analysis of Pramana - Journal of Physics. This paper focuses on publishing trend; impact factor; authorship pattern; types of articles; institutional collaboration of authors; affiliated institutions of authors; countries of contributing authors; keyword analysis; and referencing pattern. The paper reveals that the number of articles being published in Pramana and its ISI impact factor are increasing. There is an upward trend in number of collaborated papers. Nandi and Bandopadhyay (2008) have investigated the Indian economic review (1998-2002) from bibliometric This paper examines the authorship pattern, the degree of point of study. collaboration among authors and geographical distribution of the authors. Keshava et.al (2008) have conducted a bibliometric study of scholarly research papers published in the journal ACM Transactions on Information Systems during 1989-2006. The study examines the most prolific authors, the most sought-after topics, the most productive country, the collaboration trends etc. Keshava et.al (2008) in their work have tried to determine the growth of literature in the field of sociology using the data from select sociology journals published during 1999 to 2004. The study reveals the growth, authorship patters, value of group co-efficient for collaborative research and geographical distribution of papers and the degree of collaboration etc. Kumar et.al (2008) have examined the web-resources in INSPEC database using scientometric techniques during the period 1995-2005. The most productive country and year have been examined. The top websites and most preferred journals have been identified. Other factors like most used language etc have also been revealed in the study. Hajudin (1998) has analyzed the articles published in the journal of Plantation Crops during the period 1973-1996 to find out the nature of communication, geographical distribution, authorship pattern and citations. Indian authors had contributed 89.96% and foreign authors had contributed 10.04% articles. The maximum number of contributions is on coconut 167 (29.93%). central plantation crops research Institute had contributed 42.83% of the total contributions. Two author papers had accounted 38.17% followed by the three- author papers 26.34%. Sivasubramanian(2000) reported the results of a bibliometric study of articles published in the Journal of Indian Coffee, which has been published by the coffee board. Analyzed the authorship pattern, the range and frequency of references cited and year wise distribution of papers. Most of the articles dealt with topics plantation, cultivation and processing in the first order i.e. 22.46% followed by standards and quality as 15.26%. The average length of papers ranges between 1 to 6 pages, which constituted 92% of the whole. Results indicated that the trend has been towards single authorship as 64.08% and there exists a high degree of collaboration in coffee research. Survanarayana (2000) reported results of a bibliomteric analysis of contributions of the periodical 'Journal of Tobacco Research' to the literature for the years 1987-1997. He in his work has discussed the type of contributions and their distribution over these years, with an analysis of the contributing institutions and authorship pattern, the types of citations in the periodical and the preparation of core list of periodicals. Ramesh et.al (2000) have analyzed the papers published in the

quarterly International Rice Journal ' Oryza' between 1986-1995. The yearly distribution of papers, authorship patterns, geographical location of contributors, subject covered, average length of articles etc. are analyzed. Das and Sen (2001) have analysed 1049 citations appended to 34 research articles pertaining to issues nos. 2 to 4 volume 20 of the journal of Bioscience for the year 2000. The authorship pattern of citations showed that 18.68% papers are single-authored, 52.71% are double and triple authored and the remaining 28.61% are joint contributions of four or more authors. Of the cited articles .53% are Indian and the rest by foreign authors. Author self-citation shared 10.87% and journal self-citations shared 0.57%. Dutta and Sen (2001) conducted a study with 1011 citations appended to 27 research articles. The number of citations and cited authors per article is found to be 37.44% and 85.19% respectively. On an average one citing author had cited 38 authors. Dutta et.al. (2001) in their scientomeric study covered 2800 citations appended to 152 articles published in 2001 in eight scholarly journals published by National Institute of Science Communication & Information Resources. In all, 7426 authors are figuring in the citations. On average, there are 18 citations per article and 3 authors per citation. The study indicated the dominance of team research in the concerned fields. On average, journal articles account for about 79 percent of the citations. Monographs rank second with a tally of about 12 percent. Indian Journal of Marine Science receives high percentage of journal self-citation compared to others whereas Indian Journal of Chemistry Section B receives high percentage of author self-citation compared to others. Indian citations received by all journals figure only 10% on average. Senthil and Vadivel (2003) conducted a bibliometric study of the 'Spice India' Journal for the period 1997-2001. Based on the collected data, the year wise distribution of articles, year-wise distribution of citation, authorship pattern, length of articles, subject wise breakup of articles and leading authors are analyzed. In another study Senthil and

49

Vadivel (2004) analyzed the journal 'Journal of Spices and Aromatic Crops' for the period 1992-2000. Based on collected data, the study examined the year wise distribution of articles, authorship pattern, length of articles, subject wise breakup of articles, and leading authors. Koley and Sen (2003) analyzed 457 citations appended to 26 research articles published in the four issues of the quarterly Indian Journal of Physiology and Allied Sciences, vol. 55(2001). Shokeen and Kaushik(2004) aimed to find out the authorship pattern and citation pattern of articles that appeared in Indian Journal of Plant Physiology. The study covers issue nos. 1 to 4 of volume 7 published between January to December 2002, covering 61 articles published in these issues. The results indicate that 39% articles published (citing articles) in these issues are three-authored. However, it is found that two-authored citations (cited articles) are more common which single-authored papers follow. The results reveal that journal articles are predominant with 81% of total citations. The ratio of author self citation to total citations is 1:16.65. The ratio of Journal Self Citation to total citation is 1:31.91. The study reveals that a majority of documents cited in these issues are published not more than twenty years ago. Asha Narang (2004) analyzed 8396 citations appended to 737 articles published in the Indian Journal of Pure and Applied Mathematics, during the year 1998-2002 and 470 citations appended to 70m articles published in the maiden volume I Published in 1970 had been carried out to observe the distribution of contributions, authorship pattern, citation analysis, geographical distribution of contributions and the number of pages used in each volume. Roy (2004) conducted a study based on 1637 research papers in Library and Information Science (LIS) published in 10 Indian LIS journals during 1991 to 2000. The single authorship is much in vogue in LIS research work in India. Collaborative work is not very popular among the Library Information Scientists. Here it is found that single author is 66.7%, two authors are 26.45%, three authors are 5.68%, four authors are 0.97% and six

authors are 0.06%. So, it is seen that single author is dominating in the field of LIS research. Kumar and Kumar (2005) analyzed 743 research papers comprising 435 main articles and 308 short communications published in nine Volumes (1993-2001) in Journal of Oilseed Research. They have analyzed the papers using year wise distribution, length of articles etc. They have also found prolific contributors, subject wise and crop wise distribution. Paper also ranked periodicals and applied Brad ford's law Neena Singh and Dominic(2006) analyzed 687 citations appended to 30 research articles published in four issues of Allelopathy Journal. From the citation count it appeared that solo research in allelopathy is quite Substantial only 32.52%. About 64.48% of the research work contribution are the result of the team research. Of the citation count 89.69% relate to journal article, 6.11% to Theses and 3.79% to conference papers. Indian citations had been found to be more with 65.5 and foreign citation 34.35% of the total citation. The study revealed that 30.57% of the total citation is the author self-citation and 16.16% are journal Self-citation. Jena (2006) in his work has reviewed the journal "Indian Journal of Fiber and Textile Research" for the period 1996-2004. There are total of 8114 citations distributed among 35 journal issues having 507 articles. The trend of publications such as the year wise articles, bibliographic distribution of citations, authorship pattern, citation pattern, average length of articles and geographical distribution of authors had been studied. Out of total citations, journals constituted 73.92% whereas books constituted 11.61%. The average length of articles is observed as 6 pages. In the geographic distribution the highest number of contributors are from India with 1167 (85.87%). Rest from foreign authors from 21 countries. Bharvi et.al (2003) have studied 1317 papers published in first fifty volumes during 1978 to 2001 of the international journal Scientometrics. The study reveals the heterogeneity of the field with emphasis on scientometric assessment. The study indicates that the US share of papers is constantly on the

decline while that of the Netherlands, India, France and Japan is on the rise. The research output is highly scattered as indicated by the average number of papers per institution. The scientometric output is dominated by the single authored papers, however, multi-authored papers are gaining momentum. Similar pattern has been observed for domestic and international collaboration. Biradar and Mathad (2000) in their work have conducted a study on the references appended to articles appearing in the journal 'Annual Review of Ecology and Systematics' for the year 1995-1996 and identified the major forms of literature, core journals, authorship patterns, obsolescence of literature etc. Parameswaran and Smitha (2001) have conducted an analysis of 60 issues of LISA published from January 1994 to 1998 using a specially prepared data sheet. The data collected manually using the data sheet is compared with the data available from, the CD-ROM. They have used Subramanyam's formula to measure the extent of collaborative authorship and proved their hypothesis that the research papers by single authors are greater in number than collaborative work as covered by LISA. In a similar work Garg and Padhi (2000) have analyzed 952 publications published by Indian scientists and have found the most prolific and nonprolific authors in laser science and technology. Kannappanavar and Vijayakumar (2001) have applied citation analysis to the data of the Journal "Plant and Cell Physiology" of the year 1998. The distribution of citation frequencies has been statistically tested, average half life, utility and obsolescence factors have been determined. Mamdapur et.al (2011) have analysed the articles in Baltic Astronomy published during the years 2000 to 2008 with regard to distribution of contributions, authorship pattern of contributions, distribution of references, analysis of length of papers, etc.

2.3 Summary:

The above review shows a panorama of articles on diverse fields, topics and areas. The length and breadth of the works range from narrow subjects to broader topics, from colleges to universities and even international institutions, from Nobel laureates to renowned scientists and periodicals in various subjects etc. It is evident from the study that fields like medical sciences and nanotechnology have been heavily exploited while at the same time works on literature, humanities and pure sciences are relatively few. Four recent papers on remote sensing and one on GIS has been traced and these papers discuss about the global research output for various years. The Indian contribution to world literature on remote sensing and GIS has been not much emphasized and the growth pattern of the subject in India has also not been discussed in any of these works, moreover one of the works also shows major ambiguity in data. Keeping the current scenario in mind and due to the meteoric rise in the research in these fields there is a requirement for a comprehensive Bibliometric study of these subjects and determination of the growth pattern in India for past two decades.

2.4 References

- Angadi, M. Koganuramath, M. M., Kademani, B. S. and Kumbar, B. D. and Jange, S.(2006). Nobel Laureate Anthony J Leggett: A Scientometric portrait. Annals of Library and Information Studies, 5(4), 203-212.
- Anilkumar,D and Rani, Y.(2005). Indian Botanist's contribution: A Bibliometric study based on Journal of Indian Botanical society, 1997-2001. Indian Journal of Information Library and Society, 18(3-4),108-115.
- Arunachalam, S and Singh, U.N. (1985). Sophisticated science in a small country: a scientometric analysis of superconductivity research in Israel. Journal of Information Science, 10(4), 165-171.
- Arunachalam, S. and Garg, K.C. (1985). A small country in a world of big science a preliminary bibliometric study of science in Singapore. Scientometrics, 8(5), 301-313.
- Arunachalam, S. and Garg, K.C.(1986). Science on the periphery a scientometric analysis of science in the Asian countries. Journal of Information Science, 12(3),105-117.
- Aswathy, S. and Gopikuttan, A.(2012). Journal of spacecraft and rockets: A scientometric analysis. SRELS Journal of Information Management, 49(6), 671-682.
- Bala, A. and Gupta, B.M. (2010). Mapping of Indian neuroscience research: A scientometric analysis of research output during 1999-2008. Neurology India, 58(1), 35-41.

- Bala,A. and Gupta, B.M.(2010).Research Activities in Biochemistry, Genetics and Molecular Biology during 1998-2007 in India: A Scientometric Analysis.DESIDOC Journal of Library & Information Technology, 30(1), 3-14. Retrieved from http://publications.drdo.gov.in/ojs/index.php/djlit/article/view/278
- Balasubramani, R. and Murugan, C.(2011). Mapping of Tapioca (Sago) Research in India: A Scientometric Analysis. Library Philosophy and Practice, Retrieved from http://www.webpages.uidaho.edu/~mbolin/balasubramani-murugan.htm
- Barooah, P.K. and Sharma, N.N. (2001). A Bibliometric study of research papers to evaluate the collection development program of library. Annals of Library and Information Studies, 48(4), 157-165.
- Barooah, P.K., Begum, D. and Sharma, N.N. (1999). Bibliometric study of Doctoral Dissertations of inorganic Chemistry Submitted by S & T workers of RRL, Jorhat to Evaluate the Utility Factor of the Library. Annals of Library Science and Documentation, 46(1), 1-8.
- Baskaran, C. (2012). Research productivity of graph theory during 2004–2011: A bibliometric study. SRELS Journal of Information Management, 49(6), 683-691.
- Bharvi, D., Garg, K.C and Bali, A. (2003). Scientometrics of the international journal scientometrics. Scientometrics, 56(1), 81-93. 10.1023/A:1021950607895
- Bhatia, K. (2010). Innovations Publications Productivity of National Institute of Occupational Health: A Scientometric study. SRELS Journal of Information Management, 47(2), 219-227.

55

- Bhattacharya, S., Shilpa and Bhati, M. (2012). China and India: The two new players in the nanotechnology race. Scientometrics, 9(1), 59-87. 10.1007/s11192-012-0651-7
- Biradar B.S and Tippeswamy, K. (2004). Information Use pattern by Pediatrician: A Bibliometric study. SRELS Journal of Information Management, 41(1), 107-120.
- Biradar, B. S.and Sampath Kumar, B. T. (2003). Chemical Technology Literature: An Obsolescence Study. Annals of Library and Information Studies, 50,156-162.
- Biradar, B.S and Mathad, S. (2000). Bibliometric Analysis of Ecological Literature. SRELS Journal of Information Management 37.3 (2000): 199-214.
- Chinnaraj,M. and Balasubramani,R .(2013) Scientometric Mapping of Remote Sensing Research Output: A Global Perspective. Retrieved from: http://works.bepress.com/murugan_chinnaraj/1
- Damodharan, T. (1998). Growth of Doctoral Dissertations on Groundnut in India: A study. Annals of Library Science and Documentation, 45(1), 32-38.
- Das, A.K and Sen, B.K. (2001). Journal of Biosciences- an analysis of Citation Pattern. Annals of Library and Information Studies, 48(2), 59-63.
- Debbarman, S. (2008). A bibliometric study of Indian patent applications from 1995 to 2005. Annals of Library and Information Studies, 55(2),153-163.
- Devaraai,R.S., Ramesh, L.S.R.C.V. and Hussain, M.V. (1998). Infometrics on M. Srinivas. Annals of Library Science and Documentation, 45(4), 125-135.

- Dhiman, A.K. (2011). Research output in LIS: A bibliometric study of Ph.Ds awarded in India during 2006–2010. PEARL: Journal of Library and Information Science, 5(4), 42-62.
- Dutt, B., Kumar, S. and Garg, K.C. (2010). Scientometric profile of global dengue research. COLLNET Journal of Scientometrics And Information Management, 4(1): 81-91.
- Dutta, B. and Sen, B.K. (2001). Indian journal of chemistry: Analysis of citation pattern. Annals of Library and Information Studies, 48(3),121-127.
- Dutta, B., Das, B. and Sen, B.K. (2002). A Comparative Study of Citation Patterns among Eight Scholarly Journals Published by National Institute of Science Communication and Information Resources. Annals of Library and Information Studies, 49(4), 127-134
- Dutta,B. and Rath, D.S.(2013). Cosmology research in India: a scientometric study. Library Philosophy and Practice. Retieved from
- Furquan Ullah, M., Kanwar, S. S. and Kumar, P.(2004). A Quantitative Analysis of Citations of Research Reports Published by National Institute of Hydrology, Roorkee. Annals of Library and Information Studies, 51(3),108-115.
- Ganguli, R. (2008). A scientometric analysis of recent aerospace research. Current Science, 95(12), 1670-1672.
- Garg, K.C. (2002). Scientometrics of laser research in India and China. Scientometrics, 55(1), 71-85. doi: 10.1023/A:1016050920365

- Garg, K.C. and Padhi, P. (2000). Scientometrics of prolific and non-prolific authors in laser science and technology. Scientometrics, 49(3), 359-371. doi: 10.1023/A:1010529405152
- Garg, K.C. and Padhi, P. (2002). Scientometrics of laser research literature as viewed through the Journal of Current Laser Abstracts. Scientometrics, 45(2), 251-268. doi: 10.1007/BF02458436
- Garg, K.C., Dutt, B. and Kumar, S.(2006). A preliminary Scientometric investigation of malaria research. Annals of Library and Information Studies 53(1), 43-53.
- Garg, K.C., Kumar, S., Dutt, B. and Chakraborty, O. (2010). Scientometric Profile of Genetics and Heredity Research in India. Annals of Library and Information Studies, 57(3), 196-206.
- Garg, K.C., Sharma, P. Kumar, S. (2008).Scientometric profile of the journal Mausam Annals of Library Science and Documentation, 55(1), 76-80.
- Garg, K.C., Kumar, S., Bhatia, V.K., Ramasubramanian, V., Kumar, A. and Kumari, J. (2011). Plant Genetics and Breeding Research: Scientometric Profile of Selected Countries with Special Reference to India. Annals of Library and Information Studies, 58(2),184-197. Retrieved from http://nopr.niscair.res.in/handle/123456789/12189
- Girap,P., Kumar,A., Mohan, L., Surwase, G., and Kademani, B.S. (2011). Scientometric dimensions of fuel cell research as reflected in INIS database. SRELS Journal of Information Management, 48(3), 329-348.
- Goel, K. (2008). Bibliometric study of social science research in India. Journal of Library and Information Science, 33(1-2), 29-37.

- Gupta, B. M., Bala, A., Baidwan, K., Chadhha, N., Cheema, H.S.(2011). Mapping of Typhoid Research in India: A Scientometric Analysis of Publications Output in 2000-2009. Chinese Librarianship: An International Electronic Journal, (31), 1-22.
- Gupta,B.M. Kaur,H. and Bala, A.(2011). Mapping of Indian Diabetes Research during 1999-2008: A Scientometric Analysis of Publications Output. DESIDOC Journal of Library & Information Technology, 31(2), 143-152.
- Gupta,B.M.and Bala, A,(2011). A bibliometric analysis of malaria research in India during 1998–2009. Journal of Vector Borne Diseases, 48(3), 163-170.
- Hadagali, G.S., Kumbar, B D , and Sumana, D.(2009). Current science: A bibliometric study. Information Studies, 15(1),, 51-60.
- Hajudin, S. (1998). Journal of Plantation Crops- a bibliometric appraisal. Annals of Library Science and Documentation, 45(4), 117-124.
- Halder, S.N. and Chandra,A.(2009) Bibliometric Study of Published Literature in Library and Information Science in IASLIC Bulletin: 2003 – 2007. PEARL: Journal of Library & Information Science, 3(2), 4-12.
- Hazarika, T., Sarma, D., and Sen, B.K.(2010). Scientometric portrait of nayana nanda borthakur: A biometeorologist. Annals of Library and Information Studies, 57(1), 21-32. http://digitalcommons.unl.edu/libphilprac/996/
- Husain, S., and Mushtaq M., (2010). Academic ranking of Indian central universities in science and technology as represented in science citation index-expanded: Scientometric study (2005–2009). COLLNET Journal of Scientometrics and Information Management. 4(2), 81-90.

- Jena, K.L. (2006). A bibliometric Analysis of the journal ' Indian Journal of Fibre and Textile Research' 1996-2004. Annals of Library and Information Studies, 53(1), 22-30. Retrieved from
- Joshi, K.,Kshitij, A., and Garg, K.C. (2010) Scientometric profile of global forest fungal research. Annals of Library and Information Studies, 57(2),130-139.
- Kademani, B. S., Kumar, V., Kumar, A., Sagar, A., Mohan, L., Surwase, G. and Gaderao, C. R. (2005). Publication Productivity of the bioorganic division at BHABHA Atomic Research Center: A Scientometric Study. Annals of Library and Information Studies, 52(4), 135-146.
- Kademani, B.S., Kalyane, V.L. and Kademani, A.B. (1994). Scientometric portrait of Nobel Laureate Dr.C.V.Raman. Indian Journal of Information Library and Society, 7(3-4), 215-249.
- Kademani, B.S., Kalyane, V.L. and Kumar, V. (2000). Scientometric portrait of Vikram Ambalal Sarabhai: A Citation Analysis. SRELS Journal of Information Management, 37(2),107-132.
- Kademani,B.S., Sagar,A., Kumar,V., and Gupta, B.M. (2007). Mapping of Indian Publications in S&T: A Scientometric Analysis of Publications in Science Citation Index. DESIDOC Journal of Library & Information Technology, 27(1), 17-34.
- Kalaiappan, V., Kaliyaperumal,K. and Rajasekar, V. (2010). Scientometric Analysis of Literature Output of Prof. G.N. Ramachandran in the Subjects of Biophysics and Crystallography. DESIDOC Journal of Library & Information Technology, 30(6), 3-11.
- Kaliyaperumal, K. and Natarajan, K. (2009). Scientometric analysis of literature output on retina. DESIDOC Journal of Library & Information Technology, 29(4), 33-36.
- Kalyane, V.L. and Kademani, B.S. (2005). Scientometric Portrait of R.Chidambaram:A Publication Productivity Analysis. Journal of Information Science, 5(3), 101-140.
- Kalyane, V.L. and Sen, B.K. (2003). Research Productivity of Tibor Braun: An Analytical Chemist-cum-Scientometrician. Annals of Library and Information Studies, 50, 47-61. Retrieved from http://nopr.niscair.res.in/handle/123456789/4113
- Kannappanavar, B. U. and Roopashree, N.T. (2011). Journal of genetics: A bibliometric study. SRELS Journal of Information Management, 48(6), 673-694.
- Kannappanavar, B.U. and Vijayakumar, M. (2001). Authorship Trend and solo V/s team research in International Monetary Fund Literature: a Bibliometric Study. Annals of Library and Information Studies, 48(3), 117-120.
- Kannappanavar,B.U., Swamy,C. Vijay Kumar,M.(2004). Publishing Trends of Indian Chemical Scientists: A Bibliometric Study. Annals of Library and Information Studies, 51(1), 11- 21. Retrieved from http://nopr.niscair.res.in/handle/123456789/7679
- Karki, M.M.S. and Garg, K.C. (1999). Scientometrics of Indian organic chemistry research. Scientometrics, 45(1), 107-116.

- Karpagam,R., Gopalakrishnan,S. and Ramesh Babu, B. (2011). Publication trend on nanotechnology among G15 countries: A bibliometric study. COLLNET Journal of Scientometrics And Information Management,5(1), 61-80.
- Karpagam,R., Gopalakrishnan,S., Natarajan, M. and Ramesh Babu, B. (2011). Mapping of nanoscience and nanotechnology research in India: a scientometric analysis, 1990–2009. Scientometrics, 89(2),501-522.
- Kaur, H., Mahajan, P. and Gupta, B.M. (2011). Scientometric analysis of the research output: A study of Government Medical College & Hospital (GMCH), Chandigarh. COLLNET Journal of Scientometrics and Information Management, 5(2), 217-226.
- Kaur, H. and Gupta, B.M.(2010). Mapping of Dental Science Research in India: AScientometric Analysis of India's Research Output, 1999-2008.Scientometrics, 85(1),361-376.
- Kaur, H. and Gupta,B.M. (2010).Mapping of Dental Science Research in India: A Scientometric Analysis of India's Research Output, 1999-2008.
 Scientometrics, 85(1),361-376. DOI:10.1007/s11192-010-0213-9
- Kaur, H. and Gupta,B.M.(2009). Indian Contribution in Immunology and Microbiology 1999-2008: A Scientometric Analysis. DESIDOC Journal of Library & Information Technology, 29(5),36-43.
- Kaur, H. and Gupta, B.M. (2009). Indian Contribution in Pharmacology, Toxicology & Pharmaceutics during 1998-2007: A Scientometric Analysis COLLNET Journal of Scientometrics and Information Science, 3(1), 1-9.

- Kaushik, A, Haldua, H and Arya, C. (2010). Pantnagar journal of research: A bibliometric study. Pantnagar Journal of Research, 8(1), 123-130.
- Keshava, Ganjihal, G.A.and Gowda, M.P.(2008). ACM transactions on information systems (1989–2006): A bibliometric study. Information Studies, 14(4),223-234.
- Keshava, Hittalamani, V.P. and Gowda, M. P.(2008). Papers in select sociology journals (1999–2004): A bibliometric analysis. Information Studies, 14(1), 59-65.
- Keshava, Chennakumaraswamy, A.N., Lokeshappa, H. and Ganjihal, G.A.(2010). A Scientometric portrait of Prof. S.S. Kubakaddi. PEARL: Journal of Library & Information Science, 4(1), 21-27.
- Khan,M.S.I., Ahmed,S.M.Z.,Munshi,M.N.U. and Akhter,N. (1998). Library and Information Science Literature in Bangladesh: A Bibliometric Study. Malaysian Journal of Library and Information Science,3(2), 11-34.
- Koley,S. and Sen, B.K.(2003). Indian Journal of Physiology and Allied Sciences: an analysis of Citation Pattern. Annals of Library and Information Studies, 50(1), 23-26. Retrieved from http://nopr.niscair.res.in/handle/123456789/4069
- Krishna,K.M and Kumar,S. (2004). Authorship Trends in Agriculture Research: A bibliometric analysis. SRELS Journal of Information Management, 41(2),229-234.
- Krishnamoorthy, G and Amudhavalli,A.(2008). Health Sciences in India: A Scientometric Study. COLLNET Journal of Scientometrics and Information Science, 2(2),79-85.

- Krishnamoorthy, G., Ramakrishnan, J. and Devi, S. (2009). Bibliometric analysis of literature on diabetes (1995 – 2004). Annals of library and Information Studies, 56(3), 150-155.
- Kulkarni, A. P., Poshett, B. and Narwade,G.R.(2009). Indian journal of pharmaceutical education and research (1996-2006): A bibliometric analysis.Annals of Library and Information Studies, 56(4), 242-248.
- Kumar, A., Kademani,B.S. and Kumar,V.(2008). Web-resources in inspec database: A scientometric mapping. SRELS Journal of Information Management, 45(2), 197-208.
- Kumar, A. and Prakasan, E. R. and Kalyane, V. L. and Kumar, V. (2008). Pramana -Journal of Physics: a scientometric analysis. Annals of Library and Information Studies, 55(1),52-61.
- Kumar, M. and Moorthy, A.L. (2011). Bibliometric analysis of DESIDOC Journal of Library and Information Technology during 2001–2010. DESIDOC Journal of Library & Information Technology, 31(3), 203-208.
- Kumar, S. and Kumar, S. (2005). A Bibliometric study of the Journal of Oilseeds Research, since 1993-2001.SRELS Journal of Information Management, 42(3),305-334.
- Kumar, S., and Garg,K.C.(2005). Scientometrics of computer science research in India and china. Scientometric, 64(2), 121-132. DOI: 10.1007/s11192-005-0244-9

- Kumaragurupari, R , Sieving, P.C. and Lalitha, P.(2010). A bibliometric study of publications by Indian ophthalmologists and vision researchers, 2001–06.Indian Journal of Ophthalmology, 58(4), 275-279.
- Kumbar, M. and Akhtary, S.(1998). Bibliometric analysis of Ophthalmology literature. Library Science with a Slant to Documentation and Information Studies,35(3),201-207.
- Lalitha K.G. (2009). Synthetic Organic Chemistry research: Analysis by scientometric indicators. Scientometrics, 80(3), 559-570. DOI: 10.1007/s11192-007-1985-4
- Mahapatra, G and Das, B.(2000). Impact of research collaboration on growth of literature in geology: a bibliometric study. SRELS Journal of Information Management, 37(2), 95-105.
- Mahapatra, R.K and Sahoo,J.(2004). Doctoral Dissertations in Library and Information Science in India 1997-2003: A bibliometric Study. Annals of Library and Information Studies, 51(1), 58-63.
- Mahapatra, R.K. and Panda, K.C.(2004). Health Research Literature on Orissa: A Bibliometric Analysis. SRELS Journal of Information Management, 41(4), 383-392.
- Mahapatra,R. K. and Jena, P. (2006). Scientific research productivity on Orissa: A bibliometric analysis. Annals of Library and Information Studies, 53(1), 18-21.
- Maharana,B., Majhi, S. and Sethi, B.B. (2011). Citation analysis of top research papers in chemistry with specific reference to India. Library Review, 60(6), 501-512. Doi: 10.1108/00242531111147215

- Maheswaranan, S .(2009).Scientometric Analysis of Area-Wise Publications in the Field of Structural Engineering: A Case Study of SERC, India. Annals of Library and Information Studies, 56(1), 22-28.
- Mamdapur, G. M.N., Govanakoppa,R.A and Rajgoli,I.U.(2011). Baltic astronomy (2000–2008) A bibliometric study. Annals of Library and Information Studies, 58(1), 34-40.
- Manjula, K and Chudamani, K.S. (2010). Contributions of scientometric ranking algorithms of universities in Karnataka: A study. PEARL: Journal of Library & Information Science, 4(3), 167-176.
- Mela, G.S., Martinoli, C., Poggi, E. and Derchi L.E.(2003). Radiological research in Europe: A bibliometric study. European Radiology, 13(4),657-662.
- Mittal,R., Sharma, A. and Singh, G. (2006). Periodical Literature on Library and Information Science Education: A bibliometric study. Annals of Library and Information Studies, 54, 224-229. Retrieved from http://nopr.niscair.res.in/bitstream/123456789/6030/1/ALIS%2053%284%29 %20224-229.pdf
- Modak, J.M. and Madras,G.(2008). Scientometric analysis of chemical engineering publications. Current Science, 94(10), 1265-1272.
- Mukherjee, B.(2009). Do open-access journals in library and information science have any scholarly impact? A bibliometric study of selected open-access journals using Google Scholar. Journal of the American Society for Information Science and Technology, 6(3),581-594

- Mukherjee, N., Dahdouh-Guebas, F., Kapoor, V., Arthur, R., Koedam, N., Sridhar, A,
 Shanker, K. (2010). From Bathymetry to Bioshields: A Review of Post-Tsunami Ecological Research in India and its Implications for Policy. Environmental Management, 46(3), 329-339.
- Mulla, K R and Chandrashekara, M. (2011). Bibliometric analysis of literature on industry and trade. Information Studies, 17(2), 99-114.
- Munnolli, S. S., Pujar, S. M. and Kademani, B. S. (2011). Scientometric portrait of nobel laureate harald zur hausen. Annals of Library and Information Studies, 58(1), 71-78.
- Munnolli, S.S. and Kalyane, V L. (2003). Scientometric Portrait of Ram Gopal Rastogi. Annals of Library and Information Studies, 50(1), 01-17. Retrieved from http://nopr.niscair.res.in/handle/123456789/4067
- Nandi A. and Bandyopadhyay, A.K.(2008). Indian economic review (1998-2002):a bibliometric study. SRELS Journal of Information Management, 45(1),95-100.
- Narang, A. (2004). Indian Journal of Pure and Applied Mathematics: A Bibliometric study. Annals of Library and Information Studies, 51(1), 28-38. Retrieved from http://nopr.niscair.res.in/handle/123456789/7678
- Narang, A. and Kumar, A. (2010). A Bibliometric study of Indian Journal of Pure and Applied Mathematics. SRELS Journal of Information Management, 47(1), 31-39.
- Nazim, M. and Moin, A. (2008). A bibliometric analysis on nanotechnology research. Annals of ibrary and Information Studies, 55(4), 292-299.

- Neelameghan, A.and Rao I.K. R.(2012). Bibliometric support to medical historiography: a case study of the incidence of communicable diseases in 19th century India. Information Studies, 11(2), 79-92.
- Nishy, P., Panwar, Y., Prasad, S., Mandal, G.K. and Prathap, G. (2012). An impactcitations-exergy (iCX) trajectory analysis of leading research institutions in India. Scientometrics, 9(1), 245-251.
- Nishy, P., Parvatharajan, P. and Prathap, G. (2012). Visibility and impact of the Indian journal of chemistry, section B during 2005–2009 using scientometric techniques. Indian Journal of Chemistry Section B - Organic Including Medicinal, 51b(1), 269-284.
- Parameswaran, M. and Smitha, K.G. (2001). Bibliometric analysis of LISA. Annals of Library and Information Studies, 48(4), 149-156.
- Patil, S. B. (2010). Herald of library science: A bibliometric study. SRELS Journal of Information Management, 47(3), 351-358.
- Patra,S.K. and Chand,P .(2006). Library and Information Science Research in India:
 A bibliometric study. Annals of Library and Information Studies 53(4), 219-223. Retrieved from http://nopr.niscair.res.in/handle/123456789/6029
- Pradhan, P. and Chandrakar, R. (2011). Indian LIS Literature in International Journals with Specific Reference to SSCI Database: A Bibliometric Study Library. Philosophy and Practice. Retrieved from http://www.webpages.uidaho.edu/~mbolin/pallab-chandrekar.htm

- Raghuraman, K.P., Chander, R. and Madras, G. (2010). Scientometric analysis of some disciplines: Comparison of Indian institutions with other international institutions. Current Science, 99(5), 577-587.
- Raja, S., Ramkumar, P. and Viji, P. (2011). Scientometric dimension on gender in worldwide thyroid cancer: A study based on web of science database. Indian Journal of Science and Technology, 4(4), 425-428.
- Rajendran, P., Babu, R. and Gopalakrishnan, S. (2005). Bibliometric Analysis of
 'Fiber Optics' Literature. Annals of Library and Information Studies, 52 (3),
 82-85.
- Rajyalakshmi,D. and Deshpande, M.(1997). Citation study of dissertations in Library and Information Science. Annals of Library Science and Documentation, 44(2), 41-53.
- Ramesh, L. S.R.C.V., Ramana, P.V. and Hussain, M.V. (2000). Publication pattern in Oryza (Oryza sativa L) from 1986-1995: a bibliometric study. SRELS Journal of Information Management, 37(3), 215-27.
- Ray, P.P. and Sen, B.K. (2012). Gitanjali (Song Offerings): A Bibliometric Study. SRELS Journal of Information Management, 49(6), 601-613.
- Rivera, G., Puras, G., Palos, I., Ordaz-Pichardo, C. and Bocanegra-Garcia, V. (2010). Bibliometric analysis of scientific publications in the field of medicinal chemistry in Latin America, the People's Republic of China, and India. Medicinal Chemistry Research, 19(6), 603 - 616.
- Roy, P.C. (2004). Authorship Pattern of Indian Library Science journals for the period of 1991-2000. SRELS Journal of Information Management, 41(4), 393-404.

- Sagar, A., Kalyane, V. L., Prakasan, E. R., Garg, R. G. and Kumar, Vijai (2009). Scientometric Highlights on Science and Technology Related Review Articles Affiliated to India. Malaysian Journal of Library & Information Science, 14(2), 83-99. Retrieved from http://eprints.rclis.org/13114/
- Sangam,S. L., Savanur, K. and Manjunath, M. (2007). Communication and collaborative research pattern of Sivaraj Ramaseshan: A scientometric portrait. Scientometrics, 71(2), 217-230.
- Saravanan, P., Ramachandran, S., Rooban, T. and Madan Kumar, P.D. (2010). Contributions of Indian conservative dentists and endodontists to the Medline database during 1996–2009: A bibliometric analysis. Journal of Conservative Dentistry, 13(4), 169-172. doi: 10.4103/0972-0707.73374
- Sarkhel, J. K. and Choudhury, N.R. (2010). Contributions of bidhan chandra krishi viswavidyalaya to agricultural research: A bibliometric study. Annals of Library and Information Studies, 57(4), 348-355.
- Savanur, K. and Konnur, P.V. (2012). Growth and Impact of Research Output of Bangalore University, 1971-2010: A Scientometric Study. International Journal of Library and Information Science, 4(5), 71-80.
- Senthil kumaran,P. and Vadivel,V. (2003). Spice India :A Bibliometric Study. SRELS Journal of Information Management, 40(4), 431-438.
- Senthil kumaran,P. and Vadivel,V. (2004). Journal of Spices and Aromatic Crops: A bibliometric Appraisal. SRELS Journal of Information Management, 41(1), 121-131.

- Sevukan, R. and Sharma, J.(2008). Bibliometric analysis of research output of biotechnology faculties in some Indian Central Universities. DESIDOC Journal of Library & Information Technology, 28(6), 11-20.
- Sharma, R.M. (2009). Research publication trend among scientists of central potato research Institute: a bibliometric study. Annals of Library and Information Studies 56(1), 29-34.
- Shokeen, A. and Kaushik, S.K.(2004). Indian Journal of Plant Physiology: A Citation Analysis. Annals of Library and Information Studies, 51, 104-107.
- Shri Ram (2011).Research output on Artemisia (Artemisia annua): A bibliometric study. Annals of Library and Information Studies, 58(3), 237-248.
- Shukla, M.C., Saksena,S. and Riswadkar, M.R. (2001). Application of Bradford's and Lotka's Distribution to Bio-energy Literature: A study Based on ten Abstracting services. Annals of Library and Information Studies, 48(4), 149-156. Retrieved from http://nopr.niscair.res.in/handle/123456789/4164
- Singh, G., Ahmad, M. and Nazim, M. (2008). A bibliometric study of Embelia ribes. Library Review, 57(4), 289-297.
- Singh, K.P., Jain, A. and Babbar, P. (2011).Desidoc bulletin of information technology: A bibliometric study. SRELS Journal of Information Management, 48(1), 57-68.
- Singh, N. and Dominic, J. (2006). An Analysis of citation pattern of Allelopathy Journal: A Case study. IASLIC Bulletin, 51(1), 37-41.

- Sinha,S.C. and Dhiman, A.K. (2001). A Bibliometric study of Dr. R.C. Sinha, a Plant pathologist. Annals of Library and Information Studies, 48(2), 73-84.
- Sivasubramanian, V. (2000). Journal of Indian coffee: a bibliometric survey. Annals of library Science and Documentation, 47(2), 75-79.Retrieved from http://nopr.niscair.res.in/handle/123456789/17921
- Sudhier, K.G.P. and Dileep, K.V. (2010). Scientometric Study of Doctoral Dissertations in Biochemistry in the University of Kerala, India. Library Philosophy and Practice. Retrieved from http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1411&context=libp hilprac
- Surwase, G., Kademani, B.S. and Kumar, V. (2008). Scientometric dimensions of pulsed laser deposition research: a global perspective. Annals of Library and Information Studies, 55(2), 101-110. Retrieved from http://nopr.niscair.res.in/handle/123456789/1771
- Suryanarayana, Y.V.(2000). Bibliometric analysis of Contributions of Journal Tobacco research. Annals of Library Science and Documentation, 47(3), 81-100. Retrieved from http://nopr.niscair.res.in/handle/123456789/17923
- Thanuskodi, S.(2010). Journal of social sciences: A bibliometric study. Journal of Social Sciences, 24(2),77-80. Retrieved from http://www.krepublishers.com/02-Journals/JSS/JSS-24-0-000-10-Web/JSS-24-2-000-10-Abst-PDF/JSS-24-2-77-10-1119-Thanuskodi-S/JSS-24-2-77-10-1119-Thanuskodi-S-Tt.pdf

- Thirumagal, A.(2012). Bibliometric Study of Nanotechnology in India: An Analysis. SRELS Journal of Information Management, 49(5), 577-587.
- Tian, Y., Wen,C. and Hong, S.(2008). Global scientific production on GIS research by Bibliometric analysis from 1997 to 2006. Journal of Informetrics ,2 , 65– 74.
- Upadhye, R.P., Kademani, B.S., Surwase, G., Kumar, V.(2010).Scientometric dimensions of the nuclear physics division at bhabha atomic research centre. SRELS Journal of Information Management, 47(4), 437-448.
- Vijay, K.R. (2005). Bibliometric study of research publication trends among Indian Food Scientists and Technologists. Annals of Library and Information Studies, 52(3), 77-81. Retrieved from http://nopr.niscair.res.in/handle/123456789/3998
- Vijaylakshmi,S. and Ambuja, R.(2013). Growth of Remote Sensing Literature:A Bibliometric Analysis. Journal of Advances in Library and Information Science, 2(3), 157-165.
- Zafrunnisha, N. and Reddy, V.P. (2009). Indian journal of marketing: A bibliometric study. PEARL: Journal of Library & Information Science, 3 (4), 18-23.
- Zhang, H., Huang, M., Qing, X., Guoqing Li and Tian, C. (2017). Bibliometric Analysis of Global Remote Sensing Research during 2010–2015, International Journal of Geo-Information, 6(332), pp. 1-18.
- Zhuang, Y., Liu, X., Nguyen, T. He, Q. and Hong, S. (2013). Global remote sensing research trends during 1991–2010: a bibliometric analysis, Scientometrics, 96(1), 203-219.

3.1 Introduction

Research is a conscious and planned, critical and exhaustive intellectual activity, devoted to investigation of a phenomenon with the objective of expanding the frontiers of existing stock of knowledge. Such a process of investigation becomes scientific when a designated set of methods or techniques are applied to secure, measure, analyse and interpret data in a cycle of research ranging from the choice of a problem to the writing of the final report.

The research is a process, similar to undertaking a journey. There are practical steps through which we must pass in our research journey in order to find answers to our research questions.

3.2 Research Method:

This study employs bibliometrics as its research method. Bibliometrics (sometimes called scientometrics) turns the main tool of science, quantitative analysis, on itself. there are various definitions used for "bibliometrics." essentially, bibliometrics is the application of quantitative analysis and statistics to publications such as journal articles and their accompanying citation counts. It is used in research performance evaluation, especially in university and government labs, and also by policymakers, research directors and administrators, information specialists and librarians, and researchers themselves. (Thomson Reuters, 2009).

Steps in Research Process

Formulating the Research Problem



Extensive Literature Review



Developing the objectives



Preparing the Research Design including Sample Design



Collecting the Data



Analysis of Data



Generalization and Interpretation



Preparation of the Report

3.3 Database and Scope

The database used for retrieving data is the Web of Science (WoS), which is an online subscription-based scientific citation indexing service originally produced by the Institute for Scientific Information (ISI), now maintained by Clarivate Analytics (previously the Intellectual Property and Science business of Thomson Reuters), that provides a comprehensive citation search. It gives access to multiple databases that reference cross-disciplinary research, which allows for in-depth exploration of specialized sub-fields within an academic or scientific discipline ("Web of Science," n.d.).

Scope of the study is confined to research publications in the fields of Remote Sensing (RS) and Geographical Information System (GIS) by Scientists having India as the country of affiliation. Documents published only in English language during the period 1991 to 2014 have been considered for data collection.

3.4 Search Strategy:

Advanced search strategy is used for retrieving data from the WoS. For retrieving data in GIS ("Geograp* Information Sys*") *OR* ("GIS") in the TOPIC" is taken.

Similarly for the RS field the database is searched under the keyword "Remot* sens*" and "remote sensing" which includes all entries like "remote sense", "remote sensor", "remoting sensing", "remote sensory", "remoted sensing", "remotely sensing", "remotely sense", "remote sensed", "remotely sense", "remote sensing", "space remote sensing",

3.5 Data sorting procedure:

To obtain the relevant set of documents from the retrieved raw set of documents in the WoS, further data sorting becomes essential. For this process, the documents are filtered by attributes like countries, language etc. The resultant retrieved documents are called as the core documents which now consist of three categories of data namely, the citation data, bibliographic data and keyword data. This set of documents is now downloaded from the WoS database and recorded in a MS Excel sheet.

- The master file of the bibliographic data set consists of the following fields:
 - Author
 - Title of document
 - Year of publication
 - Subject of document
 - Type of document
 - Journal
 - Collaboration
 - Affiliation
 - Number of documents
- The master file of the Citation data set consists of the following fields:
 - Direct Citation Count
 - Average Citation
 - h-index
 - Top cited articles
- Keyword data consists of:
 - Author assigned keywords

3.6 Data Analysis:

The downloaded data is then analyzed using MS Excel, Origin software which is a proprietary computer program for interactive scientific graphing and data analysis. Another application which has been used to analyse the data is R, which is a programming language and free software environment for statistical computing and graphics that is supported by the R Foundation for Statistical Computing. The R language is widely used among statisticians and data miners for developing statistical software and data analysis. R is run on the platform RStudio which is a free and open-source integrated development environment for R. Bibliometrix is a package in R, which provides a set of tools for quantitative research in bibliometrics and scientometrics. Bibliometrix package has been used to analyse the publication dataset; building matrices for collaboration, and co-word analysis. It has also been used for performing network analysis and a few other data reduction techniques. APA 6th edition referencing style format has been used in this study

3.7 Summary:

This chapter gives a description of the research methodology utilized while carrying out the research work. It discusses Bibliometrics, steps involved in the research process. The chapter further talks about the Web of Science Database and the scope of the study. Search strategy undertaken has been explained in the later section of the chapter followed by the data sorting procedures involved. The chapter ends with a discussion on data analysis part and the tools undertaken for executing the same. To sum up, this chapter gives a narration on the research methodologies that will be seen in the coming chapter.

3.8 References:

ThomsonReuters.2009.Retrievedfromhttp://ipscience.thomsonreuters.com/m/pdfs/325133_thomson.pdf

VandenBos, G.R. (Ed). (2010). Publication manual of the American Psychological Association (6th ed.), Washington, DC:A American Psychological Association.

Web of Science. (n.d.). Retrieved from https://apps.webofknowledge.com.

4.1 Introduction

Data analysis can be described as the procedure of evolving solutions to the posed problems by the use of data investigation and interpretation. The steps involved in the process of data analysis mainly comprises of process consists of identifying issues, determining the availability of suitable data, deciding on which methods are appropriate for answering the questions of interest, applying the methods and evaluating, summarizing and communicating the results.

In this study of GIS and Remote Sensing the quantitative analysis of data has been undertaken, duplicate data was deleted from the master list. Quantitative data in this study has been analysed using a range of descriptive and inferential statistical procedures, MS-Excel and Bibliometrix package in R has been used for the analysis. The same has been presented in percentage and frequency form thereafter, illustrated in charts (e.g. pie, line, bar graph etc.) and tables using Microsoft Excel and Originpro. Similar methodology has been followed for the qualitative data as well, taking into consideration the number of times a journal article has been cited by other researchers.

This chapter portrays the bibliometric evaluation of the GIS and Remote Sensing research in India over the period of twenty-three years using the data collected from

the Web of Science database. The data analysis and interpretation follow in the proceeding sections:

4.2 Geographical Information System (GIS)

Quantitative Analysis: The data retrieved for GIS consisted of 1488 publications, these publications are analysed using different parameters. Table 4.2 shows the basic information about the retrieved data set pertaining to the publications.

Main Information abou	t publications
Documents	1488
Sources (Journals, Books, etc.)	412
Keywords Plus (ID)	2308
Author's Keywords (DE)	3513
Period	1991 - 2014
Average citations per documents	7.385
Authors	3272
Author Appearances	5528

Table 4.2: Publication Details of GIS

4.2.1 Publication Counts:

In 1991 first two publications have been reported which grew to 197 in 2014. The Table 4.2.1 shows the number of publications appearing each year during 1991 to 2014 by Indian Scientists.

Year	Articles
1991	2
1992	2
1993	8
1994	3
1995	8
1996	11
1997	16
1998	20
1999	10
2000	24
2001	22
2002	25
2003	26
2004	39
2005	77
2006	74
2007	100
2008	105
2009	112
2010	144
2011	144
2012	144
2013	175
2014	197

 Table 4.2.1: Publication counts per year in GIS

4.2.2 Publication Type:

A total of 1488 publications have appeared in 412 documentary sources. Chart 4.2.2 shows the distribution of these publications, articles-1419 constitute the largest share. (95.36%), reviews- 46 (3.09%), proceedings - 36(2.41%), editorials - 11(0.73%), meeting abstracts - 6 (0.40) and letters are 4 in number and constitute a small share (0.26%).



Chart 4.2.2: Distribution of research among type of documents in GIS

4.2.3 Publication Growth Pattern

The publication pattern shows high rise in the number of publications during the 24year period. The annual number of publications in GIS increased from 2 (0.134 %) in 1991 to 197(13.239 %) in 2014 which illustrated a meteoric growth in the number of publications.



Graph 4.2.3: Growth of Publications in GIS

In mathematical terms:

• The Growth Rate (GR) of this data set can be illustrated as -

Growth Rate = Present – Past / Past * 100 = 9750 %

Thus, the growth rate of research publications in GIS is 9750% which is very huge rate of increase. This also means that the number of papers in 1991 grew 97.5 times in 2014. The growth is depicted in Graph 4.2.3

• The average annual growth rate (AAGR) of GIS publications is, as depicted below:

Annual Average Growth Rate = $((Present/Past)^{1/n} - 1) * 100$

Where n = number of years

Therefore, Average Annual GR in this case is 20%

This shows that the research publications on GIS have increased at an average rate of 20 percent per year over a period of 24 years.

• The **Compound average growth rate** (CAGR) of GIS publications is 22.08%.

The CAGR number shows us that the publications have given a stable output throughout 24-year period, even if the number kept fluctuating a great deal between

the years. In all manners the growth rate shows a very significant rise in publications, which is a good sign and shows the development of the subject.

4.2.4 Growth Trend

The growth curve indicates an exponential increase though the best fit comes out to be that of a second-degree power law equation. The data shows a very high coefficient of determination ($R^2 = 0.979$), indicating a high rate of increase in the number of publications. The polynomial best fit as shown in the Graph 4.2.4 for GIS research is found to be: $y = 0.467x^2 - 1865.x + 2E+06$, where y is the cumulative number of publications and x is the number of years since 1991.



Graph 4.2.4: Growth trend of GIS research in India during 1991-2014

4.2.5 Scholarly Impact

The publications by the Indian scientists for the period 1991-2014 received a total of 10989 citations during the 24-year period with an average of about 7.39 citations per paper and an h index of 44, implying a good quality of research. Table 4.2.5 shows the various citation values.

Citation-based indicators	Number
Total Article found	1488
Sum of the Times Cited	10989
Sum of Times Cited without self-citations	9146
Citing Articles	7877
Citing Articles without self-citations	7205
Average Citations per Item	7.39
h-index	44

 Table 4.2.5: Scholarly Impact of GIS

4.2.6 Citation impact of source documents:

It is important to note that from the data in Table 4.2.6, the Review articles tend to attract the highest citation rates (17.65). Although document type – Articles has the highest no. of publications but ranks 3rd in the Citation Per Paper (hereafter CPP), Editorial Materials with Meeting Abstract papers attracting the lowest counts.

Document Type	Publication	%	Publication Citation	CPP
Article	1419	95.363	10166	7.16
Review	46	3.091	812	17.65
Proceedings Paper	36	2.419	388	10.78
Editorial Material	11	0.739	10	0.91
Meeting Abstract	6	0.403	1	0.17
Letter	4	0.269	0	0.00

Table 4.2.6: Citation rates across different types of documents in GIS

CPP: Citation per paper. Source: Web of Science (WoS)

4.2.7 Publication Vs Citation Pattern

1488 publications on GIS received a total of 10989 citations. Graph 4.2.7 depicts the year wise total number of publications and the citations received per paper per year. From this figure we can infer that the two variables i.e. the number of publications and the citations received are independent of each other, these two rises and fall separately and no apparent relation is found. It is important to mention that there are just two publications in 1992 and the number of citations is 135, it is assumed that this may be due to the field being nascent or the quality of research done at that time. However, the highest number of papers are in the year 2014, the maximum citations date back to the year 2007 i.e. 1248, this shows the research impact of the research in that year.



Graph 4.2.7: Publication vs Citations in GIS

4.2.8 Subject wise distribution of publications

Based on the classification of subject categories in the Web of Science, GIS research covered 111 subject categories. Top 10 subject categories are Environmental Sciences (450), Geosciences Multidisciplinary (349), Remote Sensing (292), Water Resources (280), Multidisciplinary Sciences (162), Engineering Civil (108), Imaging Science Photographic Technology (106) Meteorology Atmospheric Sciences (86), Ecology (54) and Engineering Electrical Electronic (49). Graph 4.2.8 demonstrate annual growth chart of articles of top 10 subject categories.



Graph 4.2.8: Comparison of Growth trends of the top productive subject categories in GIS

The number of articles in environmental sciences leaped considerably in 2014. This is an indication of recent emphasis on environmental sciences, Geosciences multidisciplinary and remote sensing research. The visible changes in the number of articles among the subject categories symbolizes the frequent shift in research focus during the period of study.

4.2.9 Top WoS Subject categories and their citation impact

The Table 4.2.9 shows the citation impact of top 20 subject categories according to the web of Science subject categories. It is seen from the above table that the subject categories "Agriculture Multidisciplinary" has the highest average impact (Avg.C=17.22) although the subject category "Environmental Sciences" has the highest no. of publication (450) with highest citation (2641) but ranked 17th in the Avg.C index.

Web of Science Categories	TP	% of TP	TC	Avg.C
Environmental Sciences	450	30.242	2641	5.87
Geosciences Multidisciplinary	349	23.454	2422	6.94
Remote Sensing	292	19.624	2193	7.51
Water Resources	280	18.817	2370	8.46
Multidisciplinary Sciences	162	10.887	831	5.13
Engineering Civil	108	7.258	1139	10.55
Imaging Science Photographic Technology	106	7.124	1511	14.25
Meteorology Atmospheric Sciences	86	5.780	389	4.52
Ecology	54	3.629	190 <mark>4</mark>	11.75
Engineering Electrical Electronic	49	3.293	207	4.22
Geography Physical		3.024	399	8.87
Geography Physical Public Environmental Occupational Health		2.487	322	8.7
Ecology Engineering Electrical Electronic Geography Physical Public Environmental Occupational Health Agronomy Engineering Environmental Agriculture Multidisciplinary		2.285	229	6.74
Engineering Environmental	33	2.218	364	11.03
Agriculture Multidisciplinary	32	2.151	551	17.22
Computer Science Interdisciplinary Applications	31	2.083	238	7.68
Environmental Studies	24	1.613	165	6.88
Biodiversity Conservation	24	1.613	280	11.67
Geography	20	1.344	219	10.95
Urban Studies	19	1.277	169	8.89

Table 4.2.9: Top WoS Subject categories and their research impact in GIS

4.2.10 Top Institutions

Table 4.2.10 shows the top 15 productive institutions during years 1991-2014. IIT Kharagpur tops the list in number of publications, total citation counts, average citations and h index, this data shows how good the research in GIS is at IIT Kharagpur both in quantitative and qualitative terms. Other notable contributions are from IIT Roorkee (4.427%), IIRS (4.359) and IIT Bombay (4.159%). Out of twenty top Institutions, 5 are the IIT's, 2 Institutions belong to the Department of Space/ Indian Space Research Organization, others are Research Laboratories and Universities. It will be good to mention that Universities like Aligarh Muslim University, Jawaharlal Nehru University have very good results and seem quite at par with the renowned Research Institutes of National Importance in spite of the general belief of Universities having less resources and funds.

Institution	TNA (%)	TC	Avg.C	<mark>c h-index</mark>
Indian Institute of Technology Kharagpur	87 (5.83)	1187	13.64	20 -
Indian Institute of Technology Roorkee	66 (4.42)	881	13.35	16
Indian Institute Remote Sensing	65 (4.35)	469	7.22	11
Indian Institute of Technology Bombay	62 (4.15)	551	8.89	14
National Remote Sensing Centre	60 (4.02)	388	6.47	11
Jawaharlal Nehru University	39 (2.61)	431	11.05	10
Indian Institute of Science	39 (2.61)	287	7.36	9
Anna University	33 (2.21)	257	7.79	7
National Institute of Hydrology	31 (2.07)	287	9.26	10
Ministry of Earth Sciences	31 (2.07)	178	5.47	8
Indian Agricultural Research Institute	25 (1.67)	245	9.80	8
Birla Institute of Technology	22 (1.47)	65	2.95	4
National Geophysical Research Institute India	19 (1.27)	205	10.79	6
National Environmental Engineering	19 (1.27)	100	5.26	7
Research Institute				
Geological Survey India	19 (1.27)	102	5.37	7

Table 4.2.10: Top Institution and their research impact in GIS

4.2.11 Top Journals

Articles on GIS appeared in 402 journals (Table 4.2.11). GIS research in India appeared in highest numbers in the "Journal of the Indian Society of Remote Sensing", published by the Society itself, followed by the journal "Current Science". These 20 out of the 402 journals had published 788 (52.95 %) of the total 1488 articles. An important point to mention here is that the "Journal of Hydrology" though ranks 13th in the number of publications ranking it has the highest AvCPA (18.38) which shows that it has high impact.

Journal	TNA(%)	TC	AgC
Journal of the Indian Society of Remote Sensing	170(11.424)	450	2.65
Current Science	116(7.796)	666	5.74
International Journal of Remote Sensing	64(4.301)	1171	18.3
Journal of the Geological Society of India	53(3.562)	118	2.23
Water Resources Management	46(3.091)	565	12.28
Environmental Monitoring and Assessment	44(2.957)	243	5.52
Environmental Earth Sciences	40(2.688)	195	4.88
Arabian Journal of Geosciences	39(2.621)	87	2.23
Natural Hazards	32(2.151)	129	4.03
Geocarto International	26(1.747)	41	1.58
Journal of Earth System Science	19(1.277)	77	4.05
Hydrological Processes	17(1.142)	179	10.53
Journal of Hydrology	16(1.075)	294	18.38
Environmental Geology	16(1.075)	235	14.69
Tropical Ecology	14(0.941)	50	3.57
Hydrological Sciences Journal	14(0.941)	197	14.07
Disaster Advances	14(0.941)	109	57
Indian Journal of Agricultural Sciences	11(0.739)	3	0.27
Agricultural Water Management	11(0.738)	183	16.64
Hydrogeology Journal	9(0.604)	54	6
IEEE Transactions on Dielectrics and Electrical	9(0.604)	46	5.11
Journal of Hydrologic Engineering	8(0.537)	21	2.62

Table 4.2.11: Top Journals and their research impact in GIS

4.2.12 Top Authors

The 1488 counts on GIS have been contributed by 3272 authors. Table 4.2.12(a) shows the top 20 productive authors during the 24-year period. These 20 out of the 3272 authors had published 344 (23%) of the total 1488 publications. Top 20 productive authors are ranked based on the number of publications. Out of these 20 productive authors, Roy, P.S. produced maximum publications 29 (1.949 %) followed by Kumar, S. 26 (1.747 %), Mukherjee, S. 23(1.546%) respectively. It is seen from the above table that GIS related articles authored by Chowdary, V. M. have the highest average impact (AvgCPA=20.84) followed by Mal BC (AvgCPA=16.92) and though Roy, P.S. leads the list in number of publications, is ranked 4th in the AvgCPA index.

Author	TP (%)	TC	TC woSC	CI	CIwoSC	AgC	h-index
Roy DS	20(1.040)	304	287	255	245	10.48	10
Kumar S	26(1 747)	144	141	130	136	5 54	7
Mukheriee S	23(1.546)	103	163	148	132	8 39	7
Singh R	22(1.478)	147	145	147	145	6.68	8
Kumar, A.	21(1.411)	44	41	42	40	2.1	4
Chowdary, V. M.	19(1.277)	396	366	326	312	20.84	10 +
Singh, C. K.	17(1.142)	85	73	71	62	5	6
Reddy, C. S.	17(1.142)	42	23	31	21	2.47	3
Dadhwal, V. K.	17(1.142)	87	80	85	80	5.12	5
Vijith, H	16(1.075)	99	94	91	87	6.19	7
Singh S	15(1.008)	76	76	75	75	5.07	6
Kumar R	15(1.008)	82	80	73	71	5.47	6
Srivastava PK	14(0.941)	133	100	76	66	9.5	7
Pandey A	14(0.941)	221	208	180	174	15.79	8
Kushwaha SPS	14(0.941)	94	86	85	79	6.71	6
Srivastava A	13(0.874)	101	90	84	79	7.77	7
Panigrahy S	13(0.874)	60	57	57	54	4.62	5
Mal BC	13(0.874)	220	209	200	193	16.92	9
Ghosh S	13(0.874)	61	53	50	45	4.69	6
Chandrasekar N	13(0.874)	65	49	44	39	2.82	4

Table 4.2.12(a): Top Authors and their research impact in GIS

TP (%): Total no. of GIS related publications by an author (followed by percentage of GIS related articles by an author of the total GIS related article) TC: Total no. of citation; TC woSc: Sum of Times Cited without self-citations; CI: Citing Articles; CIwoSC: Citing Articles without self-citations; AgC: Average Citations per Article; h-index: h articles cited at least h times

Another important way of indicating the top authors is by ranking them by their Dominance Factor (DF), the Dominance Factor is a ratio indicating the fraction of multi-authored articles in which a scholar appears as the first author. Table 42.12(b) indicates the top authors ranked by their dominance factor.

	Dominance	Multi	First	Rank
Authors	Factor	Authored	Authored	by DF
GHOSH S	0.61538462	13	8	1
SRIVASTAVA A	0.61538462	13	8	2
PANDEY A	0.57142857	14	8	3
JAIN SK	0.53846154	13	7	4
REDDY CS	0.52941176	17	9	5
KUMAR S	0.42307692	26	11	6
KUMAR R	0.4	15	6	7
VIJITH H	0.375	16	6	8
KUMAR A	0.36363636	22	8	9
SRIVASTAVA PK	0.35714286	14	5	10
SINGH CK	0.35294118	17	6	11
SINGH R	0.27272727	22	6	12
CHOWDARY VM	0.26315789	19	5	13
ROY PS	0.20689655	29	6	14
SINGH S	0.2	15	3	15
PANIGRAHY S	0.15384615	13	2	16
KUSHWAHA SPS	0.14285714	14	2	17
JHA CS	0.08333333	12	1	18
CHANDRASEKAR N	0.07692308	13	1	19
MUKHERJEE S	0.04347826	23	1	20

Table 4.2.12 (b) Authors listed in order of dominance factor in GIS

4.2.13 Top Cited Publication

S.No.	Bibliography	TC
1	Xiao, X. M., Boles, S., Frolking, S., Li, C. S., Babu, J. Y., Salas, W., & Moore, B.	165
	(2006). Mapping paddy rice agriculture in South and Southeast Asia using multi-	
	temporal MODIS images. Remote Sensing of Environment, 100(1), 95-113.	
	http://doi.org/10.1016/j.rse.2005.10.004	
2	 Xiao, X. M., Boles, S., Frolking, S., Li, C. S., Babu, J. Y., Salas, W., & Moore, B. (2006). Mapping paddy rice agriculture in South and Southeast Asia using multi-temporal MODIS images. <i>Remote Sensing of Environment, 100</i>(1), 95–113. http://doi.org/10.1016/j.rse.2005.10.004 PACHAURI, A., & PANT, M. (1992). LANDSLIDE HAZARD MAPPING BASED ON GEOLOGICAL ATTRIBUTES. Engineering Geology, 32(1-2), 81–100. http://doi.org/10.1016/0013-7952(92)90020-Y Kanungo, D. P., Arora, M. K., Sarkar, S., & Gupta, R. P. (2006). A comparative study of conventional, ANN black box, fuzzy and combined neural and fuzzy weighting procedures for landslide susceptibility zonation in Darjeeling Himalayas. <i>Engineering Geology</i>, 85(3-4), 347–366. http://doi.org/10.1016/j.enggeo.2006.03.004 Saha, A. K., Gupta, R. P., & Arora, M. K. (2002). GIS-based Landslide Hazard Zonation in the Bhagirathi (Ganga) Valley, Himalayas. <i>International Journal of Remote Sensing</i>, 23(2), 357–369. http://doi.org/10.1080/01431160010014260 Saraf, A. K., & Choudhury, P. R. (1998). Integrated remote sensing and GIS for groundwater exploration and identification of artificial recharge sites. <i>International Journal of Remote Sensing</i>, 19(10), 1825–1841. http://doi.org/10.1080/014311698215018 Prakash, A., & Gupta, R. P. (1998). Land-use mapping and change detection in a goal mining area - a case study in the Jharia coalfield, India. <i>International Journal</i> 	134
	BASED ON GEOLOGICAL ATTRIBUTES. Engineering Geology, 32(1-2), 81-	
	100. http://doi.org/10.1016/0013-7952(92)90020-Y	
3	Kanungo, D. P., Arora, M. K., Sarkar, S., & Gupta, R. P. (2006). A comparative	119
	study of conventional, ANN black box, fuzzy and combined neural and fuzzy	
	weighting procedures for landslide susceptibility zonation in Darjeeling	
	Himalayas. Engineering Geology, 85(3-4), 347–366.	
	http://doi.org/10.1016/j.enggeo.2006.03.004	
4	Saha, A. K., Gupta, R. P., & Arora, M. K. (2002). GIS-based Landslide Hazard	118
	Zonation in the Bhagirathi (Ganga) Valley, Himalayas. International Journal of	
	<i>Remote Sensing</i> , 23(2), 357–369. http://doi.org/10.1080/01431160010014260	
5	Saraf, A. K., & Choudhury, P. R. (1998). Integrated remote sensing and GIS for	114
	groundwater exploration and identification of artificial recharge sites.	
	International Journal of Remote Sensing, 19(10), 1825–1841.	
	http://doi.org/10.1080/014311698215018	
6	Prakash, A., & Gupta, R. P. (1998). Land-use mapping and change detection in a	92
	coal mining area - a case study in the Jharia coalfield, India. International Journal	
	of Remote Sensing, 19(3), 391-410. http://doi.org/10.1080/014311698216053	
7	Krishnamurthy, J., Kumar, N. V., Jayaraman, V., & Manivel, M. (1996). An	92
	approach to demarcate ground water potential zones through remote sensing and a	
	 http://doi.org/10.1016/j.rse.2005.10.004 PACHAURI, A., & PANT, M. (1992). LANDSLIDE HAZARD MAPPING BASED ON GEOLOGICAL ATTRIBUTES. Engineering Geology, 32(1-2), 81– 100. http://doi.org/10.1016/0.013-7952(92)90020-Y Kanungo, D. P., Arora, M. K., Sarkar, S., & Gupta, R. P. (2006). A comparative study of conventional, ANN black box, fuzzy and combined neural and fuzzy weighting procedures for landslide susceptibility zonation in Darjeeling Himalayas. Engineering Geology, 85(3-4), 347–366. http://doi.org/10.1016/j.enggeo.2006.03.004 Saha, A. K., Gupta, R. P., & Arora, M. K. (2002). GIS-based Landslide Hazard Zonation in the Bhagirathi (Ganga) Valley, Himalayas. International Journal of <i>Remote Sensing</i>, 23(2), 357–369. http://doi.org/10.1080/01431160010014260 Saraf, A. K., & Choudhury, P. R. (1998). Integrated remote sensing and GIS for groundwater exploration and identification of artificial recharge sites. International Journal of Remote Sensing, 19(10), 1825–1841. http://doi.org/10.1080/014311698215018 Prakash, A., & Gupta, R. P. (1998). Land-use mapping and change detection in a coal mining area - a case study in the Jharia coalfield, India. International Journal of Remote Sensing, 19(3), 391–410. http://doi.org/10.1080/014311698216053 Krishnamurthy, J., Kumar, N. V., Jayaraman, V., & Manivel, M. (1996). An approach to demarcate ground water potential zones through remote sensing and a geographical information system. International Journal of Remote Sensing 17(10), 1867–1884. 	
	17(10), 1867–1884.	

8	Saha, A.K., Gupta, R.P., Sarkar, I., Arora, M.K. & Csaplovics, E. (2005). An approach for GIS-based statistical landslide susceptibility zonation - with a case study in the Himalayas. <i>Landslides</i> , 2(1), 61-69. doi: 10.1007/s10346-004-0039-8	87
9	Sarkar, S. and Kanungo, D.P. (2004). An integrated approach for landslide susceptibility mapping using remote sensing and GIS. <i>Photogrammetric Engineering and Remote Sensing</i> , 70(5). 617-625	79
10	Jaiswal, R.K., Mukherjee, S., Krishnamurthy, J. & Saxena, (2003) R. Role of remote sensing and GIS techniques for generation of groundwater prospect zones towards rural development - an approach. <i>International Journal of Remote</i> <i>Sensing</i> , 24(5), 993-1008. doi: 10.1080/01431160210144543	74

Style: APA (6th ed)

Table 4.2.13: Top Cited Papers in GIS

The highest cited article during the 24-year period of study is "Mapping paddy rice agriculture in South and Southeast Asia using multi-temporal MODIS images". It is authored by Xiao, X. M., Boles, S., Frolking, S., Li, C. S., Babu, J. Y., Salas, W., & Moore, B. It appeared in 2006 in the journal "Remote Sensing of Environment" and has been cited 165 times.

4.2.14 Collaboration and Network Mapping

Collaboration trends make us understand the spatial clusters of authors, institutes, work etc. worldwide, this makes the research trends clearer. Another way of depicting the collaboration among concepts and arguments is by the use of network maps. These maps help us visualize the relationships between authors, publications, institutions and countries etc. using diagrams.

Visualization networks are basically created using a set of scientific publications and related parameters. Citation/Co-citation Networks and Collaboration Networks have been created for this study. Nodes are representative of authors or similar entities

within a network. The edges in the network represent the links between two or more entities. The bigger the node, the more concentration of collaborative work, cocitation etc. Based on the collaborations between authors, countries and Institutions, we can map the world-wide geographic distribution of GIS research publication in collaboration with India in many ways. In the collaboration regime, the major spatial clusters of research institutes are located in North America and Europe, followed by East Asia. Several minor clusters are distributed in other parts of the world. Africa and South America have relatively less research collaborations with India. Out of 72 Countries/territories which participated in GIS research, United States has the maximum no. of collaboration (89) followed by Germany (39), Netherlands (32) and England (32). Out of rest, 38 have 1–2 collaborations, 12 have 3–10 and 7 have 11-18 collaborations respectively. It is seen from the Table 4.2.14 that GIS related articles authored in France have the highest average impact (AvgCPA=24.07) and though the USA is 1st in the number of publications, it ranks 6th in the AvgCPA index.

Country	TP	%	TC	AvgCPA	h-index	
USA	89	5.981	1252	14.07	19	
Germany	39	2.621	590	15.13	13	
Netherlands	32	2.151	423	13.22	11	
England	32	2.151	387	12.09	11	
Australia	18	1.210	196	0.89	8	
Canada	17	1.142	140	8.24	6	
France	15	1.008	361	24.07	8	
Malaysia	11	0.739	200	18.18	5	
Japan	11	0.739	112	10.18	6	
Iran	11	0.739	79	7.18	4	
Brazil	11	0.739	208	18.91	8	
South Africa	10	0.672	108	10.8	4	
South Korea	9	0.605	103	11.44	6	
Switzerland	8	0.538	80	10	5	
Saudi Arabia	7	0.470	11	1.57	2	
Peoples R China	7	0.470	98	14	6	
Nepal	7	0.470	13	1.86	3	
Kenya	7	0.470	107	15.29	6	
Scotland	6	0.403	47	7.83	4	
Ethiopia	6	0.403	5	0.83	1	
Collaboration networks show the collaboration of authors, institutions, or countries in the production of scientific research. The most basic type of collaboration network is the co-author network, in which nodes represent authors and edges represent publications on which authors have collaborated. By extracting author affiliations and addresses from co-author networks, we can create institutional and country collaboration networks.

Reference Co-citation Network:

Reference Co-Citation analysis given in Graph 4.2.14(a) shows the structure of the GIS field through the linkages between co-cited works. The nodes in this figure represent the references denoted by the first author and the edges are the reference co-citation links between references. This figure helps us to understand the mesh of collaboration between major research groups and their focus areas of common interests (**Please see Graph 4.2.14 (a), Pg. No. 98**)

Country Coupling:

The Graph 4.2.14(b) shows the country coupling in the field of GIS. It can be seen that a dense mesh of collaboration exists among the third world countries. It is also seen that there is strong linkage between the South Asian countries with whom India has collaborated on the front foot. (**Please see Graph 4.2.14 (b), Pg. No. 99**)

Collaboration Networks:

Collaboration networks show how authors, institutions (e.g. universities or departments) and countries relate to others in a specific field of research. The Graph 4.2.14(c) shows the co-author network in the field of GIS. It is used to identify the groups of research scholars and groups of important or productive authors. (Please see Graph 4.2.14 (c), Pg. No. 100)



Graph 4.2.14 (a): Reference Co-citation Network in GIS



Graph 4.2.14 (b): Country wise Coupling in GIS



Graph 4.2.14 (c): Author Collaboration Network in GIS

Institutional collaboration network:

The Graph 4.2.14 (d) is called "Edu collaboration network" it reveals the most prominent academic and research institutions in GIS and the collaborative links amongst them.



Graph 4.2.14 (d): Visualization of Institutional Collaboration in GIS

4.2.15 Keyword Analysis

Keywords data obtained from the WoS indicates towards the "hot" areas of research. Their in-depth analysis helps in understanding the thought content of the publications thus giving us a clear picture of the research trends in any given field of research. In this study, a total of 5556 different keywords, from 1991 to 2014 in the GIS are identified, of these only 4934 are unique key words. To obtain accurate results, the keywords are pre-processed, singular and plural keywords like "geographic information system" and "geographic information systems" are merged similarly synonyms/similar forms of words like "climatic change" and "climate change" and "ground water" have been counted as single keyword. Among these keywords 4161 appear once or 611 appear twice at the most. The results as shown in the Table 4.2.15(a) below indicate that GIS research has extensively been carried out in the fields of Water, Land, Remote Sensing, Soils so and so forth. The Graph 4.2.15(a) below shows how the research trends have changed over the 24-year period and how the top 10 keywords have gained importance.

Keywords	TP
Water	353
Land	349
Remote Sensing	303
Model	271
Soil	160
Groundwater	149
Area	131
Basin	118
River	106
Watershed	106
Erosion	94
Himalaya	92
Region	81
Diversity	78
Dem	69
Conservation	68
Sediment	61
Pollution	55
District	54

Table 4.2.15(a): Top Author Keywords in GIS



Graph 4.2.15 (a): Evolution of top author used keyword in GIS Research

Another type of keywords retrieved from the WoS is the KeyWords Plus, which are the keywords assigned by the Web of Science and consist of words and phrases harvested from the titles of the cited articles. Table 4.2.15(b) shows the WoS assigned keywords which have been used the maximum times in the published research in GIS during 1991-2014.

Keywords-Plus	(ID) Articles
GIS	228
INDIA	117
MANAGEMENT	73
MODEL	56
AREA	47
SYSTEM	47
BASIN	41
IDENTIFICATION	36
DISTRICT	35
MODELS	35

Table 4.2.15(b): Top Keywords Plus as per WoS in GIS

Keyword Co-occurrence network:

Keyword co-occurrence networks are used to depict the conceptual structures of the field by revealing the links between the topics using term co-occurrences, this enables us to get a better understanding of the concepts under investigation by the research groups in the fields of study here GIS. The Graph 4.2.15(b) shows the keyword co-occurrence for the field of GIS and it can be seen that how a few terms like Management, Modelling, GIS, etc. are highly researched upon and the interlinks between them shows the inter dependency of these terms and concepts.



Keyword Co-occurrences

Graph 4.2.15 (b): Major Clusters of Keyword Occurrences in GIS

4.3 Remote Sensing (RS)

Quantitative Analysis: The data retrieved for the field of Remote Sensing (RS) consisted of 2563 publications, these publications have been analysed using different parameters. Table 4.3 shows the basic information about the retrieved data set pertaining to the publications.

Main Information about data				
Total Publications on RS	2563			
Sources (Journals, Books, etc.)	569			
Keywords Plus (ID)	4064			
Author's Keywords (DE)	5249			
Period	1991 – 2014			
Average citations per documents	9.831			
Authors	5159			
Author Appearances	9633			

Table 4.3: Publication Details of RS

4.3.1 Publication Counts

In 1992-38 publications have been reported which grew up to 287 in 2014. The Table 4.3.1 shows the number of publications appearing each year during 1991 to 2014 by Indian Scientists. There is a dip in the numbers during the late nineties and then a constant rise.

38
50
22
57
38
45
53
37
36
33
53
48
60
60
70
124
131
139
180
174
188
192
216
282
287

 Table 4.3.1: Publication counts per year in RS

4.3.2 Publication type: Chart 4.3.2 is a depiction of s the distribution of the publications in the field of Remote Sensing (RS) by Indian authors during the period 1991-2014. Total 2563 publications consist of articles-2451 (95.63%), review-65(2.53%) proceedings - 94 (3.66%), editorials – 22 (0.85%), letters – 11 (0.42%), Note- 10 (0.39%) and News Item and meeting abstracts - 2 (0.07%).



Chart 4.3.2: Distribution of research among types of documents in RS

4.3.3 Publication Growth Pattern:

Graph 4.3.3 shows the increase in annual number of publications in RS. The publications have grown from 38 (1.48 %) in 1991 to 287(11.19 %) in 2014. In mathematical terms the Growth Rate of this data set can be illustrated as – Growth Rate = {(Present – Past) / Past} * 100 = 655.26 %. Thus, the growth rate of research publications in RS is 655.26 %.



Graph 4.3.3: Growth of Publications in RS

The Average Annual Growth Rate (AAGR) of RS publications is:
 Annual Average Growth Rate = ((Present/Past) 1/n - 1) * 100, where n = number of years

Therefore, the AAGR in this case will be 8.88%, This shows that the research publications on RS have increased at an average rate of 8.88 percent per year over a period of 24 years.

• The **Compound average growth rate** (**CAGR**) of RS publications is 9.18 % The CAGR percentage implies that given a remarkably stable output throughout 24-year period, even if the fluctuations are there in between, growth rate shows a very significant rise in publications, which is a good sign and shows the development of the subject.





Graph 4.3.4: Growth trend of RS research

The growth curve (Graph 4.3.4) indicates an exponential increase though the best fit comes out to be that of a third-degree power law equation. The data shows a very high coefficient of determination ($R^2 = 0.967$), indicating a high rate of increase in the number of publications. The polynomial best fit as shown in the Graph 4.3.4 for RS research is found to be: $y = 0.0023x^3 - 12.827x^2 + 24274x + 2E + 07$, where y is the cumulative number of publications and x is the number of years since 1991.

4.3.5 Scholarly Impact :

The publications by the Indian scientists for the period 1991-2014 received a total of 25198 citations (Table 4.3.5) during the 24-year period with an average of about 9.83 citations per paper and an h index of 63, implying a good quality of research. Table 4.3.3 shows the various citation statistics.

Citation-based indicators	Number
Total Article found:	2563
Sum of the Times Cited	25198
Sum of Times Cited without self-citations	22418
Citing Articles	18177
Citing Articles without self-citations	17018
Average Citations per Item	9.83
h-index	63

Table 4.3.5: Scholarly Impact of RS

4.3.6 Citation Impact of Source Documents:

Document Type	Publication	%	PublicationCitation	CPP
Article	2451	95.63	23588	9.62
Proceedings Paper	94	3.66	828	8.81
Review	65	2.53	1512	23.26
Editorial Material	22	0.85	16	0.73
Letter	11	0.42	12	1.09
Note	10	0.39	69	6.90
News Item	2	0.07	0	0.00
Meeting Abstract	2	0.07	1	0.50

CPP: Citation per paper. Source: Web of Science (WoS)

Table 4.3.6: citation rates across different document types in RS

The Table 4.3.6 reflects how the Review Articles attract the highest citation rates (23.26). It is seen that Journal Articles have the highest number of publications but rank 2nd in the Citation Per Paper (hereafter CPP) followed by Proceedings Papers (8.81), Editorial Materials with Meeting Abstract papers attracting the lowest counts.

4.3.7 Publication Vs Citation Pattern:

2563 publications on RS have received a total of 25198 citations. Graph 4.3.7 shows the year wise total number of publications and the citations received per paper per year. It can be inferred that the two variables i.e. the number of publications and the citations received are independent of each other as viewed from the figure. There are 38 publications in 1991 and the number of citations is 305, the highest number of papers appear in the year 2014 i.e. 287 with 688 citations on the contrary the maximum citations received date back to the year 2006 i.e. 2302 for 131 publications.



Graph 4.3.7: Publication Vs Citation Pattern of RS

4.3.8 Subject wise distribution of publications: Based on the classification of subject categories in the Web of Science, RS research covered 135 subject

categories. Top subject categories are Remote Sensing (871), Environmental Science (591), Imaging Science Photographic Technology (534), Geosciences Multidisciplinary (484), Multidisciplinary Sciences (320), Water Resources (219), Meteorology Atmospheric Sciences (217), Engineering Electrical Electronic (185), Geographical Physics (135), Geochemistry and Geophysics (89) Graph 4.3.8 demonstrates the annual growth chart of articles of top 10 subject categories. The visible change in the number of articles among the subject categories symbolizes the frequent shift in research focus during the period of study.



Graph 4.3.8: Comparison of Growth trends of the top productive subject categories in RS

RS – Remote Sensing, ES – Environmental Science, ISPT – Imaging Science Photographic Technology, GM-Geosciences Multidisciplinary, MS - Multidisciplinary Sciences, WR – Water Resources, MAS - Meteorology Atmospheric Sciences, EEE - Engineering Electrical Electronic, GP - Geographical Physics, GG- Geochemistry and Geophysics

4.3.9 Top WoS Subject categories and their citation impact:

The Table 4.3.9 shows the citation impact of top subject categories in reference to the number of papers published. It is seen from the table that the subject categories

"Computer Science Artificial Intelligence" has the highest average impact (AvgCPA= 21.33), it is seen that the subject category "Remote Sensing" has the highest number of publications (871) with highest citations (8879) and it ranks 11th in the AvgCPA index

Web of Science Categories	ТР	% of TP	тс	Avg.C
Remote Sensing	871	33.984	8879	10.19
Environmental Sciences	591	23.059	4034	6.83
Imaging Science Photographic Technology	534	20.835	7347	13.76
Geosciences Multidisciplinary	484	18.884	4430	9.15
Multidisciplinary Sciences	320	12.485	2208	6.9
Water Resources	219	8.545	2383	10.88
Meteorology Atmospheric Sciences	217	8.467	2259	10.41
Engineering Electrical Electronic	185	7.218	2136	11.55
Geography Physical	135	5.267	1553	11.5
Geochemistry Geophysics	89	3.472	1477	16.6
Ecology	85	3.316	1428	16.8
Astronomy Astrophysics	7 9	3.082	707	8.95
Engineering Civil	78	3.043	1124	14.41
Oceanography	67	2.614	499	7.45
Engineering Aerospace	52	2.029	366	7.04
Computer Science Artificial Intelligence	46	1.795	981	21.33
Telecommunications	45	1.756	150	3.33
Agronomy	43	1.678	372	8.65
Biodiversity Conservation	42	1.639	718	17.1
Computer Science Interdisciplinary Applications	29	1.131	266	9.17

Table 4.3.9: Top WoS Subject categories and their research impact in RS

4.3.10 Top Institutions:

Institution	TP (%)	тс	Avg.C	h-index
Indian Space Research Organization (ISRO)	829(32.34)	6642	8.01	33
Indian Institute of Technology IIT Roorkee	130(5.07)	1773	13.64	23
Indian Institute of Technology IIT Kharagpur	91(3.55)	1220	13.41	20
Ministry of Earth Sciences Moes India	86(3.35)	498	5.79	12
Indian Institute of Technology IIT Bombay	85(3.31)	800	9.41	14
Indian Institute of Science Iisc Banglore	70(2.73)	987	14.1	15
National Institute of Oceanography India	65(2.53)	867	13.34	14
Indian Statistical Institute	55(2.14)	1042	18.95	16
Indian Institute of Technology IIT Kanpur	52(2.02)	1118	21.5	17
Anna University Chennai	43(1.67)	251	5.84	8
Indian Institute of Technology IIT Delhi	39(1.52)	487	12 <mark>.4</mark> 9	13
Jadavpur University	38(1.48)	781	20.55	15
Nationall Institute of Hydrology	37(1.44)	460	12.43	13
Indian Institute of Technology IIT Madras	35(1.36)	358	10.23	11
Indian Institute of Tropical Meteorology IITM	32(1.24)	241	7.53	9
Jawaharlal Nehru University	28(1.09)	245	8.75	8
Indian Agricultural Research Institute	28(1.09)	122	4.36	6
Banaras Hindu University	28(1.09)	129	4.61	6
TERI University	27(1.05)	145	5.37	7
Andhra University	27(1.05)	211	7.81	7

Table 4.3.10: Top Institutions and their research impact in RS

Table 4.3.10 shows the most productive institutions for the period 1991-2014. These institutions have collectively published 1346 articles contributing 53% of the total articles published during this period. ISRO tops the list of in number of publications, total citation counts, and h index. In terms of average citations per paper IIT Kanpur is the leading Institution having 21.5 citations per paper when the total contribution to the field is 52 articles. Jadavpur University stands second in this category. Other notes worthy contributions are from IIT Roorkee (130), IIT Kharagpur (91) and MoES (86). The table shows that the top institutions in the field are a blend of research institutes

like ISRO, IITs like IIT Kanpur, Roorkee, Kharagpur and Universities like Jadavpur University, Anna University, JNU, TERI University etc. This feature seems to be indication of how well spread the field is in terms of education and research.

4.3.11 Top Journals:

Journal	TP (%)	тс	Avg.C
International Journal of Remote Sensing	314 (12.25)	4389	13.98
Journal of the Indian Society of Remote Sensing	273 (10.65)	764	2.80
Current Science	216 (8.42)	1460	6.76
Journal of the Geological Society of India	67 (2.61)	250	3.73
Advances in Space Research	45 (1.75)	327	7.27
IEEE Transactions on Geoscience and Remote Sensing	42 (1.63)	1020	24.29
Environmental Monitoring and Assessment	42 (1.63)	286	6.81
Water Resources Management	39 (1.52)	661	16.95
Journal of Earth System Science	39 (1.52)	185	4.74
Geocarto International	39 (1.52)	96	2.46
International Journal of Applied Earth	27 (1.05)	434	16.07
Observation and Geoinformation			
Natural Hazards	26 (1.01)	126	4.85
ISPRS Journal of Photogrammetry	26 (1.01)	335	12.88
and Remote Sensing			
IEEE Journal of Selected Topics in Applied Earth	24 (0.93)	154	6.42
Observations and Remote Sensing			
Acta Astronautica	23 (0.89)	94	4.09
IEEE Geoscience and Remote Sensing Letters	22 (0.85)	176	8.00
IETE Technical Review	21 (0.81)	10	0.48
Environmental Earth Sciences	21 (0.81)	168	8.00
Remote Sensing of Environment	20 (0.78)	809	40.45
Indian Journal of Marine Sciences	20 (0.78)	106	5.30

4.3.11 Top Journals and their research impact in RS

Articles on RS appeared in 644 journals. RS research in India appeared in highest numbers in the "International Journal of Remote Sensing" with 314 publications and 4389 citations. "Journal of the Indian Society of Remote Sensing" is the second in position and "Current Science" third with highest number of papers though Current Science has more citations in comparison to the Journal of the Indian Society of Remote Sensing. IEEE transactions on Geosciences and Remote Sensing has very high citation numbers reflecting the high qualitative aspect of the journal (Table 4.3.11).

Author	TP (%)	TC	TCwoSC	CI	CIwoSC	Avg.C	h-index
Roy, P.S.	59 (2.302)	690	641	592	566	11.69	14
Singh, R.P.	49 (1.912)	962	941	805	789	19.63	16
Dadhwal, V.K.	48 (1.873)	421	392	364	344	8.77	11
Panigrahy, S.	47 (1.834)	329	305	286	267	7.00	10
Kumar, A.	45 (1.756)	174	158	145	133	3.87	8
Kumar, S.	37 (1.444)	280	278	277	275	7.57	8
Parihar, J.S.	36 (1.405)	257	247	234	225	7.14	9
Arora, M.K.	32 (1.249)	825	807	738	725	22.78	15
Joshi, P.K.	31 (1.210)	281	271	253	246	9.04	10
Ghosh, A.	29 (1.131)	401	356	320	302	13.83	11
Singh, S.	25 (0.975)	178	171	166	162	7.12	9
Saraf, A.K.	25 (0.975)	425	415	374	365	17.00	10
Nayak, S.	25 (0.975)	285	269	250	238	11.40	10
Kulkami, A.V.	25 (0.975)	384	317	244	228	13.92	10
Reddy, C.S.	24 (0.936)	98	69	67	53	4.08	5
Kushwaha, S.P.S.	23 (0.897)	187	178	169	162	8.13	8
Dwivedi, R.S.	23 (0.897)	311	306	230	226	13.52	10
Ghosh, S.K.	21 (0.819)	113	102	97	90	5.38	7
Ghosh, S.	21 (0.819)	234	203	187	175	11.14	8
Singh, R	20 (0.780)	175	171	173	170	8.75	8

4.3.12 Top Authors:

Table 4.3.12(a): Top Authors and their research impact in RS

The 2563 articles on Remote Sensing have been contributed by 3272 authors. Table 4.3.12(a) shows the top productive authors during the 24-year period. Out of the top productive authors, Roy, P.S. produced maximum publications 59 (%) followed by Singh, R.P 49 (%), Dadhwal, V.K. 48(%) respectively. It is seen from the table that RS related articles authored by Arora, M.K have the highest average impact 116

Authors	Dominance	Multi	First	Rank by DF
	Factor	Authored	Authored	
JAIN SK	0.61904762	21	13	1
DWIVEDI RS	0.56521739	23	13	2
SARAF AK	0.44	25	11	3
REDDY CS	0.41666667	24	10	4
KUMAR A	0.32608696	46	15	5
CHAUHAN P	0.3	20	6	6
JOSHI PK	0.25806452	31	8	7
SINGH R	0.25	20	5	8
SINGH RP	0.24489796	49	12	9
GHOSH A	0.24137931	29	7	10
KULKARNI AV	0.24	25	6	11
GHOSH S	0.23809524	21	5	12
KUSHWAHA SPS	0.2173913	23	5	13
KUMAR S	0.21621622	37	8	14
ROY PS	0.20338983	59	12	15
PANIGRAHY S	0.19148936	47	9	16
NAYAK S	0.16	25	4	17
SINGH S	0.16	25	4	18
ARORA MK	0.0625	32	2	19
DADHWAL VK	0.02083333	48	1	20

(AvgCPA=22.78) followed by Singh, R.P (AvgCPA=19.63). Table 4.3.12(b) indicates author rankings by their contributions in their papers, i.e. dominance factors.

Table 4.3.12(b): Authors listed in order of Dominance Factor in RS

4.3.13 Top Cited Publication:

The top highly cited papers in RS are derived using the WoS database, the citation details are given in Table 4.3.13 in the decreasing order of the "total number of citations". Serial no. 1 "Using remote sensing to assess biodiversity is the most cited

paper with 232 citations. This is followed by 209 citations for the paper "Texture classification using wavelet transform".

S.No.	Bibliography	TC
1	Nagendra, H. (2001). Using remote sensing to assess biodiversity.	232
	International Journal of Remote Sensing, 22(12), 2377–2400.	
	http://doi.org/10.1080/01431160117096	
2	Arivazhagan, S., & Ganesan, L. (2003). Texture classification using wavelet	209
	transform. Pattern Recognition Letters, 24(9-10), 1513–1521.	
	http://doi.org/10.1016/S0167-8655(02)00390-2	
3	Singh, R. P., Dey, S., Tripathi, S. N., Tare, V., & Holben, B. (2004).	199
	Variability of aerosol parameters over Kanpur, northern India. Journal of	
	Geophysical Research-Atmospheres, 109(D23), D23206.	
	http://doi.org/10.1029/2004JD004966	
4	Pal, M. (2005). Random forest classifier for remote sensing classification.	190
	International Journal of Remote Sensing, 26(1), 217–222.	
	http://doi.org/10.1080/01431160412331269698	
5	Walters, B. B., Ronnback, P., Kovacs, J. M., Crona, B., Hussain, S. A.,	156
	Badola, R., Dahdouh-Guebas, F. (2008). Ethnobiology, socio-economics	
	and management of mangrove forests: A review. Aquatic Botany, 89(2),	
	220-236. http://doi.org/10.1016/j.aquabot.2008.02.009	
6	Pal, M., & Foody, G. M. (2010). Feature Selection for Classification of	140
	Hyperspectral Data by SVM. IEEE Transactions on Geoscience and Remote	
	Sensing, 48(5), 2297–2307. <u>http://doi.org/10.1109/TGRS.2009.2039484</u>	

	7	Berthier, E., Arnaud, Y., Kumar, R., Ahmad, S., Wagnon, P., & Chevallier,	139				
		P. (2007). Remote sensing estimates of glacier mass balances in the					
		Himachal Pradesh (Western Himalaya, India). Remote Sensing of					
		Environment, 108(3), 327-338. <u>http://doi.org/10.1016/j.rse.2006.11.017</u>					
	8	Kanungo, D. P., Arora, M. K., Sarkar, S., & Gupta, R. P. (2006). A	134				
		comparative study of conventional, ANN black box, fuzzy and combined					
		neural and fuzzy weighting procedures for landslide susceptibility zonation					
		in Darjeeling Himalayas. Engineering Geology, 85(3-4), 347–366.					
		http://doi.org/10.1016/j.enggeo.2006.03.004					
	9	Sathyendranath, S., Gouveia, A., Shetye, S., Ravindran, P., & Platt, T.	128				
		(1991). Biological-Control of Surface-Temperature in the Arabian Sea.					
		Nature, 349(6304), 54–56. <u>http://doi.org/10.1038/349054a0</u>					
		Saraf, A. K., & Choudhury, P. R. (1998). Integrated remote sensing and RS	123				
	10	for groundwater exploration and identification of artificial recharge sites.					
		International Journal of Remote Sensing, 19(10), 1825–1841.					
		http://doi.org/10.1080/014311698215018					
1							

Style: APA (6th Ed.)

Table 4.3.13:	Top cited	papers	in	RS
---------------	------------------	--------	----	----

4.3.14 Collaboration and Network Mapping:

The world-wide geographic distribution of Remote Sensing research publications in collaboration with India can be mapped based on the author affiliations. The major spatial clusters of research collaborations are identified in England and Germany, followed by France, Japan, Netherlands and Italy. Minor clusters are distributed in other parts of the world like those of Nepal, Sri Lanka, Sweden, South Africa etc. It is seen from the Table 4.3.14 that Remote Sensing articles authored in Sweden have the highest average citations (AvgCPA=48.38). The highest H-index is that of Germany, followed by England and France respectively. This can be said as a reflection of bend of collaborations with the European countries and the quality of research as well.

Country	TP (%)	тс	Avg.C	h-index
	(5 (0 50)	1202	20.05	10
England	65 (2.53)	1303	20.05	18
Germany	64 (2.49)	1216	19	19
France	45 (1.75)	1065	23.67	17
Japan	44 (1.71)	593	13.48	14
Netherlands	34 (1.32)	569	16.74	12
Italy	26 (1.01)	640	24.62	13
Canada	26 (1.01)	862	33.15	12
Australia	26 (1.01)	543	20.88	12
Switzerland	14 (0.54)	304	21.71	8
Scotland	14 (0.54)	191	13.64	6
South Korea	12 (0.46)	206	17.17	7
Peoples R China	12 (0.46)	283	23.58	6
Malaysia	12 (0.46)	168	14	6
Thailand	10 (0.39)	202	20.2	6
Nepal	10 (0.39)	154	15.4	5
Sri Lanka	9 (0.35)	254	28.22	6
Iran	9 (0.35)	35	3.89	4
Sweden	8 (0.31)	387	48.38	7
South Africa	8 (0.31)	38	4.75	5
Wales	7 (0.27)	205	29.29	6

Table 4.3.14: Country wise collabotaion in RS

Research networks in Remote Sensing Literature Reference Co-Citation analysis given in Graph 4.3.14(a) shows the structure of the Remote Sensing field through the linkages between co-cited works. The nodes in this figure represent the references

denoted by the first author and the edges are the reference co-citation links between references.



Graph 4.3.14(a): Reference Co-citation Network in RS

In this map the nodes are representing the references which qualify for analysis. The rings represent citation frequency and the color spectrum reflects the time range of the citations. The size of the nodes, wherever larger signifies that this particular paper has been cited more times during the time span of the study. The co-cited references are indicated by the line connecting the two in between. The thickness of the connection line indicates the intensity of the connection between the two nodes. i.e. references.

Institutional Collaboration Network:



Graph 4.3.14(b): Network of major Institutional Collaborations in RS

This network, Graph 4.3.14(b) is a fierce demonstration of association between various research institutes. The authors from the Institutes of the Department of Space, India have collaborated many times among themselves, that's the reason the thick blue lines are seen linking the National Remote Sensing Center, Indian Institute of Remote Sensing, Space Application Center and Vikram Sarabhai Space Center. The other linkages reveal the other major research groups of Indian authors in Remote Sensing.

4.3.15 Keyword Analysis:

The analysis of the keywords gives us a picture of the research trends in a given field. The Chart 4.3.15 indicates the "hot" areas of research in RS. A total of 8866 different keywords, from 1991 to 2014 in RS are identified. To obtain accurate results, the keywords are pre-processed, singular and plural keywords like "remote sensing" and "remotely sensed" are merged and results noted.



Chart 4.3.15: The top Author Keywords in RS

Articles Keywords-Plus	Articles
INDIA	151
MODEL	107
CLASSIFICATION	94
GIS	93
VEGETATION	76
IMAGERY	71
ALGORITHM	65
MANAGEMENT	60
BASIN	53
CONSERVATION	52

Table 4.3.15: Top Keyword Plus as per WoS in RS

Table 4.3.15 is a depiction of Top used keywords defined according to the WoS subject categories. Some common keywords are seen and some new ones are added in comparison to the author keywords.



Graph 4.3.15(a): Evolution of top author keyword in RS Research

Graph 4.3.15(a) gives a picture of the evolution of top 10 author used keyword in RS

Research. It is interesting to observe how the most frequently used keywords have seen more and more usage with the passage of time, thus indicating more focus on these areas of research.



Conceptual Structural Map of Remote Sensing:

Graph 4.3.15(b): Conceptual Structural Map of RS

Conceptual structure is often used to understand the topics covered by scholars (socalled research front) and identify what are the most important and the most recent issues. The Graph 4.3.15(b) shows the conceptual framework map of the field of Remote Sensing. It can be seen that the many micro-topics are revealed which have drawn recent and frequent Attention of the researchers.

4.4 Summary:

This chapter unfolds the soul of this study, it reveals the data analysis of the fields of GIS and Remote Sensing and the interpretations and findings of the research work. The chapter is divided in two major parts with several sub-headings viz. one is dedicated to the GIS and the other to Remote Sensing. The sub-heads include the qualitative and the quantitative analyses of both the fields. The results are depicted through figures and tables and interpretations are given.

4.5 **References:**

Dahdouh-Guebas, F. (2002). The Use of Remote Sensing and GIS in the Sustainable Management of Tropical Coastal Ecosystems, Retrieved from https://www.researchgate.net/figure/226519231_fig1_Figure-1-Requirementsof-different -research-fieldstopics-a-and-specifications-of

Definition of GISystem, Available at: http://map.sdsu.edu/geoagent/gis_intro.htm

- Goodchild, M.F. (1992) "Geographical Information Science", International Journal of Geographical Information Systems, Vol. 6. pp 31-45.
- Goodchild, M.F. (1991) "Geographical Data Modelling", Computers and Geosciences, Vol. 18, pp. 401-408.
- Maguire, D.J. (n.d.). An overview and Definition of GIS, Retrieved from https://www.gisresources.com/wp-content/uploads/2013/09/BB1v1_ch1.pdf
- Pandey, P. and Thaker, U. (2016). GIS Research in India from 1991-2014: A Bibliometric. Contemplation, IRJLIS, 6 (1), pp. 144 158.
- Web of Science. (n.d.). Retrieved April 14, 2015, from https://apps.webofknowledge.com.
- Wenting X, Yangge T, Shuang D (2009) "Comparison of GIS papers between SCI and EI databases using bibliometric analysis", The 1st International Conference on Information Science and Engineering (ICISE2009), pp. 2012-2015: Available at http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=5454435
- Yangge T, Cheng W, Song H. (2009) "Global scientific production on GIS research by Bibliometric analysis from 1997-2006", Journal of Informetrics 2, Vol. 2, pp.65-74.

5.1 Introduction

This study is conducted to quantify the literature of GIS and Remote sensing research by Indian scientist written in English from 1991 to 2014. With the help of bibliometrics analysis, various statistical tools and software significant amount of research has been identified such as growth of literature, productivity and collaboration pattern, assessing the productivity of scientific institutions and journals etc. The major findings are summarized below.

5.2 Findings

A. Characteristics of Research Publications

Volume of Publications:

The field of GIS has seen a total of 1488 publications in the period of study i.e. 1991 to 2014 and RS fetched out 2563 publications during this course.

These publications saw maximum papers published in Journals with 95.36% in GIS and 95.63% in RS. GIS had 3.09% as Review articles, 2.41% in proceedings, further both the fields have less than 2% publications in editorials, meeting abstracts and letters.

A total of 3272 authors have contributed to GIS research in the period of study with publications in 412 document sources. Data on RS revealed a total of 5159 authors and appearance of publications in 569 sources. In GIS average citations per documents is 7.84 and in RS it is 9.83.

The publication counts have shown continuous increase which is an indication of interest these fields have garnered during the period of study. The differences between the beginning numbers (which are as nominal as 2 in the case of GIS) and the ending ones are significantly huge, this is indicative of expansion of the fields in Indian context. Large author counts are another such indicators.

Growth of Publications:

GIS in India has seen a significantly high growth in the number of publications i.e. from 2 in 1991 to 197 in 2014, giving rise to 97.50 times rise in the number of publications, similarly RS has seen 287 publications in 2014 with the number starting from 38 in 1991, which accounted for 6.55 times rise in growth of publications.

The Average Annual Growth Rate for GIS is 20% and for RS has been 8.88%. In addition, the Compound Average Growth Rate for GIS during the period of 1991 to 2014 is 22.08% and for RS it is 9.18%.

GIS has seen a trendline of second-degree power law equation with the value of R^2 being 0.979. A third-degree power law model illustrates the relations between cumulative number of publications and the year wise growths in RS and the R^2 turns out to be 0. 9671.

These figures in growth rates are indicative of proliferation of these subjects in Indian context and accelerated research trends. A growth as high as 97.50 times is huge figure that this study reports in the field of GIS. A quick look at the periodic growth pattern will show that the maximum percentage of growth took place in the 2009 to 2014 period, which indicates towards more growth in the recent times, thus more research as well.

B. Scholarly Impact of Publications:

In the field of GIS, the publications by the Indian scientists for the period 1991-2014 received a total of 10989 citations with an average of about 7.39 citations per paper and an h index of 44. Similarly, RS publications have received 25198 citations, with an average citation of 9.83 per paper and an h-index of 63. Review articles have attracted the maximum citations followed by the journal, proceedings etc. in both the fields.

GIS publications have garnered maximum citations of 1248 for 100 publications in the year 2007 and RS received 2302 citations for 131 publications in 2006. The scholarly impact which has been assessed with the help of the citations received shows that the h-indices of both the fields are very high, indicative of high-quality research being pursued by the Indian scientists. The high citations rates during the 2005-2008 period show sudden interest of scientists in these fields and also some good work (high citations) has been reported during that period.

C. Research Indicators:

Subjects:

Based on the subject categories in WoS, the GIS research covered 111 subject categories. Maximum papers are in the areas of Environmental Sciences, Geosciences Multidisciplinary and Remote Sensing. In RS, the research covered 135 subject categories. Top subject categories are Remote Sensing, Environmental Science, Imaging Science Photographic Technology and Geosciences Multidisciplinary. In the field of GIS "Agriculture Multidisciplinary" has the highest average citation impact i.e. 17.22, and "Computer Science Artificial Intelligence" has the highest average impact of 21.33 in the field of RS. The number of articles in environmental sciences & ecology see a leap in the year 130

2010 showing an increased application of GIS in this area of research. The results display a drastic change in the research focus among the subjects during the towards the end of the study period. In GIS, the number of articles in environmental sciences leaped considerably in 2014. Similarly, in RS visible upward changes are seen in the fields of Environmental Science and Imaging Science Photographic Technology while a steep downfall is seen towards the end in Multidisciplinary Sciences. These increments and decrements are symbolic of the frequent shift in research focus during the period of study.

Institutions:

IIT Kharagpur tops the list in number of publications, total citation counts, average citations and h index in the field of GIS. The data shows the quantitative and qualitative excellence of research at IIT, Kharagpur.

RS has maximum publications from the Indian Space Research Organization (ISRO) contributing 829 papers also with highest h-index of 33. Among the Universities - JNU and Jadavpur University have high number of publications. It is interesting to note that Jadavpur University has the highest AvgCPA of 20.55. It is worth noting that owing to the variance in the nature of these institutions and their subject fields, it can be concluded that this field has found its application in many fields like Agriculture, Space Sciences, Geosciences, Oceanography etc. and has become an integral part of both education and research.

Journals:

"Journal of the Indian Society of Remote Sensing" has published the maximum papers in the field of GIS, in the field of RS the most active journal is "International Journal of Remote Sensing" with 314 publications and 4389 citations. The "Journal of Hydrology" has the highest AvgCPA (18.38) in GIS. AvgCPA of the Remote Sensing of Environment is 40.45, which is the highest in all the journals in which research is published in the field of RS.

Authors:

The results of data analysis show that Roy, P.S. is the most productive author in GIS. The articles authored by Chowdary, V. M. have the highest average impact (AvgCPA=20.84) and h-index as well presenting him as the most prolific author in terms of quality. It is also seen that by the way of dominance factor, the top author is Ghosh, S.

In the field of RS as well Roy, P.S. is the top productive author like GIS. This shows his versatility in terms of research fields. In terms of highest average impact, Arora, M.K rules the roost, while Singh, R.P has the highest h-index. In terms of dominance factor, Jain, S.K. is the top author as he has 13 first author paper out of 21, which is a big deal in today's collaborative research trends.

It is seen from the authors data that there are different ways to declare best author, numbers, citations, indices, authorship etc. are main factors which signify the importance of authors in a field. RS and GIS has seen authors from different areas of application ruling the roost.

Top Cited Publications:

The top publication of GIS is: Xiao, X. M., Boles, S., Frolking, S., Li, C. S., Babu, J. Y., Salas, W., & Moore, B. (2006). Mapping paddy rice agriculture in South and Southeast Asia using multi-temporal MODIS images. Remote Sensing of Environment, 100(1), 95–113. http://doi.org/10.1016/j.rse.2005.10.004. This paper has received 165 citations.
The top publication in the field of RS is: Nagendra, H. (2001). Using remote sensing to assess biodiversity. International Journal of Remote Sensing, 22(12), 2377–2400. http://doi.org/10.1080/01431160117096.This paper has received 232 citations.

Collaboration:

Indian researchers have collaborated with several researchers in other countries worldwide and the top most collaborations in RS have been with England while the h-index with Germany has been the highest i.e. 19. The maximum collaborations have been with England, Germany, France, Japan and Netherlands, this significantly symbolizes the high collaborative research work of Indian and European agencies in the field of RS.

D. Keywords

The keyword analysis of the research trends in the GIS revealed that Water, Land, Remote Sensing, Model, Soil, and Groundwater are the most used keywords. The keyword analysis of the studied publications revealed the hot directions of the research trends in the RS. The most used keywords are Model, Image, Water, GIS, Classification, Satellite, Vegetation.

GIS, India, management, model, area, system, basin, identification, district, models are the WoS category keywords plus in the field of GIS. India, model, classification. GIS, vegetation, imagery, algorithm, management, basin, conservation is the top WoS category keyword plus in the field of RS. The keyword analysis gives an idea of the research focus of GIS and RS and it is interesting to note that the scope ranges from Sky to Earth and Oceans, vegetations giving the wide penetration and scope of research in the field. The extent to which these two fields have gone, shows their application in numerable other areas of research.

E. Network Visualization:

The network visualization has been carried out for the GIS and Remote Sensing literature using the netmatrix package of R. It reveals some interesting results depicted through network plots. The Reference Co-citation network depicts the major co-cited references in both the fields respectively giving an insight into the major research groups and scholars in the fields. The Collaboration networks reveal the major institutes contributing collectively to the advancements of these two fields, and finally the keyword co-occurrence shows the most sought-after keywords and the interlinks between them. The conceptual structural map of Remote sensing shows the most recent research work being pursued in Indian context.

5.3 Conclusion and Suggestions

This study gives a crystal-clear view of how the research in GIS and Remote Sensing have grown over the period of 1991 to 2014 in the Indian context. The analysis has statistically presented the pattern of growth, models of growth and the evolution of subjects over time. The growth in the number of papers saw a meteoric rise, thus indicating the speedy research directions these fields have followed.

The findings signify that the GIS and RS research has travelled a long journey in India and surely has become an integral part of development of science and research in India. Even though these are nascent subjects yet picked up a very high pace in terms of growth and applications.

This study investigated the prolific areas of research so it would prove helpful to the policy makers in allocation of funds, finding the accurate measure of growth, research gaps and remedies thereof.

For the library professionals, the study will help to identify the core institutions, journals, researchers in the fields of GIS and RS. It will assist in collection development of a library. It will also help the library professionals to satisfy the potential target users in these fields by giving them pin-pointed information related to their fields of interest.

From an institutes' point of view, this study can prove useful in budgetary control, promotion and recruitment policies, creating gender balance etc. To, the subject specialists and researchers in these fields, this study can prove to be a pathfinder for knowing the more explored areas and less visited corners, this will provide direction to choose their areas of research.

Following suggestions are made based on the study:

1. It is suggested that the organizations which are a part of this study should use it for conducting a reality check in context with already set research objectives and whether those have been achieved or not.

2. Study on the h-indices of the faculty members from Universities should be carried out, this will help to obtain funding from various Govt. agencies based on their excellence in research.

3. Based on the Bibliometric indicators, productivity analysis should be carried out in each research discipline in order to find the loop-holes in the system and the remedies thereof. 4. A country based funding-policy may be defined in the fields of GIS and Remote Sensing in terms of global and domestic standards in research quantity and quality.

5. Periodic review of the research metrics of the leading authors should be made a complusory excercise in the institutions in order to set clear and measurable benchmarks for new researchers.

5.4 Future Work

The results of this study show a meteoric rise in the growth of the subjects. Still there are some parameters which need detailed investigation of these two fields, these are application of the bibliometric laws to the collected data. These laws include Lotka's Law, Bradford's Law and Zipfs Law respectively. The application of these laws will give an insight into some other micro details of these subjects as well.

Further the network mapping section needs deeper investigation into the detailed analysis of the structures. It is also felt that similar studies can be performed for other nascent fields that have come up in past few years to provide a solid backing while framing science policy at individual, institutional and national levels. It is also suggested for initiating a research quality assurance service at institutional level using bibliometric data.

Bibliography

- Chinnaraj, M and Balasubramani, R. (nd.). Scientometric Mapping of Remote Sensing Research Output: A Global Perspective. Library Philosophy and Practice (e-journal). Retrieved from <u>http://digitalcommons.unl.edu/libphilprac/801</u>
- Daniel, R.R. Concepts in Space Science. (2002). University Press. India. Remote Sensing-Eye in the Sky
- Dayasindhua, N and Chandrashekar,S. (2005) Indian Remote sensing program: A national system for innovation? Technological Forecasting & Social Change, 72, pp. 287–299.
- Deekshatulu, B.L. and Joseph, G. (1992). Evolution of Remote Sensing in India. In Space in pursuit of new horizons:A festschrift of Prof. U.R.Rao,by Verma, R.K. et al. : Indian Academy of Science: Allahabad.
- George, J. Fundamentals of Remote Sensing. (2003). University Press. India. PP. 102-145.
- Natarajan, T and Rajan, Y. S. (1984). Training Opportunities in Remote Sensing In India. Adv. Space Res. Vol.4, No.11, pp.31—34
- Rajan, Y. S. and Rao, V. R. (1984). A Decade Of Remote Sensing In India Some Salient Results. Adv. Space Res. Vol.4, No.11, pp.3 - 11
- Rajitha, K., Mukherjee, C.K. and Vinu Chandran, R. (2007). Applications of remote sensing and GIS for sustainable management of shrimp culture in India, Aquacultural Engineering, 36, 1–17.

- Sabins, F. F. Remote Sensing: Principles and Interpretation.W.H. Freeman and Company: San Francisco:1978
- Tian, Y., Wen, C. and Hongb,S. (2008), Global scientific production on GIS research by bibliometric analysis from 1997 to 2006. Journal of Informetrics, 2, 65–74.
- VandenBos, G.R. (Ed). (2010). Publication manual of the American Psychological Association (6th ed.), Washington, DC:A American Psychological Association
- Xiang, W. and Tian, Y. and Deng, S. (), Comparison of GIS papers between SCI and EI databases using bibliometric analysis, The 1st International Conference on Information Science and Engineering
- Zhuang, Y et al. (2013), Global remote sensing research trends during 1991–2010: a bibliometric analysis, Scientometrics 96:203–219. Available at DOI 10.1007/s11192-012-0918-z