

CHAPTER-II

REVIEW OF LITERATURE

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This chapter attempts to review and summarize some of the important works and findings related to various aspects of the present study. A review of literature not only provides glimpses of earlier studies carried out in this particular area, but also reflects the direction in which it is moving. It also provides a basis for interpretation and discussion of findings. Review of literature is a significant area for any type of research and it helps to avoid duplication in research. Keeping in mind the objectives set forth in this study, an attempt has been made in this chapter to review the available literature, which has meaningful relevance to the present study.

Bibliometrics stands on the solid theoretical foundation laid down by the research works of some pioneers like Lotka, Zipf, Price, Bradford, Brookes, Bookstein, Gross, Leimkuhler, the Cole brothers, Vickery, Fairthorne, Braun, Pritchard, Moravesik, Egghe, Garfield and many others. Bibliometric research has attained sophistication and complexity, and is national, international and interdisciplinary in character. It is a viable and distinctive research tool for quantitative measurement of human knowledge.

The literature on bibliometrics is growing very rapidly. The literature reviewed has been categorized under the following headings:

1. General Literature and Reviews on Bibliometrics
2. Citation Studies
3. Studies Based on Citations Appended to Theses and Dissertations
4. Citation Analysis of Journals
5. Citation Analysis of Specific Subjects
6. Citation Analysis of works of Scientists, Institutions, Universities and Countries
7. Webometric Studies
8. Authorship Pattern and Collaborative Research
9. Self-Citations
10. Ranking and Scattering of Journals
11. Obsolescence of Literature

2.1 General and Reviews on Bibliometrics

The first review article on bibliometrics by Narin and Moll (1977)¹ appeared in the *Annual review of Information Science and Technology* in 1977. Hjerpe (1980)² published a bibliography on bibliometrics and citation indexing containing 2,020 items arranged alphabetically by first author in 1980. This work indicates the growth of literature and the international activity in the field during that time. Lawani (1981)³ discussed the definition and history of bibliometrics, its theoretical foundations, bibliometric laws and distributions (Bradford's Law, Lotka's Law and Zipf's Law), sources of data for bibliometric studies, examples and applications of bibliometric study including historical, sociological and other applications.

Sen and Narendra Kumar (1986)⁴ reviewed Indian contributions relating to bibliometrics for the period 1958-1984. The study covered 191 published contributions made by Indians residing in India and abroad. They discussed the year-wise output of literature in India, subject-wise activity and the most productive journals and authors in the field. The most comprehensive review on bibliometrics by Hertz (1987)⁵ appeared in the *Encyclopaedia of Library and Information Science* and covered the origin, history and development of bibliometrics; empirical laws of bibliometrics; citation analysis; and seminal bibliometric papers. King (1987)⁶ reviewed the various bibliometric indicators like publication counts, citation analysis, journal impact factor, co-citation analysis, co-word analysis and bibliometric coupling in terms of their strengths, weaknesses and particular applications.

Another comprehensive review on bibliometrics by White and McCain (1989)⁷ appeared in the *Annual Review of Information Science and Technology* and covered studies relating to Zipf's Law, Lotka's Law and Bradford's Law; document co-citation, author co-citation; and ageing of literature. Sengupta (1992)⁸ discussed the scope, application and development of bibliometrics, informetrics, scientometrics and librmetrics. Osareh (1996)^{9,10} reviewed the literature on bibliometrics, citation analysis and co-citation analysis in two parts. The first part presented the background of bibliometrics, citation analysis and application of citation analysis. The second part reviewed author co-citation analysis, journal-by-journal citation analysis and country-by-country citation analysis. It also discussed the limitations, problems, reliability and validity of citation analysis as a research method.

According to Hood and Wilson (2001)¹¹ the terms bibliometrics, scientometrics and informetrics refer to component fields related to the study of dynamics of disciplines as reflected in the production of their literature. Areas of study range from charting changes in the output of a scholarly field through time and across countries, to the library collection, problem of maintaining control of the output and to the low publication productivity of most researchers. These terms are used to describe similar and overlapping methodologies. The origins and historical survey of the development of each of these terms are presented. Profiles of the usage of each of these terms over time are presented using appropriate subject categories of databases on the DIALOG information service. List of the top journals in the three fields and list of major reviews and bibliographies that have been published over the years are given.

Thelwall (2008)¹² reviewed the distance that bibliometrics has travelled since 1958 by comparing early bibliometrics with current practice and by giving an overview of a range of recent developments, such as patent analysis, national research evaluation exercises, visualization techniques, new applications, online citation indexes and the creation of digital libraries. Webometrics, a modern, fast-growing offshoot of bibliometrics is reviewed in detail. And future prospects are discussed with regard to both bibliometrics and webometrics.

Jalal and others (2009)¹³ briefly described the trend from bibliometrics to webometrics. They also discussed some important application areas of webometric research, the methodology adopted for data collection, techniques and tools of web analysis and the problems encountered in webometric research. Methods of computing, web impact factors and highlights of the research possibility in webometric study are considered. A webometric case study of thirteen Indian Institutes of Technology and Indian Institute of Management is presented.

Ravichandra Rao (2013)¹⁴ surveyed the scientometric literature of India for the period 2000-2012 to study and understand scientometric research in India. The data was collected from LISA and 175 documents were covered in this survey. The areas covered are India's contribution to world literature, growth of Indian literature, proportion of collaborative research, etc. This review indicates that the Indian publications are now visible and they are increasing. There is hardly any research

being done to evaluate and measure research outcome and there is also no evidence that the results of the scientometric research are being used in drafting science policy or in science administration.

2.2 Citation Studies

Citation analysis is an effective tool in quantitative studies of science and technology. Citation analysis in simple terms means the analysis of the citations or references appended to primary communication publications.

Raising (1960)¹⁵ in his article discussed the uses of citation data in evaluating scientific journals and was of the view that the amount of material published in a particular journal must be considered in calculating the weightage of citations of that journal. He suggested a measure called 'index of research potential realized'. It is calculated by dividing the number of articles cited by the number of articles published.

According to Malin (1968)¹⁶ "citation implies a relationship between a part or the whole of the cited document and a part or the whole of the citing document". Ziman (1968)¹⁷ observed that "a scientific paper does not stand alone; it is embedded in the 'literature' of the subject". Mitra (1970)¹⁸ reviewed the role of citations and summarized the citation studies and observation made up to 1970.

Weinstock (1971)¹⁹ observed that scientific tradition requires that when a reputable scientist or technologist publishes an article, he or she should refer to earlier articles which relate to his or her theme. These references are supposed to identify those earlier researchers whose concepts, methods, apparatus, etc., inspired or were used by the author in developing his article. He enumerated the following reasons for citing a document:

1. Playing homage to pioneers;
2. Giving credit for related work (homage to peers);
3. Identifying methodology, equipment etc.;
4. Providing background reading;
5. Correcting one's own work;
6. Correcting the work of others;

7. Criticizing previous work;
8. Substantiating claims;
9. Alerting readers to forthcoming work;
10. Providing leads to poorly disseminated, poorly indexed, or uncited work;
11. Authenticating data and classes of fact-physical constants, etc.;
12. Identifying original publications in which an idea or concept was discussed;
13. Identifying the original publications describing an eponymic concept or term as, e.g., Hodgkin's disease, Pareto's Law, Friedel-Crafts reactions;
14. Disclaiming work or ideas of others; and
15. Disputing priority claims of others.

Miller and Truesdell (1972)²⁰ reviewed the history and applications of citation indexing in 1972. Martyn (1975)²¹ reviewed the origin and application of citation analysis and according to him, prior to the introduction of *Science Citation Index*, citation studies were confined to the production of raw citation counts for preparing ranked lists of journals or to determine 'core' journals in a subject field. Shortly after the publication of *Science Citation Index*, studies began to appear which used citation devices for looking at relationships between groups of journals or groups of authors and, by implication, the relationship in and between areas of scientific activity.

Garfield's book on citation indexing (1979)²² and his "current comments" columns reprinted from *Current Contents* (1980)²³ provides a wealth of information on citation analysis and its applications. Gupta and Nagpal (1979)²⁴ reviewed citation analysis by categorizing the main contributions under the heads: information and library oriented studies; source-oriented studies; and management-oriented studies.

In the words of Smith (1981)²⁵ "Citations are signposts left behind after information has been utilized and, as such, provide data by which one may build pictures of user behaviour without ever confronting the user himself. Any set of documents containing reference lists can provide the raw material for citation analysis, and citation counts based on a given set of documents that are precise and objective". Just as there are a number of reasons why citation exists, there may be a number of reasons why a citing document has not provided a link to certain other

documents. The most obvious reason is that a work in question is not relevant to the previous document or due to the fact that the citing author was not aware of the existence of the document or the document was not accessible to the citing author or the author could not read it because of the language barrier.

Bonzi (1982)²⁶ investigated which characteristics of citing and cited works may aid in determining relatedness between documents. Thirteen variables were tested on thirty one library/information science articles containing nearly 500 citations. Analysis indicates that source of cited works, source of citing work, number of times a work is cited in text and type of citing article show promise of predicting relatedness between article and cited works. Todorov and Glanzel (1988)²⁷ reviewed some limitations of the traditional citation measures such as immediacy index, number of references per paper, self-citations and impact factor; and also briefly discussed the relation between journal citation measures and subjective evaluation of scientific journals.

MacRoberts and MacRoberts (1989)²⁸ reviewed the problems associated with citation analysis. The main problems identified by them are: biased citing; self-citing; formal influences not cited; informal influences not cited; variations in citation rate related to type of publication, nationality, time period, size and type of specialty; and technical limitations of citation indices and bibliographies like multiple authorship, synonyms, homonyms, clerical errors and coverage of literature.

Moed and Vriens (1989)²⁹ presented a detailed analysis of discrepancies between target articles and cited references with respect to author names, publication year, volume number and starting page number. The data consisted of some 4,500 target articles published in five journals containing 25,000 citations. It was found that the percentage of citations not showing any discrepancy accounted for ninety one per cent of the total citations, while the citations with discrepancies in one data field only (author name, volume or page number) accounted for almost five per cent of the total citations.

A comprehensive review on citation studies dealing with the complexities and underlying norms of the citation process, citation functions, citation quality, citation concepts and citation motivation was published by Liu³⁰ in 1993.

Herubel and Buchanan³¹ published a selective annotated bibliography on citation studies devoted to humanities and social science disciplines in 1994. Kelland and Young (1994)³² selectively reviewed the citation analysis literature dealing with citation validity and accuracy; citer motivation and the relationship between citation frequency and library use of materials.

Shih and Huang (2006)³³ examined the distinctive factors and results on calculation of citedness score of scholarly literatures between Science Citation Index Expanded and Scopus by adoption of comparison as research methodology. They have selected 372 research papers from research grant publications of the College of Engineering at Tamkang University as research subject to test the citation counts from SCIE and Scopus simultaneously. As a consequence, one may generalize that four factors heavily impact on the different citedness scores between SCIE and Scopus as follows: coverage of collected data, integrity of cited references, quality of citation record and citation pointer between citing and cited references.

El-Maamiry and Ghauri (2013)³⁴ studied the measuring information quality which is indicating the bibliometric indicators. These are three types of bibliometric indicators that are used to measure the quality of work: Structural indicators; which measure the connection between author, publication and area of research, quality indicators, which measure the quality of researcher's output and quantity indicators, which measure productivity of a particular research. The paper also provides an overview of currently used indicators to measure the quality of information and summarizes the critical elements that caution evaluator of the quality of information.

Pyke (2013)³⁵ in his paper discussed the four goals of citations. These are high significance, high influence, excellent presentation and sustained effort. Citation of published articles is becoming increasingly important to individual scientists, the journals in which they publish and the institutions where they are based. Citations matter most in the future. Sharma (2014)³⁶ discussed the benchmarks for the quality research journals like ISSN, peer review, journal impact factor and immediacy index. He also discussed the benefits of open access research, online journals, h-index, g-index and journal citation factors. According to Welsh (2015)³⁷ the special issue on bibliometrics and scientometrics published by the Journal of Qualitative and

Quantitative Methods in Libraries contains numerous papers and presentations related to bibliometrics and represents a variety of bibliometric research methodologies.

2.1.1. Studies Based on Citation appended to Theses and Dissertations

Many bibliometric studies based on the citations appended to theses and dissertations have been carried out by various researchers. Kubota (1976)³⁸ studied the citations in 113 graduation theses in the field of library and information science presented to the Keio University during the period 1973-1974. The results showed that journals contributed 62.2 per cent of the total citations; more than fifty per cent of the literature cited was under four years old; citations to foreign literature comprised 23.1 per cent; and nine journals accounting for more than fifty per cent of citations to domestic journals. The holdings of Keio University Libraries and Information centres were the main source of information for the students accounting for 80.8 per cent of the total cited literature.

LaBorie and Halperin (1976)³⁹ analysed the citations in library and information science dissertations to find out the adequacy of Drexel University Library in supporting research programmes in library science.

Omoruyi (1978)⁴⁰ analysed the citations of articles in journals in eighteen social science theses and dissertations submitted to the University of Ibadan during 1965-1970. It was found that a large percentage (98.71%) of articles was in English, mainly from journals published in the USA (38.50%), and the median age of the citations was nine years.

Maheswarappa and Prakash (1982)⁴¹ studied the literature use pattern by researchers in the field of botany by analyzing 2,726 citations appended to fifteen doctoral theses accepted by the University of Mysore during 1973-1980. The bibliographic form-wise distribution of citations showed that journals occupied the first place accounting for 75.61 per cent of the total citations, followed by books (12.42%) and conference proceedings (4.55%). The country-wise distribution of citations revealed that USA occupied the first place accounting for 29.25 per cent of the total citations, followed by India (14.65%) and UK (13.29%). The half-life of botanical literature was found to be twelve years.

De Oliveira (1984)⁴² studied citation patterns in the veterinary sciences by analyzing 495 citations in fourteen master degree theses submitted to the Universidade Federal de Vicosa, Brazil. The bibliographic form-wise distribution of citations showed that journals accounted for seventy per cent of the total citations, followed by books (19%) and theses (3%). The country-wise distribution of cited journals showed that USA occupied the first position with 36.1 per cent of the total cited journals accounting for 51.1 per cent of the total citations, followed by UK (13.8%) and Brazil (12.5%). The half-life of veterinary medicine literature was about twelve years and the literature did not conform to Bradford's Law of Scattering.

Sangam (1985)⁴³ studied the citations in 131 doctoral dissertations in social sciences accepted by the Karnataka University during the period 1964-1982. The findings show that books are highly cited (56.17%), followed by journal literature (32.57%). The country-wise scatter of citations showed that India occupied the first position with 86.73 per cent of the total citations, followed by USA (7.35%) and UK (4.76%). The researchers preferred documents published in the English language (95.75%) and 34.5 per cent of the cited literature was available in the Karnataka University Library.

Nweke (1988)⁴⁴ studied 964 citations in eight theses in Zoology submitted to the Ibadan University, Nigeria, during the period 1970-1975. Out of the total citations, 77.8 per cent of citations pertain to journal articles, followed by books (10.6%), reports (3.5%) and others (8.1%). The language-wise distribution of citations revealed that English was by far the most used language (91.8%), followed by French (4.9%), German (1.6%) and others (1.7%).

Sangam and Biradar (1990)⁴⁵ studied the information use pattern by researchers in the field of surgery by analyzing 7,576 citations appended to 145 MS dissertations accepted by the Gulbarga University, Gulbarga, during 1982-1989. The bibliographic form-wise distribution of citations revealed that journal articles are the major source of information accounting for 54.23 per cent of the total citations, followed by books (35.39%), conference proceedings (5.00%), and others (5.38%). The language-wise scattering of cited documents showed that English was the predominant language with 99.78 per cent of the total citations. The country-wise distribution of cited documents revealed that 41.71 per cent of the cited documents

were from USA, followed by UK (28.45%), India (26.38%) and other countries (3.46%). The half-life of cited journal literature was observed to be twelve years.

Ujjappa (1991)⁴⁶ carried out citation analysis of doctoral dissertations accepted by Karnataka University in the field of library and information sciences.

Madkey and Rajyalakshmi (1994)⁴⁷ carried out a citation analysis of doctoral dissertations in the field of environmental science and engineering, which were consulted by the scientists working at National Environmental Engineering Research Institute, Nagpur, during 1977-1991. The results revealed that the single authored papers were maximum in number. USA occupied the prime place accounting for 52.05 per cent of the total citations and the half-life period for books and journals was found to be 18 and 17 years respectively.

Sylvia and Leshner (1995)⁴⁸ studied the citations appended to theses and dissertations of graduate students in the psychology and counseling departments of St. Mary's University, Texas, and prepared a ranked list of journals in counseling and psychology. The top seventy five titles contributed sixty two per cent of the total citations.

Aravinda (1996)⁴⁹ studied the characteristics of the literature of physical anthropology by analysing the citations in Annual Review of Anthropology for the period 1980-1994. Out of the total citations, 59.23 per cent of the citations of journal articles, followed by books (31.71%), conference papers (4.66%) and technical reports (1.19%). The country-wise distribution of citations revealed that 66.88 per cent of the citations were from USA, followed by UK (17.62%) and Switzerland (2.39%). The language-wise scatter of cited literature showed that English was the predominant language with 98.13 per cent of the total citations, followed by German (0.83%) and French (0.56%). The half-life of cited journal literature was found to be 14 to 15 years.

Mishra (1996)⁵⁰ performed the citation analysis of doctoral theses in library and information science submitted to Universities of Manipur and Orissa.

Mubeen (1996)⁵¹ studied the information use pattern of researchers in chemistry by analyzing the citations in twenty two doctoral dissertations in chemistry,

submitted to the Mangalore University, Mangalore. The study identified sixty core journals out of a total of 418 referred to, by researchers. The bibliographic form-wise distribution of citations showed that journals accounted for seventy three per cent, followed by books (11.48%) and patents, followed by India (20.01%) and UK (19.31%). The application of Bradford's Law of Scattering revealed an exponential trend and the Bradford's multiplier was seen to observe a geometric series pattern.

Vimala (1997)⁵² studied the citations appended to 200 doctoral dissertations in the field of biological sciences submitted to the Sri Venkateswara University, Tirupati. The bibliographic form-wise distribution of citations revealed that journal literature was the most preferred source of information (85.34%), followed by books (9.89%) and conference proceedings (2.05%). Researchers preferred documents published in the English Language (91.63%), followed by French (0.40%) and Russian (0.19%). The country-wise scattering of citations revealed that USA alone covered 56.55 per cent of citations and UK and India covered 13.66 per cent and 11.02 per cent respectively. The study of the authorship pattern showed that papers with two authors were maximum in number (40.41%) and single authored papers constituted 26.67 per cent of the total cited papers. The half-life period for journals and books citations was found to be 11.43 years and 12.79 years respectively.

Aruna Prasad Reddy (1999)⁵³ studied the citations appended to 186 doctoral dissertations in the field of chemistry submitted to the Andhra University, Visakhapatnam. The study reveals that journal literature was most preferred source of information (85.03%), followed by general books (7.97%), collected works of books (1.84%) and Patents (1.25%). Researchers preferred documents published in the English Language (73.86%), followed by Russian (4.44%) and Japanese (1.46%). The country-wise scattering of citations revealed that USA alone covered 35.51 per cent of total citations, followed by UK (17.91%) and India (11.04%). The study of the authorship pattern showed that papers with two authors were maximum in number (46.60%) and single authored papers constituted 22.50 per cent of the total cited papers. The half-life period for citations of journals and books is 17.84 years and 17.68 years respectively.

Kundra (2002)⁵⁴ carried out bibliometric study of medical literature accepted by Pune University by analysing the citations appended to doctoral dissertations. The

results of the study reveal an increasing trend towards collaborations and large disparities in the rate of collaborations between pure and applied areas. The findings clearly showed a higher degree of collaboration i.e., an average of 21.95 papers in basic fields of medical science in contrast to an average of 7.63 papers in applied medicine.

Shafi and Gazi (2005)⁵⁵ carried out citation analysis of one hundred doctoral theses submitted to Kashmir University during the period 1980-2000 in the field of Natural Sciences. A total of 11,862 citations were analysed for identifying bibliographic form, citation potential, journal ranking and obsolescence rate. The study of bibliographic form-wise distribution of citations shows that journal articles are the most preferred source of information for researchers in natural sciences (68.08%) followed by seminar papers (8.75%), books (1.68%) and theses (1.47%). The half-life period of journal literature is 37 years.

Valasayya (2005)⁵⁶ studied the literature use pattern of scholars in Telugu language and literature based on the analysis of 162 PhD theses submitted to Andhra University during 1945-1992. He has analysed a total number of 10,180 citations appended to 101 theses available in the library of Andhra University. The study reveals that the average number of citations per thesis is 100.79. The bibliographic form-wise distribution of citation reveals that books are the most preferred source of information accounting for 76.79 per cent of total citations followed by journals (9.89%), theses (2.77%) and reports (2.67%). The study of authorship pattern reveals that single authored papers are maximum in number (95.72%) followed by papers with two authors (2.87%) and papers with three authors (1.02%).

Vallejo and others (2006)⁵⁷ offered a longitudinal background of citation trends in the field of mathematics education based on the doctoral dissertations contained in the Spanish database TESEO during the period 1975-2002. The results of the study reveal the existence of a pattern of 200 references per thesis, the predominance of the English language in the journals, while the Spanish language prevails in the case of books. Two journals (Journal for Research in Mathematics Education and Educational Studies in Mathematics) are extensively cited.

Zafrunnisha (2007)⁵⁸ carried out citation analysis of PhD theses of Sri Venkateswara University, Tirupati, Osmania University, Hyderabad and Andhra University, Visakhapatnam in the field of Psychology. She has analysed 22,565 citations appended to 141 doctoral dissertations. The bibliographic form-wise distribution of citations shows that journals contributed the highest number of citations accounting for 63.7 per cent of the total citations followed by books (31.5%). The language wise distribution of citations reveals that English language occupies the first place with 99.59 per cent of the total citations. The country-wise distribution of citations shows that USA occupies the first place (73.11%) followed by India (12.60%) and UK (11.27%). The study of authorship pattern reveals that the single authored papers are maximum (47.12%) followed by papers with two authors (35.26%) and papers with three authors (11.20%). The ranked list of journals reveals that nearly 25.00 per cent of the articles are contributed by the first ten journals. The half-life period for journal citations in psychology is 14 years and the same for book citations is 19 years.

Nabe (2008)⁵⁹ carried out citation analysis of PhD dissertations in plant biology and zoology accepted by the Southern Illinois University, Carbondale. The findings of the study help to evaluate the value of electronic journal backfiles and the need to maintain print backfiles.

Sathiyamurthy and others (2008)⁶⁰ carried out citation analysis of 17 PhD theses in history accepted by the Annamalai University during the period 1967-2010. The total number of 3,352 citations appended to these theses were analysed for identifying the bibliographic form, year-wise distribution of theses, authorship pattern, different types of documents used, ranking of core journals, country-wise distribution of cited documents and subject-wise distribution of cited journals. The form-wise distribution of citations reveals that books occupies the first place with 52.63 per cent of citations followed by journals (19.33%), conference proceedings (8.29%), reports (7.16%) and newspapers (5.55%). The study of authorship pattern reveals that single authored occupies the first rank (76.07%) whereas papers with two authors occupy third rank (5.05%) and papers with four, five and above authors occupy, fourth and fifth ranks respectively. The study of the ranked list of journals reveals that the first eight journals contributed fifty per cent of the total citations. The

country-wise distribution of cited journals reveals that India occupied the first place (83.19%), followed by USA (12.50%) and Great Britain (4.01%).

Vallmitjana and Sabate (2008)⁶¹ carried out bibliometric analysis of 4,203 citations appended to forty six doctoral theses in the field of chemistry accepted by the Institut Quimic de Sarria (IQS) during 1995-2003. The results revealed that the most frequently used documents were scientific papers, which accounted for seventy nine per cent of the total; thirty three journals satisfied fifty per cent of the informational needs; and the age of fifty per cent of the citations was nine years.

Eckel (2009)⁶² performed citation analysis of ninety six Master's theses and twenty four PhD dissertations accepted by the Western Michigan University's College of Engineering and Applied Sciences during 2002-2006. The data analysis indicates that doctoral engineering students use a significantly greater number of scholarly journal articles (44.3 to 29.3) and conference papers (21.9 to 12.5) than master's students. Also, master's students depend more heavily upon literature available on the web (web sites, government papers, grey literature, trade magazines, and patents). This study shows that there is a significant difference in the proportions of scholarly and other research sources used by master's and doctoral engineering students. The implications of these citation patterns in the development of the engineering scholar are discussed.

Hadagali and others (2009)⁶³ examined the citation patterns of researchers in the field of physics by analyzing the citations appended to thirty seven theses submitted to the Karnataka University, Dharwad, during 1992-2006. The analysis was carried out to study the distribution of citations according to different bibliographic forms, authorship pattern, half-life period of journals and to determine the applicability of Bradford's Law of scattering to the citation data. The bibliographic form wise distribution of citations shows that journals occupy the first place contributing 80.54 per cent of the total citations followed by books (10.95%) and proceedings (3.17%). The study of authorship pattern shows that the number of citations with two authors is 34.5 per cent followed by single authored papers (about 30%) and three authored papers (about 20.97%). The study also reveals that about seventy per cent of the total citations are of joint authorship. The ranked list of cited journals reveals that the first ten journals contributed more than half of the citations.

The half-life period for journal articles is found to be thirty three years. The Bradford's Law of Scattering fits the citation data.

Nandi and Bandyopadhyay (2009)⁶⁴ studied 141 theses submitted to the Department of chemistry of the University of Burdwan during 1960-2000 and 979 articles based on them. The study was carried out to find trends of research, articles productivity, choice of journals, authorship pattern and the position of the university in the state. Highest number of theses (30) was submitted during 1986-1990 and 1991-1995. Highest number papers (283) were published during 1991-1995. Maximum number of theses (58) were submitted in inorganic chemistry followed by nuclear and analytical chemistry (34). About fifty three per cent of the papers (522) are published in Indian Journals. Other countries of preference for publishing papers are The Netherlands (15.32%), UK (11.64%) and USA (10.01%).

Brito and others (2010)⁶⁵ performed citation analysis of 5,683 citations appended to thirty five doctoral dissertations in the field of life science programme, biomedical science and chemistry accepted by the Universidad Autonoma de Mexico (UNAM) in the year 2009. The most cited articles were mainly of scientific nature and in English language. The average publishing date of the cited articles was in the range of 2000-2004. The twenty six most cited titles in the three programs were identified. It was concluded that both the libraries of the post-graduate centres and those of the UNAM Library System have the necessary sources of information to support students in pursuing their research.

Jamal and others (2010)⁶⁶ carried out citation analysis of 4,500 citations appended to doctoral theses submitted to the Aligarh Muslim University, Aligarh, during 1990-2010 in the discipline of history. The study was carried out to determine the use pattern of literature by the researchers in the field of history. The result shows that books have the highest number of citations, accounting for 72.50 per cent of the total citations. The language wise distribution of citations shows that English language occupies the first place with 45.52 per cent of the total citations. It is observed that 61.29 per cent of the articles are published from India. The study of authorship shows that papers with single authors occupy the first place (77.41%) followed by two authors and three or more authors.

Shukla and others (2010)⁶⁷ studied that bibliometric analysis of PhD theses in botany. The study was undertaken to trace the development of botany research at doctoral level in Vikram University, Ujjain, Madhya Pradesh during 1991-2006. The study found that the highest number of theses (8) have been submitted in the year 1991 and the lowest (1) in the years 1994, 1995, 1997, 2003 and 2006. The subject, air pollution, is the first choice of the researchers, which has been followed by seed science. On the other hand, fields like national resource management, water pollution, weed management, etc. need more attention as they are important research areas.

Sudhier (2010)⁶⁸ studied the application of Bradford's Law Scattering to the literature of physics by analysing the 11,319 journals and articles collected from seventy nine doctoral theses accepted by the Indian Institute of Science, Bangalore, in the field of physics during the period 2004-2008. The ranked list of journals reveals that eight out of the first ten journals are published from USA. The applicability of Bradford's Law of various methods was tested. The journal distribution pattern of the IISc doctoral theses does not fit the Bradford's distribution pattern. The Bradford multipliers were calculated and the law was found to be applicable with the value of k as 1.2. The distribution of the journals in three zones was made and the number of references in each zone was then estimated. The applicability of Leimkuhler model was also tested with the present data.

Verma and Thakur (2010)⁶⁹ studied thirty five doctoral dissertations in the area of botany accepted by Pt. Ravishankar Shukla University during 1966-2004. A total of 7,916 citations were analyzed to identify their bibliographic form, authorship pattern and ranking of journals. The study revealed that journals are the most preferred by the researchers in the field of botany accounting for 72.54 per cent of the total citations. The study and authorship pattern reveals that majority of the contributions are from single authors. Researchers in the field of botany cited Indian journals heavily.

Burman and Sheela (2011)⁷⁰ studied citations appended to dissertations of law submitted to University of Delhi in the year 2006. The findings of the study reveal that journal articles were the most preferred source of information compared to books and other information sources.

Munindra Sakharkar (2011)⁷¹ studied the research productivity of 111 doctoral theses awarded by R.T.M. Nagpur University, Nagpur during 2005-2008 in different languages.

Nandi and Bandyopadhyay (2011)⁷² studied the citations appended to seventy three theses submitted to the Department of mathematics of the University of Burdwan during 1960-2000 and 269 articles based on them. The study was carried out to find the trends of research, article productivity, choice of journals, authorship pattern and most prolific authors with their credit and impact. The highest number of theses submitted was fifteen during 1986-2000. The highest number of articles were seventy one during 1991-1995. The Degree of Collaboration is 0.47. The leading Journals preferred by the researchers in mathematics are *Bulletin of Calcutta Mathematical Society* with thirty eight papers followed by *Indian Journal of Pure and Applied Mathematics* with thirty four papers and *Indian Journal of Theoretical Physics* with eleven papers. India occupied the first place with 65.05 per cent of published papers followed by USA (9.66%), UK (6.32%) and Hungary (5.20%).

Rahman and Bhattacharya (2011)⁷³ carried out citation analysis of thirty three doctoral dissertations submitted to North Bengal University, Darjeeling, West Bengal in the field of mathematics during 1987-2007. A total number of 4,512 citations appended to these theses were analysed to study the productivity of research supervisors, bibliographic form-wise distribution of citations, authorship pattern, degree of collaboration, country-wise distribution of cited journals and to prepare the ranked list of cited journals. The results reveal that journal citations constitute 88.51% of the total citations followed by seminar and conference papers (6.01%) and books and monographs (2.84%). The study of authorship pattern reveals that two authored papers comprised the highest percentage (42.00%) of total citations and single authored papers constituted 31.41 per cent of the total cited papers. Papers with three authors account for 18.38 per cent followed by papers with four authors (5.18%), five authors (2.23%) and more than five authors (0.80%). The degree of collaboration is 0.685 on a whole. The country-wise distribution of cited journals reveals that India occupies the first place with 26.08 per cent of the total cited journals followed by USA (18.13%), UK (11.87%), The Netherlands (3.38%) and Singapore (2.93%). In the ranked list of cited journals, the Indian journals 'Indian Journal of Pure and

Applied Mathematics' (5.48%) and 'Bulletin of Calcutta Mathematical Society' (4.24%) occupy the first and second ranks respectively.

Siva Prasad and others (2011)⁷⁴ analysed fifty two doctoral theses in marine geology submitted to Andhra University during 1954-2009. A total of 9,453 citations were analysed for identifying their bibliographic form, authorship pattern, ranking of cited journals and subject-wise distributions of citations. The findings reveal that nearly 71.27 per cent of the citations were citations of journals and 13.51 per cent of citations are these of books. USA, India and UK together contribute 83.77 per cent of citations. The authorship pattern reveals that multi authored papers are maximum in number (73.70%).

Kehinde Fasae (2012)⁷⁵ studied the 4,227 citations appended to fifty two dissertations of master's degree and sixteen doctoral theses submitted to the Federal University of Technology, Akuru, Nigeria during 2004-2009. The distribution of citations according to bibliographic form show that journals occupy the first place with 34.97 per cent of the total citations followed by books (25.15%), conference proceedings (15.31%), reports (11.31%), theses and dissertations (4.49%). The study of authorship reveals that papers with single author occupy the first place with 52.21 per cent of the total citations followed by joint authors (32.40%) and corporate authors (14.38%)

Kumar and Raghunadha Reddy (2012)⁷⁶ carried out the citation analysis of 991 citations appended to ninety one Masters degree dissertations submitted to the Department of Library and Information Science, Sri Venkateswara University, Tirupati, during 2000-2007. The bibliographic form-wise distribution of citations reveals that a high percentage of citations (40.06%) were of journal articles followed by books (39.66%), Web (10.49%) and conference proceedings, seminars and workshops (7.67%). The first three journals in the ranked list contributed nearly 28 per cent of the total citations and the next six journals contributed nearly 25 per cent of the citations.

Nasir and Devendra Kumar (2012)⁷⁷ analysed the 4,875 citations appended to forty doctoral dissertations submitted to the Aligarh Muslim University, Aligarh, in the field of economics during 1990-2010 to study the authorship pattern, distribution

of literature by format, language and country and to prepare the ranked list of journals by citation frequency. The distribution of citations by bibliographic form reveals that books occupy the first place with 44.01 per cent followed by reports (3.49%). The distribution of citations by language reveals that English occupies the first place with 93.05 per cent of the total citations followed by Arabic (2.85%) and Hindi (1.48%). The ranked list of cited journals reveals that the first five journals contributed nearly 25 per cent of the total citations. The trends in authorship pattern reveals that papers with single authors account for 81.19 per cent of total citations followed by papers with two authors (16.24%) and papers with three and more than three authors (2.58%). The study of distribution of cited books by country of publication shows that India occupies the first place with 53.05 per cent of citations followed by USA (19.61%) and UK (11.27%). The distribution of cited journals by country of publication revealed similar results showing that India occupies first place with 25.93 per cent of citations followed by USA (21.29%) and UK (15.72%).

Pramod Kumar and Chauhn (2012)⁷⁸ studied 3,442 citations appended to eighteen theses accepted by HNB Garhwal Central University, Srinagar in the discipline of psychology. The study is carried out to find out the distribution of citations by form, distribution of journals by frequency of citations and year and country-wise distribution of journal articles. The results reveal that journal articles occupy the first place with 42.71 per cent of the total citations followed by books (40.53%), reports (7.44%) and government publication (5.49%). The country-wise distribution of citations reveals that USA occupies first place with 40.18 per cent of the total citations followed by India (37.39%) and UK (13.83%).

Trayambakrao and Sonwane (2012)⁷⁹ carried out citation analysis of 2,876 citations appended to thirty four PhD theses submitted to Dr. Babasaheb Ambedkar Marathwada University, Aurangabad, during 2002-2010 in the field of economics. The form-wise distribution of cited literature reveals that books occupy the first place with 57.86 per cent of total citations followed by reports (19.19%), journals (18.70%) and government publications (4.07%). The language-wise distribution of cited documents shows that English occupies the first place with 52.33 per cent of the total cited documents followed by Marathi (45.76%) and Hindi (1.91%). The country-wise

distribution of cited documents shows that 68.75 per cent of documents were published from India followed by UK (2.02%) and USA (1.67%).

Gupta and Khare (2013)⁸⁰ analysed the citations appended to theses which were submitted to Bundelkhand University, Jhansi and Dr. Harisingh Gour University, Sagar. The study analysed 13,482 citations appended to sixty three theses submitted during 1992-2009 to these two universities. Analysis of data indicates that the average rate of citations per thesis is 218.6. The bibliographic form-wise distribution of citations shows that books occupy first place with 38.40 per cent of the total citations in both universities followed by journal articles (37.10%), conference proceedings (6.20%) and websites (5.50%). The study of authorship pattern of cited books shows that papers with single author are more in number (75.10%) followed by papers with two authors (19.30%) and papers with three or more authors (5.60%). The country-wise distribution of cited journals indicates that the highest number of journals are published from USA (44.00%) followed by India (19.80%), UK (16.20%) and The Netherland (7.10%).

Kannappanavar (2013)⁸¹ carried out citation analysis of doctoral theses in biotechnology submitted to Kuvempu University, Karnataka. The study reveals that journals are the most preferred source of information used by the researchers in the field of biotechnology accounting for 79.72 per cent of the total citations followed by books, proceedings, theses, reports and patents. The study of authorship pattern reveals that multi-authored papers are the highest and the degree of collaboration is 0.85.

Krishna Dass and Jayaraman (2013)⁸² analysed the 7,892 citations appended to sixty doctoral theses submitted to various universities in our country in the discipline of management studies in the year 2013. The distribution of citations according to bibliographic form shows that journals occupy the highest place (56.81%) followed by books (21.88%), e-resources (13.16%) and reports (5.66%).

Rahman and Bhattacharya (2013)⁸³ carried out bibliometric study of 8,478 citations appended to forty three doctoral theses in zoology, submitted to the North Bengal University, Darjeeling, during 1987-2007. The study reveals that the average number of citations per thesis is 197.6. The bibliographic form-wise distribution of

citations reveals that journal articles account for 83.19 per cent of the total citations followed by books (10.10%) conference papers (1.67%) and dissertations (1.66%). Papers with two authors are maximum in number (38.50%), followed by single authored papers (25.35%). The degree of collaboration is 0.746 and USA is the leading country with 25.49 per cent of the total cited journals followed by UK (17.52%) and India (14.55%).

Singh and Bebi (2013)⁸⁴ carried out citation analysis of 5,766 citations in twenty five doctoral theses in the field of sociology accepted by University of Delhi during 1995-2010. The study presented analysis of several parameters like forms of literature, authorship pattern, country-wise scattering of citations and ranking of journals. The bibliographic form-wise distribution of citations reveals that books are the most preferred source of information (67.32%) followed by journal articles (22.20%), book chapters (4.26%) and reports (2.20%). The study of authorship pattern reveals that papers with single authors are the highest in number accounting for 83.94 per cent of the total citations followed by papers with two authors (11.58%) and papers with three authors (1.80%). The country-wise scattering of citations reveals that 43.98 per cent were from India followed by USA (26.81%) and UK (22.42%). The two Indian journals in the ranked list, *Economic and Political Weekly* and *Indian Journal of Psychiatry*, occupy first and second place respectively and collectively contribute 18.36 per cent of the total citations.

Suma and Sudhier (2013)⁸⁵ analysed 137 PhD theses submitted to three different universities in Kerala viz., University of Kerala, Cochin University of Science and Technology, and Mahatma Gandhi University by the researchers working in National Institute for Interdisciplinary Science and Technology, Thiruvananthapuram, during 2001-2010. The study reveals that the average number of citations per thesis is 242.79. The distribution of theses according to broad subject area reveals that chemistry occupies the first place with 78.10 per cent of total theses followed by physics (10.95%) and bio-technology (2.19%). The bibliographic form-wise distribution of citations included in the theses by the researchers reveals that journal articles are the most preferred source of information accounting for 60.09 per cent of the total citations followed by proceedings of national conferences/seminars (24.33%) and proceedings of international conferences and seminars (6.97%).

Tunga and Dasgupta (2013)⁸⁶ carried out citation study of 10,845 citations appended to eighty doctoral theses in the field of horticulture awarded by Bidhan Chandra Krishi Viswavidyalay (BCKV) and Uttar Banga Krishi Viswavidyalay (UBKV), West Bengal to determine the use pattern of the cited literature by the researchers during 1991-2010. The study attempted to identify the department-wise and crop-wise distribution of theses, bibliographic forms, ranking of the most cited journals, geographical, chronological and obsolescence studies of literature in horticulture. The bibliographic form-wise distribution of citations reveals that journals contribute the highest number of citations contributing 77.796 per cent of the total citations followed by books (12.236%) and conference proceedings (4.721%). The ranked list of the most cited journals reveals that a slightly more than twenty seven per cent of the total citations were contributed by the first five journals and the next twenty five per cent of the citations were contributed by the next seven journals in the ranked list. The journals data does not fit in to the Bradford's distribution. The half-life of journal articles is found to be twenty four years. The country-wise distribution of cited journals reveals that India occupies the first position with 35.046 per cent of citations followed by USA (17.248%), UK (12.477%), Japan (8.807%) and Pakistan (6.422%).

2.2.2 Citation Analysis of Journals

Sengupta (1974)^{87,88} studied the growth of the literature of pharmacology and microbiology by analysing the citations in *Annual Review of Pharmacology* and the *Annual Review of Microbiology* during the period 1968-1970 and prepared a ranked list of journals in pharmacology and microbiology.

Anand (1979)⁸⁹ studied the citing pattern of Indian chemists by analysing the citations in the *Journal of the Indian Chemical Society* for the year 1979. The authorship pattern revealed that papers with two authors were maximum in number accounting for 50.87 per cent, followed by papers with three authors (31.22%) and single authored papers which accounted for 8.52 per cent. The bibliographic form-wise distribution of citations showed that journals accounted for 88.56 per cent of the total citations and self-citations accounted for 11.26 per cent.

Nagappa and Maheswarappa (1981)⁹⁰ analysed 2,663 citations appended to the articles in the journal *Indian Phytopathology* during 1971-1972. The bibliographic form-wise distribution showed that journal articles accounted for 83.3 per cent of the total citations followed by books (10.40%) and conference proceedings (2.30%). The first twenty journals in the ranked list contributed 55.77 per cent of the total citations.

Maheswarappa (1983)⁹¹ analysed 5,533 citations in the journal *Phytomorphology* during the period 1995-1979. The bibliographic distribution of citations showed that citations to journals occupied first place accounting for 78.85 per cent of the total citations, followed by books (17.53%), theses (1.69%) and conference proceedings (1.44%). The productivity of cited journals showed that fifty per cent of the journal literature used by the phytomorphologists was contributed by the first twenty four journals in the ranked list and the remaining fifty per cent of the literature was scattered in the remaining 640 journals. The geographical distribution of citations showed that USA occupied the first place accounting for 28.44 per cent of the total journal citations, followed by India (14.85%), UK (13.45%) and Germany (11.29%).

Kapoor (1984)⁹² studied the citations in the journal *Annual Review of Earth and Planetary Sciences* during the period 1973-1981 and prepared a ranked list of eighty two journals contributing seventy six per cent of the total citations out of the 833 titles cited. The country-wise distribution of citations showed that USA occupied the prime position by contributing 56.02 per cent of the total citations, followed by UK (23.25%), The Netherlands (8.54%) and Germany (4.12%).

Dutta and Sen (2000)⁹³ carried out citation analysis of 743 citations appended to forty one research articles published in the January to April 2000 issues of *Indian Journal of Pure and Applied Physics*. The result reveals that journal articles accounted for eighty three per cent of the total citations and ratio of Indian to foreign citations is found to be almost 1:8. The percentage of author self-citation is found to be slightly more than seventeen per cent and that of journal self-citation just 3.6 per cent. The ratio of Indian affiliated citing author to foreign affiliated citing author is 6.3:1. Of the citing articles, three are single authored, seventeen are two authored, ten are three authored, six are four authored and four are five authored.

Tiew and others (2002)⁹⁴ carried out bibliometric examination of the journal articles published in the *Malaysian Journal of Library and Information Science* for the period 1996-2000. The result reveals that 69.74 per cent of the articles are research oriented; the multi-authored papers account for 52.60 per cent; the most prolific author contributed twelve articles and forty five per cent of the authors are geographically affiliated to Malaysia.

Narang (2004)⁹⁵ studied 8,396 citations appended to 737 articles published in the *Indian Journal of Pure and Applied Mathematics*, volumes 29 to 33, during the years 1998-2002 and 470 citations appended to 70 articles published in the maiden volume 1 published in 1970. To observe the distribution of contributions, authorship pattern, citation analysis, geographical distribution of contributions and number of pages used in each volume, a comparative study of articles published in five volumes vis-a-vis those in volume 1 has been made. Results indicate that the number of contributions is increasing in successive volumes. Highest number of papers has been written by joint authors. The most cited documents are articles from the research journals. The contributions in this journal from India and other countries are almost equal. Among the Indian states, Uttar Pradesh is the top contributor whereas among the Indian universities/institutes, University of Delhi is at the top. At the International level, India is the top contributor followed by China. The growth and popularity of this journal is found to be showing an upward trend.

Jena (2006)⁹⁶ carried out the bibliometric analysis of the journal, *Indian Journal of Fibre and Textile Research* for the period 1996-2004. The trends of publications such as the year wise distribution of articles, bibliographical distribution of citations, authorship pattern, citation pattern, average length of articles, number of tables and figures used, time lag and geographical distribution of authors have been studied.

Verma and others (2007)⁹⁷ carried out the analysis of 131 contributions of the journal titled *Annals of Library and Information Studies* during 1999-2005. The study shows that most of the articles are contributed by single author and that most of the contributors are from New Delhi. Citation analysis reveals that journals are the most cited publications amongst the library and information scientists and the source journal, i.e. *Annals of Library and Information Studies*, is the most cited journal.

Bakri and Willett (2008)⁹⁸ carried out bibliometric analysis of all the journal articles published in the *Malaysian Journal of Library and Information Science* during 2001-2006. They compared the results with those obtained in an earlier study by Tiew and others in 2002, covering the period 1996-2000. The results showed that the number of publications had increased, with statistically significant changes in the types of article, in the numbers of references per article and in the lengths of the article.

Bhat and Kumar (2008)⁹⁹ studied the citation analysis of research articles from scholarly electronic journals in the field of library and information sciences published during the period 2000-2006. The study found that 81.49 per cent of articles published during the period had web references. Out of 25,730 references, 56.54 per cent of references were print journal references and 43.52 per cent of them were web references.

Sam (2008)¹⁰⁰ presented the results of an analysis of articles published in the *Ghana Library Journal* from 2000-2006. The majority of the items cited were journals followed by books and reports. Only four of the top twenty two journals cited frequently were of African origin, the rest were European or US-based. The most researched subject area was academic libraries.

Kumar and others (2009)¹⁰¹ analysed 18,224 papers published by 3,439 institutions in 445 Indian science journals and abstracted by *Indian Science Abstracts* (ISA) during 2006-2008. The result indicates that the major publication output came from academic institutions followed by state agricultural universities and medical colleges. Among the state agriculture universities, Punjab Agriculture University ranked first followed by CCS Haryana Agriculture University. The highest number of papers were published in the disciplines of agriculture, forestry, animal husbandry and fisheries followed by medical and veterinary sciences. The Indian publication output in 2006 has increased considerably as compared to the year 1984.

Jayaraman (2011)¹⁰² carried out citation analysis of the articles published in the e-journal *Library Philosophy and Practice* for the period 2005-2010. The subject-wise distribution of articles shows that the highest number of articles (17.66%) appeared under library and information science followed by library and Internet

(16.92%), user studies (13.68%), special libraries (9.20%) and academic libraries (7.71%). The mean degree of collaboration is 0.63 and a high percentage (53.23%) of articles were contributed by universities followed by colleges (29.11%) and research institutions (13.93%). The bibliographic form-wise distribution of cited documents reveals that journals occupy the first place with 62.71 per cent of the total citations followed by books (18.17%), seminar/conference proceedings (8.17%) and dissertations (4.51%).

Poonkothai (2011)¹⁰³ carried out scientometric analysis of 347 articles published in nine volumes of *Proceeding mathematical Sciences* for the period 2000-2008. The number of contributors and their distribution in different volumes, authorship pattern, foreign and Indian authored contributions, institution-wise contribution and contributions at national and international level have been studied. The maximum number of contributions is by single author and India is the major contributor. The growth and popularity of the journal is showing a steady upward trend.

Arya (2012)¹⁰⁴ studied the *Indian Journal of Veterinary Medicine* published during the period 1999-2007. The study shows that multi-authored papers are 95.55 per cent and single authored papers are 4.45 per cent. The degree of collaboration in the field of veterinary medicine is 0.96. Average number of authors per paper varies from 2.92 to 4.08.

Jena and others (2012)¹⁰⁵ carried out bibliometric study of 4,056 citations appended to 247 articles published in thirty six issues of *Annals of Library and Information Studies* (Vol.49 to 57) published during the period 2002-2010. The bibliographic form-wise distribution of citations reveals that journals occupy the first place with 57.421 per cent of the total citations followed by books (16.543%) and web resources (11.588%). The study of authorship pattern of 247 articles reveals that papers with two authors are the highest in number (47.368%) followed by papers with single author (32.389%), papers with three authors (17.409%) and papers with four and above authors (2.834%).

Bansal (2013)¹⁰⁶ carried out bibliometric analysis of the journal *DESIDOC Journal of Library & Information Technology* to assess the pattern of growth of the research output published in the journal, pattern of authorship and geographic distribution of output, subjects covered, citation analysis of the references attached to the papers and change in them over two different periods (2001-2006) and (2007-2012). It is found that 391 papers were published during the period of study (2001-2012). The maximum number of articles (65) were published in 2012. The maximum number of contributions were through joint collaboration forming 61.40 per cent. Most of the contributions (88%) are from India and twelve per cent are foreign contributions. The study revealed that majority of the authors preferred journals as the source of information providing the highest number of citations.

Das (2013)¹⁰⁷ analysed 239 scholarly communications published in the inaugural five volumes of *Journal of Informetrics* (JOI) to examine the growth of literature, types of communications, authorship pattern, collaboration trend, predominant research domains, etc. Subsequent analysis focuses on prolific contributors, degree of collaboration and time-lag trend. The findings reveal that the publication output doubles over the study period as article publications increase considerably; though single-authored contributions were significant (30.00%), majority of contributions were collaborations by two-authors (36.00%), while average authorship accounts for 2.28 per communications. Degree of collaboration was impressive (0.699) but not overwhelming as research collaborations emanated from 199 higher learning institutions of thirty two countries across the globe. Result also shows upward trend of keyword usage with an average of 4.55 per items, of which h-index, citation analysis, bibliometrics, g-index, etc, expectedly predominate. Scholarly nature of source journal has been further ascertained from increasing citations and reference usage trend. Moreover, growing hardness of the field has been attributed to JOI due to the increasing usage of tables and figures. Study also showed that the journal takes an average of about four months to publish a manuscript.

Dash and Parida (2013)¹⁰⁸ studied the diffusion in two medical journals viz., *Indian Journal of Cancer* and *Journal of Communicable Diseases*. The data was collected from SCOPUS database for the period 2001-2010. It is found that there is

improvement in diffusion factor for both the journals, but there is significant rise for *Indian Journal of Cancer*.

2.2.3 Citation Analysis of Specific Subjects

Rangra and others (1972)¹⁰⁹ studied the coverage of Indian literature on chemistry and chemical technology excluding metallurgy in *Referativnyi Zhurnal-Khimiya*, based on the literature reported in *Indian Abstracts*, and found that only thirty one per cent of the literature had been covered in the journal.

Grefrath (1974)¹¹⁰ analysed the citations appended to 308 journal articles in the field of chemistry published in 1963. The results showed that theoretical articles had a longer life time than articles on practical aspects.

Ayers (1981)¹¹¹ studied the journal articles and conference proceedings relating to chemical history, education and documentation based on the data collected from *Chemical Abstracts* for the years 1969 and 1979. The results showed that the percentage of articles published in the English language has decreased from 62.50 per cent in 1969 to 55.80 per cent in 1979 and in the Russian language from 18.10 per cent in 1969 to 14.50 per cent in 1979, whereas the percentage of articles published in German and Japanese languages has increased from six per cent to 12.30 per cent and from 0.80 per cent to 3.60 per cent respectively for the corresponding years.

Guay (1986)¹¹² conducted a quantitative survey of the emergence of organic chemistry in India based on the data collected from *Chemical Abstracts* for the period 1907-1926. Chemists who were conducting research in India were grouped under three distinct groups on the basis of their cultural identity and educational background. The important disparities between these three groups both in terms of research fields and in terms of publication outlets were identified.

A bibliography comprising 316 items on AIDS for the period 1981 to 1984 was analysed by Gupta (1988)¹¹³ to study the characteristics of AIDS literature. The rate of growth has been found to be exponential after the first publication; journal literature constituted the major portion accounting for eighty six per cent of the total literature, followed by books, conference proceedings, audio-visual materials and reports.

Afolabi (1992)¹¹⁴ studied the productivity of journals, the language, subject and title dispersion of journals which published articles on librarianship in Nigeria during 1910-1985. The observation was that there were four core journals with respect to the Nigerian library literature; ten per cent of the journals were published in Nigeria; title dispersion of journals was low; and articles were predominantly in English (99.7%), while the remaining articles were published in Russian, French and Scandinavian languages.

Kajberg (1996)¹¹⁵ carried out citation analysis of library and information science literature published in Denmark during the period 1957-1986, to study the characteristics of the periodical literature and communication patterns. The country-wise distribution of citations showed that Denmark accounted for 64.10 per cent of the total citations followed by USA (9.50%) and UK (7.40%). The bibliographic form-wise distribution of citations showed that journals accounted for 40.50 per cent of the total citations, followed by monographs (18.80%) and technical reports (15.80%). Findings on the age dispersion of citations revealed that 69.10 per cent of citations were of works which were five years old, or less, at the time the article was written.

Meera (1998)¹¹⁶ carried out a bibliometric study of journal citations in the field of plant ecology for the period 1994-1995. The results revealed that the first fifteen journals in the ranked list accounted for thirty five per cent of the total citations. The country-wise distribution of citations showed that USA occupied first position with 19.7 per cent of the total citations, followed by UK (18.00%) and The Netherlands (12.31%). English was the most preferred language of communication of research findings accounting for 85.58 per cent of the total citations followed by Chinese (3.12%), Italian (1.89%) and Russian (1.81%).

Gaffney (2004)¹¹⁷ mapped the scholarly literature in the discipline of food science using co-citation analysis and explored the relationships found within this literature. Using the Journal of Food Science, an examination of a random sample of its articles published from 2000-2002 yielded a ranked list of frequently-cited journals. The top thirteen most frequently-cited journals formed a core set for further analysis. Using the Science Search online database SPSS package, a two-dimensional map was created, relationships between the journals were studied and the discipline of

food science was explored. The results are consistent with previous indications of the interdisciplinary nature of the field of food science, drawing as it does from many fields such as chemistry, microbiology, engineering and agricultural science.

Singh and Gupta (2005)¹¹⁸ studied the quantitative profile of a research and teaching institute, with a view to get idea about its major research contribution performance and impact in different fields of science and technology. A number of quantitative and qualitative indicators have been used for studying the relative performance of institutes across various subjects. They concluded that the three subjects, namely mathematics, biology and clinical medicine, although contributing smaller number of papers, secured first three ranks in terms of average normalized impact factor per paper. They have also done fairly in terms of percentage of collaborative papers, with the exception of clinical medicine. These three fields have performed the best in terms of publication effectiveness index.

Ramakrishnan and Ramesh Babu (2007)¹¹⁹ carried out bibliometric analysis of the literature output in the field of Hepatitis covered in three bibliographic databases namely MEDLINE, CINAHL and IPA for the period 1984-2003. MEDLINE covered the maximum of 75,750 records during the study period, followed by CINAHL and IPA databases. There are a total number of 82,617 records in three databases in the field of hepatitis during the study period. The total number of duplicate records among the three databases is 3,305 (4.00%). Total number of records after removing duplicate records is 79,312 (96.00%). One-third of the citations indexed with the term 'hepatitis' for the period of this study have more than five (32.91%) authors, 85.17 per cent of the total contributions are tending to be collaborative research with different degrees of collaborations ranging from 0.82 to 0.86. Collaborative research tends to be more in the field of Hepatitis.

Yi (2008)¹²⁰ performed keyword analysis to evaluate research trends of DDT (1,1,1-trichloro-2,2-bis (p-chlorophenyl) ethane) based on papers published during 1991-2005 in any journal of all the subject categories of the Science Citation Index. DDT was used as a keyword to search parts of titles, abstracts, or keywords. The analysis showed that DDT research steadily increased over the past fifteen years and the annual publication output in 2005 was about twice that of 1991. The two peaks in 1997 and 2000 were closely related to two new research fields on DDT, namely the

endocrine disruption and the persistent organic pollutants (POPs). Keyword analysis indicated that the research interest changed remarkably from 1991 to 2005. "Endocrine disruption" was one of the most frequently used author keywords in the period between 2002 and 2005 whilst it did not appear before 1997. The new conception of POPs showed the same trend.

Ahila and Nagarajan (2011)¹²¹ analysed the research output performance on pharmacology. A total of 22,065 research articles published in Web of Science were analysed to find the performance of scientists from all over the world in terms of growth during the period 1999-2010 (12 years). The study covers annual growth rate, global publication share and rank among fifteen countries of the world, authorship pattern, high productivity institutions, journals, etc. The country-wise distribution of articles reveals that 41.58 per cent of the total articles were contributed by the authors from USA followed by England (10.37%), Germany (8.21%), France (6.24%) and Japan (5.02%). The language-wise distribution of articles shows that most of the articles were published in the English language (96.53%) followed by German (1.18%) and French (1.16%). The study of authorship pattern reveals that papers with more than three authors occupy the first place (53.62%) followed by papers with two authors (17.20%), papers with single author (15.22%) and papers with three authors (13.96%).

Balasubramanian and Ravanani (2011)¹²² carried out scientometric analysis of scientific output in the area of agriculture for the last sixty six years. The data was extracted from Web of Science database from January 1995 to December 2010. The results reveal that USA is at the top in terms of productivity with 32.59 per cent of publications followed by England (6.72%), Canada (5.78%) and Germany (5.52%). Language-wise distribution of publications shows that the agriculture literature is published in twenty nine different languages. English language occupies the first place with 91.61 per cent of the total publications followed by German (3.15%) and French (1.49%).

Veeramani and Sivaraman (2011)¹²³ analysed a total of 8,342 bibliographic records retrieved from Science Citation Index Extended and Scopus databases for a period of ten years (2001-2010) to study the research trends in chemistry in our country. The research output has been analysed by year, document type, authorship

pattern and collaboration. The results of the study reveal that the chemistry literature has grown steadily during the study period: articles are predominant source of information: the research in chemistry is fairly collaborative and scattering of journal articles does not fit into Bradford's distribution

Baskaran (2012)¹²⁴ examined the research growth, relative growth rate and doubling time of publications, institution-wise and ranking of authors in research productivity of graph theory during 2004-2011. The average number of papers published per year was 910.75 during the period. The highest number of papers published were above thousand during the years 2009 to 2011. It is observed that Relative Growth Rate (RGR) has shown increased and decreased trend from 2005 (0.113) to 2011 (0.057). The Doubling Time (Dt) has shown a fluctuating trend during the period of study. The results examined the author exponential growth using least squares excluding high productive authors and maximum likelihood method. Lotka's law is found to be applicable to graph theory research during the study period.

Ma (2012)¹²⁵ analysed the intellectual structure and its evolution of library and information science (LIS) in China with time series data from Chinese Social Sciences Citation Index which is the properest database for ACA practice in the field of social science at present. The result indicates that the subfields of Library and Information Science in China kept changing from 1998 to 2007: some subfields have emerged and developed a lot, e.g., webometrics and competitive intelligence; some subfields maintain, e.g., bibliometrics and intellectual property; and some subfields have begun to decline, e.g., cataloging. Through the comparison with the international LIS, it is found that there are some unique subfields in Chinese LIS from 1998 to 2007, such as competitive intelligence and intellectual property.

Dutt and Nikam (2013)¹²⁶ examined solar cell research in India as revealed by the publications indexed in Web of Science for a period of twenty years from 1991 to 2010. It was seen that academic institutions contributed about half of the total output. Indian Association for the Cultivation of Science outperformed all other institutes in the country. Solar cell research by Indian scientists is well connected to international research trends in the field. The recent trends suggest more domestic and international collaborative research involving larger team sizes. More emphasis is being laid on research in solar cells based on materials other than silicon.

Saha and others (2013)¹²⁷ assessed the contributions of PLANNER (Promotion of Library and Networking in North Eastern Region) in terms of automation articles contributed by the authors in the four conventions. They have presented year-wise contributions, authorship pattern, bibliographic form-wise distribution of cited documents and the ranked list of journals cited in all the four volumes.

Shahabuddin (2013)¹²⁸ has mapped neuroscience research in India for the years 1992-2005 using Neuroscience Citation Index and PubMed. The data consists of 18,138 papers published in 1,975 journals from forty seven different countries. The results reveal that fourteen out of the top eighteen productive journals are from India, of which only six have impact factor. The data set have been found to be a perfect fit for the Bradford's Law of Scattering - both verbal and graphical formulation of the law. About twenty per cent of the papers are published in journals which are having no impact factor and sixty one per cent of papers are published in journals having impact factor less than three. However, only 128 papers are published in Journals having impact factor more than ten. More than seventy per cent of the papers are not cited at all and those published in 1998 have been better cited. Papers having international collaborations are cited more often.

Sivasubramani and Thirumagal (2013)¹²⁹ carried out bibliometric analysis of medicinal and aromatic plant research output by collecting the data from Web of Science for a period of five years i.e. 2008 to 2012. The result reveals that 99.52 per cent of publications are published in English language followed by German (0.16%). The country-wise distribution of citations shows that India occupies the first place with 500 citations followed by USA with 23 citations.

Thirumagal (2014)¹³⁰ carried out bibliometric investigation of wind energy covering the period 1999 to September 2011. The data was extracted from Web of Knowledge database. The data analysis was done by the analytical tool of Histcite and Bibexcel. The study of single and multiple authors reveals that publications by multiple authors constitute 73.98 per cent and publications by single author constitute 26.02 per cent.

Nagaiah and Srimannarayana (2015)¹³¹ analysed the papers in the field of organic chemistry published in *Indian Journal of Chemistry-B* during the period 2011-2013. The study reveals that a large number of published papers are from state universities including the affiliated PG colleges (72.80%). The contributions of national institutes/universities which include Central Universities, CSIR, IIT, IISc, IISER and NITTTR during the period range from four per cent to thirteen per cent, private and deemed universities (0.85% to 6.00%) and private pharma including custom research organizations (3.53% to 6.00%). It was also found that there is more enthusiasm to publish papers in higher ranking international journals than the premier journals published from our country.

Song and others (2015)¹³² carried out content analysis of Alzheimer's disease research by collecting metadata of 96,081 articles retrieved from PubMed. The analysis carried out includes productivity analysis (year, journal, author and Medical Subject Heading terms), network analysis (co-occurrence frequency, centrality and community) and content analysis. The results indicated that the year 2013 is the most productive year and *Journal of Alzheimer's Disease* is the most productive journal.

Terekhov (2015)¹³³ conducted scientometric analysis of carbon nanostructures in Russia based on scientific publications and patents for the period 1990-2011. The data relating to scientific publications was extracted from the Science Citation Index Expanded data base. The patent information was extracted from data bases of the United States Patent and Trade Office, the World Intellectual Property Organization and Russian Federal Service for Intellectual Property. Bibliometric methods are used to rank countries, institutions and scientist's contribution to the carbon nanostructures research. The ranking of countries by the number of publications for the study period 1990-2011 reveals that USA occupies the first position with 22,579 publications followed by China with 17,937 publications and Japan with 10,532 publications. The study of authorship pattern during the study period reveals that papers with three authors are maximum in number (16.80%) followed by papers with four authors (16.00%), papers with two authors (14.30%) and papers with five authors (13.70%). The study also analysed the current state and trends of the research in Russia as compared to other countries.

2.2.4 Citation Analysis of works of Scientists, Institutions, Universities and Countries

Usha and others (1991)¹³⁴ studied the citing behavior of scientists of India, USA, UK and Canada by analysing the citations in some selected journals of chemistry and chemical technology. It was found that Indian authors generally cited older literature whereas American authors cited more recent literature irrespective of their place of work. The citation practice of British and Canadian scientists had fallen between USA and Indian scientists.

Arunachalam and others (1998)¹³⁵ studied more than 42,000 papers published by Indian scientists in 2,300 journals indexed in the SCI during 1989-1992. Indian contribution to world scientific literature is showing a decline as India came down from the 8th position in 1980 to 12th position during 1989-1992.

Gopalakrishnan and others (2002)¹³⁶ studied the nature and pattern of citations in seminar proceedings by information scientists of Indian origin. The study reveals that the trend of citations has changed over time and web citations would replace other citations in future.

Bar-Ilan (2006)¹³⁷ carried out an ego-centric citation and reference analysis of the works of the mathematician and computer scientist, Michael O. Rabin. The present study utilized and compared three major sources that provide citation data: the Web of Science, Google Scholar and Citeseer. Most cited works, citation identity, citation image makers and co-authors were identified. The citation image makers acquired through these sources differ considerably. Advantages and shortcomings of each of the tools are discussed in the context of computer science. A major issue in computer science is multiple manifestations of a work, i.e., its publication in several venues (technical reports, proceedings, journals, collections). The implications of multiple manifestations for citation analysis are discussed.

Garg and others (2006)¹³⁸ analysed 11,067 papers published by Indian scientists and indexed by *Science Citation Index* (SCI) for the year 1997. The study indicated that academic institutions are the major contributors to the scientific publications output. Major contribution came from twenty nine institutions, which

contributed about forty five per cent of the total Indian scientific output and forty six per cent of all high quality papers are published in India. It was observed from the study that about two-thirds of the total papers had appeared in journals with low and medium normalized impact factors.

Kanwar and others (2004)¹³⁹ analysed 20,046 citations mentioned in 777 scientific and technical reports published by National Institute of Hydrology, Roorkee, India, since its inception in 1978. The study covered 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 PhD Thesis, ME /MTech dissertation, bulletins and standards. A ranked list of fifty six most important journals related to hydrology and water resources has been prepared. This ranked list of journals covers 92.7 per cent of the total journal citations. The analysis has revealed that forty per cent of the total journal citations relate to only three journals, namely, *Water Resources Research* (19.01%), *Journal of Hydrology* (13.43%) and *ASCE's Journal of Hydraulic Engineering* (7.56%).

Bala and Gupta (2009)¹⁴⁰ analyzed sixteen years (1992-2007) research activities of the Government Medical College and Hospital(GMCH),Chandigarh, covered in Scopus International Multidisciplinary Bibliographical Database. The study found that GMCH stands at 9th rank in research output and 13th in average citation per paper among the top fifteen medical colleges of the country.

Varghese and Rajan (2009)¹⁴¹ analysed 632 publications of Rajiv Gandhi Centre of Biotechnology (RGCB) scientists during 1995-2006. The study shows that the publications of RGCB scientists include journal articles, conference papers, patents, chapters in books and PhD dissertations guided by them. They have published 112 journal articles (25.87%) during the year 2005-2006 and it is considered as the most productive year. The productivity of the scientists of RGCB shows substantial growth both quantitatively and qualitatively with the development of the institution.

Sengar (2012)¹⁴² analysed the publications output of Institute of Microbial Technology (IMTECH), India, published during 1991-1995 and 2005-2009 and assessed how science at IMTECH has progressed during the time. The publication

output has been analysed using quantitative and qualitative indicators, such as the number of papers published in Science Citation Index (SCI) and non-SCI journals during the 1991-1995 and 2005-2009, normalised impact factor per paper citations received per paper, subject-wise areas of research distribution, international collaboration with the other countries and characteristics of the highly productive authors of the institute.

Satpathy and Maharana (2012)¹⁴³ studied websites of twenty one National Institutes of Technology of India using web impact factors. Altavista search engine was used for collecting the required data. The simple web impact factor, self link web impact factor, external impact factor and revised web impact factor of the NITs have been calculated. The study was made during August- September 2010. The study revealed that some NITs have higher number of web pages but their official link pages are very small in number and websites fall behind in simple, self link and external link web impact factor.

Bala and Kumari (2013)¹⁴⁴ analysed the research performance of National Institutes of Technology (NITs) of India during 2001-2010 on several parameters including NITs overall contribution, its growth pattern, citation impact, the share of international collaboration, identification of significant participating countries in NITs international collaboration, contribution and impact by different subject areas, identification of weak and strong subject areas, productivity and impact of characteristics of high cited papers of NITs. The Scopus Citation Database has been used to retrieve the data for ten years (2001-2010). The study shows that the NIT-Rourkela scores the 1st rank with its publication share of 12.83 per cent. Twelve NITs have shown rise in their publication share, with NIT- Karnataka witnessing the highest 4.4 per cent rise. It improved its rank from 8th to 3rd during 2001-2005 to 2006-2010. Similarly, NIT-Bhopal has registered the maximum increase of 3.82 citation impact per paper during 2001-2005 to 2006-2010.

Shravan Kumar (2013)¹⁴⁵ studied the publications productivity of the Department of Atomic Energy, Government of India institutions. The data was collected from the Scopus Database. The study reveals that the Bhabha Atomic Research Centre leads other DAE institutes with systematic growth in number of publications from the year 2008 to 2011.

Hellgardt and others (2001)¹⁴⁶ described the results of the application of numerical taxonomy and specifically a taxonomic similarity measure (the Gower similarity co-efficient) to compare the publication output of a number of senior academics in chemical engineering in both UK and US universities. The measure takes account of both the numbers of articles published and the impact factors of the journals in which they were published. Using this co-efficient, it was found that most of the academics are not similar to the 'ideal' chemical engineering researcher, as defined by ISI's Journal Citation Reports, but some academics and some departments, are closer to the ideal than others.

Kumber and others (2008)¹⁴⁷ studied the growth, contribution and impact of research by the scientists of University of Mysore in Science and Technology during 1996-2006. They analysed the strong and weak areas of university research; their growth rate and impact in terms of average citations received and studied the output and impact of research under different existing subject departments of the university. Study found that the international collaborative research activity in the university was still very small, accounting for just fourteen per cent share. The collaborative research in the university was also confined to selected countries. USA occupies the first place (51.00%) in collaborative research with the university followed by Germany (23.00%), Japan (10.00%), Canada (6.00%), South Korea (5.00%) and Denmark (4.00%).

Raghuraman and others (2010)¹⁴⁸ carried out a three-part study comparing the research performance of Indian Institutions with the International Universities. In the first part, the publication profiles of various Indian institutions were determined and it was shown that the publications and citations per institution were the highest for the Indian Institutions. In the second part, the publication profiles of various institutions in the high-impact journals were examined. It was observed that the number of papers in these journals from India is miniscule compared to those from the US universities. The third part of the study focused on the publication profiles of specific science and engineering departments in the various Indian universities and these were compared with the top Asian and US universities based on publications and citations per faculty per year for each department. The Indian institutions lag far behind the top US

universities at the institutional level, especially if parameters like the total number of publications and citations per faculty are considered.

Ashraf and Jindal (2012)¹⁴⁹ studied research pattern and carried out citation analysis of publications of University of Delhi, Delhi, for the period 2002-2012 by downloading the data from the Web of Science Database. The study reveals an impressive research contribution of University of Delhi during the study period of 12 years. The analysis of data reveals that there were a large number of publications in physics and chemistry subjects amounting to 21.8 and 16.6 per cent respectively. In research collaboration, USA occupies the first position and Taiwan occupies the last position.

Anil Kumar and Kumar (2015)¹⁵⁰ investigated the research contributions of Maharshi Dayanand University, Rohtak, in terms of its publication output during 2000-2013 as reflected through Scopus Database. The study analysed the year-wise research productivity, its citations impact, national and international collaborations, top collaborating institutions, subject-wise distribution of papers, journals used for communication, most preferred journals for publication, most prolific authors, number of citations received and top cited papers of the university during the period under study.

Anil Kumar and others (2015)¹⁵¹ carried out bibliometric analysis of the research publications of Gujarat University during the ten-year period between 2004 and 2013. The data for this study was collected from Scopus and included a total of 760 publications that were attributed to authors affiliated to Gujarat University. The publication data was analysed with respect to the type of publications where eighty three per cent are journal articles. The paper also analysed the publication trend of Gujarat University and found that from 2008 onwards there was a steady increase in the number of publications. The other aspects that were identified in the paper were the most prolific authors, collaborative authorship patterns and trends, most preferred publications and so on. The collaboration was found to be the highest in the year 2012 at 0.70 based on the modified collaboration coefficient.

Gautam and Mishra (2015)¹⁵² analysed scholarly research publications of Banaras Hindu University, Varanasi, during the period 2004-2013. For the study, 1,041 articles were collected from Indian Citation Index. The study measured year-wise distribution of publication output, co-authorship index, collaborative co-efficient of collaborating universities/institutions/colleges, states and countries. The result indicates that research productivity of Banaras Hindu University is increasing at the average rate of 104.1 publications per year. Most of the research works are contributed by joint authors. Thirty nine per cent of articles were published in Science Citation Index Expanded indexed journals.

Ravi and others (2007)¹⁵³ investigated the rates of successful doctorates awarded in the Faculty of Science at Annamalai University in the fields of marine biology, physics, chemistry, botany, zoology, biochemistry, mathematics, statistics and geology during the period 2001-2005. The study followed that the marine biology (24.79%) has the highest rates with fifty eight theses, followed by chemistry (10.80%) which secured the second place with forty four theses.

Madasamy (2009)¹⁵⁴ carried out analysis on doctoral degrees awarded in library and information science during 2003-2008. The data was collected from University News. Analysis of data reveals that Andhra Pradesh has produced the highest number of PhDs during the period. Information sources and services, user studies, library management and bibliometrics are the leading areas on which most of the research has been carried out. The results conclude that more research needs to be carried out in the areas of digital libraries and ICT applications.

Krishna Reddy (2013)¹⁵⁵ studied the research productivity of Department of Mathematics, Sri Krishnadevaraya University during the years 1976-2011. A total of ninety nine doctoral degrees were awarded during the study period and out of these seventy seven theses belong to the sub-discipline applied mathematics. A total number of fifty one theses were submitted during 2006-2011.

Merhotra and Lancaster (1984)¹⁵⁶ analysed 38,000 research publications produced in India during 1979-1981 and indexed in SCI. It was found that Indian scientists published 50 per cent of their papers in Indian journals and 50 per cent in foreign journals with highest impact factors.

Braun and others (1994)¹⁵⁷ presented a comprehensive and detailed study on the publication output and citation impact for individual countries in all science fields.

Gupta and Dhawan (2009)¹⁵⁸ studied the current indicators on Indian Science and Technology for measuring the country's progress in research. The study uses for the purpose eleven years publications data on India and top twenty productive countries as drawn from the Scopus database for the period 1996-2006. The study shows that Science and Technology in India continues to be on growth track, logging 7.00 per cent average annual publications growth rate during 1996-2006, but peak is 10.7 during 2002-2006. India has to harness full potential of its science and technology enterprise. At present, it is still not harnessing its full potential as nearly 85 per cent of India's world share is still coming only from just seven states such as Tamil Nadu, Maharashtra, Delhi, Karnataka, West Bengal, Uttar Pradesh and Andhra Pradesh. Some of the states in India such as Gujarat, Madhya Pradesh, Kerala, Rajasthan, Haryana, Uttarakhand and Punjab are still the medium productivity states.

Madhan and others (2010)¹⁵⁹ studied the research papers published by Chinese and Indian researchers in all of sciences as seen from Web of Science during 1998-2007. The study reveals that India had published 2,35,679 papers in the ten years; and of these 758 were cited at least one hundred times; China had published 5,29,856 papers during the same period and of these 2,142 were cited at least one hundred times. China has published a far higher proportion of highly cited papers in high impact journals such as *Nature* (impact factor 28.75) than India. The study also revealed that USA is occupying the first place among journals cited by the scientific researchers in India and China.

Garg and Kumar (2013)¹⁶⁰ analysed the letters published by top ten publishing countries in journals indexed by Science Citation Index Expanded (SCIE) during 1987-89, 1997-99 and 2007-09. The study indicates that the letters published by developed countries including China have declined as proportion of their total output. The number of letters published by Indian scientists remained constant during the three blocks. These letters were scattered in a large number of journals published from advanced countries of the world and India. The letters came from more than 1,000 institutions located in different parts of the country. The highest number of letters

were published in the discipline of medicine and the letters published in the field of chemistry had the highest Relative Citation Impact (RCI).

2.3 Webometric Studies

Many webometric studies based on the websites have been carried out by various researchers. Thomas and Willett (2000)¹⁶¹ made a webometric analysis for the departments of Library and Information Science in United Kingdom universities. The findings indicate that it is not possible to identify any significant correlation between the citation data and peer evaluations of research excellence embodied in the Research Assessment Exercise (RAE) rankings.

Thelwall and others (2003)¹⁶² made webometric study of the universities of sixteen European countries to know academic interlinking. It is found that university websites tended to link mostly to countries geographically nearer. Similar patterns may also appear within a single country such as UK and Canada.

Aguillo and others (2006)¹⁶³ made an analysis of Web presence of universities in Latin America using cybermetric indicators. The authors have studied the Brazilian Universities to know the web presence through web and tried to visualize the web presence using the co-link maps of 167 Brazilian universities.

Stuart and others (2007)¹⁶⁴ investigated the potential of web links to act as an indicator of collaboration through a detailed classification of 2,600 links from universities to government, commercial and other domains. Whilst there are significant differences in the proportion of web links that reflect collaboration, depending on the source page owner and the target page top-level domain, the majority of web links on a university web page do not reflect collaboration between the web page owner and the target web page owner. However, there are still a significant number of links reflecting collaborative relationships which can provide a rich source of information.

Jalal and others (2009)¹⁶⁵ made a comparison among different types of ranking approaches for Southern region universities having valid NAAC score. It is found that there is a high correlation between NAAC ranking and WISER ranking.

Jeysankar and Ramesh Babu (2009)¹⁶⁶ examined and explored through a webometric study the websites of forty five universities in Tamil Nadu comprising twenty seven state and eighteen private universities. The study identified the domain systems of the websites; analysed the number of web pages and link pages, and calculated the simple web impact factor, self link web impact factor and external web impact factor of the university websites in Tamil Nadu and ranked the websites as per the web impact factor. The study reflects that some universities in Tamil Nadu have higher number of web pages but correspondingly their link pages are very small in number and websites fall behind in their simple, self link and external link web impact factor.

Vijaykumar (2012)¹⁶⁷ carried out webometric analysis of university web sites in Sri Lanka. The study reveals that the universities of Sri Lanka are possessing varied domains for their home pages namely .ac .net and .lk but most of them (89.47%) prefer the sub level domain link .ac. The University of Colombo, University of Sri Jayewardenepura and University of Peradeniya ranked one by possessing highest web pages, inlinks and self links respectively.

Vijaykumar and others (2012)¹⁶⁸ made a study focused on the identification of web presence and their links among SAARC countries. The research finds that India possesses a maximum of 1,41,00,000 web pages, 58,20,000 external links 1,18,00,000 internal links, and 9,83,00,000 over all links. They noted that except India no SAARC country possesses all sub domains, but these countries possess only a few sub domains like .edu, .gov, .net and .org.

2.4 Authorship Pattern and Collaborative Research

The phenomena of multiple authorship are well known in the literature of science. Collaboration in research has become an established practice since the second part of 20th century. Collaborative research means two or more researchers working together on a research project by contributing their intellectual and physical resources. The degree of collaboration varies from one discipline to another depends on factors such as the nature of the research project, availability of research funds, magnitude of instrumentation, manpower requirements and demographic factors. It is generally high in scientific and technical fields compared to humanities. Subramanyam

(1983)¹⁶⁹ has reviewed the research on collaboration and identified six types of collaboration depending on three participants viz., teacher-pupil collaboration, collaboration among colleagues, superior-assistant collaboration, researcher-consultant collaboration, collaboration between organizations and international collaboration. He developed a formula for computing the degree of collaboration of a discipline.

The concept of bibliographic coupling was introduced by Kessler¹⁷⁰ of the Massachusetts Institute of Technology in 1963. He postulated that a number of scientific papers bear a meaningful relation to each other (they are coupled) when they have one or more references in common.

Price (1963)¹⁷¹ described the phenomenon of multiple authorship from a historical perspective. Based on data from Chemical Abstracts, he showed that at the beginning of 20th century more than eighty per cent of papers were by single authors and almost all the remaining were multiple author papers. Since then, the trend towards multi-authored papers has increased steadily. He predicted “if it continues at the present rate, by 1980 the single author paper will be extinct”.

Clarke (1964)¹⁷² refuted Price’s contention and showed that the average number of authors per paper had remained almost constant at about 2.3 based on the authorship data collected from biomedical papers presented at the annual meetings of the Federation of American Societies for experimental biology for the period 1934-1963.

Zuckerman (1967)¹⁷³ studied forty one Nobel laureates in science and observed a high degree of correlation between collaboration and productivity. In general, laureates in science published more and were more likely to collaborate.

Small (1973)¹⁷⁴ studied the application of co-citation analysis as a useful tool in mapping the structure of science and described co-citation analysis as a useful tool in mapping the structure of science. He described co-citation as the frequency with which two documents are cited together.

Beaver and Rosen (1978, 1979, 1979)^{175,176,177} studied the history of research collaboration from the 17th century onwards. They showed that research collaboration

is in related to professionalization of the scientific community; and collaboration generally leads to greater productivity and mobility.

Gordon (1980)¹⁷⁸ showed a significant relationship between levels of multiple authorship of papers submitted to a leading astronomy journal for a period of six years and their frequency of acceptance for publication. It was found that twenty six per cent of single authored papers were rejected, compared with twelve per cent for papers with two authors and nine per cent for papers with three or more authors.

Heffner (1981)¹⁷⁹ studied the relationship between collaboration and financial support for research in the fields of political science, psychology, biological sciences and chemistry. It was observed that in all these disciplines, financial support for research was associated with an increase in the total number of authors involved in the production of knowledge per research paper and the association was particularly strong in biological sciences and chemistry.

White and Griffith (1981)¹⁸⁰ developed author co-citation based on co-citation analysis as a new tool for providing a method for tracing the intellectual structure of science.

Maheswarappa and others (1984)¹⁸¹ studied collaborative research in science and technology in India based on the authorship data collected from *Indian Science Abstracts* covering the calendar years 1965, 1970, 1975, 1980 and 1983. The results showed that papers with two authors were maximum in number in science and technology in India; the proportion of papers with three and four authors had doubled as a function of time and, correspondingly, papers with single authors declined approximately by half; the average number of authors per paper had increased from 1.84 in 1965 to 2.33 in 1983; and the relative figures for the degree of collaboration ranged between 0.61 to 0.80.

Maheswarappa and Mathias (1987)¹⁸² studied the authorship pattern and collaborative research in different disciplines of physical sciences based on the data collected from *Indian Science Abstracts* for the years 1965, 1970, 1975, 1980 and 1983. An increasing trend towards collaboration was found in all the disciplines of physical sciences, but the actual increase varied from discipline to discipline. Among

the different subjects in the field of physical sciences, the highest number of multi-authored papers was found in chemistry. The average number of authors per paper in chemistry had increased from 2.15 in 1965 to 2.61 in 1983 and the degree of collaboration had increased from 0.81 to 0.92 for the corresponding years.

Hart (1990)¹⁸³ studied the authorship characteristics of articles in library and information science journals which were published in the year 1986. He compared the characteristics of authors of articles that resulted from funded research with those of articles that were not supported by funding. The findings revealed that the authors of funded research collaborated with other authors, possessed doctoral degrees and were employed in a college or university.

Norris (1993)¹⁸⁴ studied authorship patterns in the *Canadian journal of Nursing Research* for the period 1970-1991. The results revealed a decrease in single authored papers from 77.50 per cent during 1970-1976 to 33.67 per cent during 1987-1991, whereas the papers with two authors and papers with three or more authors had increased from 16.25 per cent to 42.86 per cent and from 6.25 per cent to 23.47 per cent respectively for the corresponding years. The author/article ratio had increased from 1.12 in 1970 to 2.55 in 1991.

Joshi and Maheswarappa (1994)¹⁸⁵ reviewed the literature of multiple authorship trends in different disciplines of science and technology. The subjects covered were mathematics, astronomy, physics, chemistry, geology, paleontology, genetics, biochemistry, botany, zoology, entomology, biomedical sciences, engineering, agricultural sciences, chemical technology and space technology.

Haiqi (1996)¹⁸⁶ studied authorship patterns by analysing the citations in the *Japaneese Journal of Pharmacology* and *Acta Pharmacologica Sinica*, published from Japan and China respectively for the period 1991-1995. The results revealed that there were considerable variations in the number of authors per article from the two countries. National and international collaboration had increased annually.

Joshi and Maheswarappa (1997)¹⁸⁷ studied authorship trends and collaborative research among Indian phytopathologists by analysing a total of 4,943 articles published during 1950-1989 in the journal *Indian Phytopathology*. Out of the total

articles, papers with two authors accounted for 54.38 per cent, papers with three authors accounted for 19.33 per cent and single authored papers constituted 19.16 per cent. The average number of authors per paper had increased from 1.92 in the 1950s to 2.26 in the 1980s with an average of 2.16 for the period as a whole.

O'Neill (1998)¹⁸⁸ studied authorship patterns in two theory based journals namely *Educational Theory* and *Journal of Educational Thought* for the period 1955-1994 and 1970-1994 respectively. The results revealed that the majority of papers were single authored in both the journals irrespective of the date of publication.

Arunachalam and others (2000)¹⁸⁹ studied the papers indexed in three years of *Biochemistry* and *Biophysics Citation Index* (1992, 1995 and 1998) and found that 103 institutions in Israel have published 4,112 papers in more than 990 journals and sixty four non-journal sources published from twenty seven countries. More than sixteen per cent of papers have appeared in journals with an impact factor (IF) higher than 7.00 and an equal fraction of papers have appeared in journals with an IF of less than 1.00. The sum of the IFs of the journals in which papers have been published has been used as a rough measure to quantify each institution's research contribution. To overcome the problems of conducting world-class research in a small country, Israel uses collaboration with overseas laboratories to great advantage. More than forty two per cent of papers in the sample involve international collaboration; half of them with laboratories in the USA and some with Germany, France, UK and Canada. Over ten per cent of papers have resulted from domestic collaboration. In general, internationally collaborated papers are published in higher-impact journals, but domestically collaborated papers more often appear in lower-impact journals than single-institution papers. While the USA remains the most important partner of Israel, papers co-authored with French and UK collaborators raise the IF value of Israeli contributions more than those with other partner countries.

Ezhilrani and others (2006)¹⁹⁰ investigated authorship pattern in aquaculture journals based on the data collected from Aquatic Sciences and Fisheries Abstracts Part I for a period of three years ie. 1991, 1996 and 2001. In all the years papers with multiple authors were more than those of single author in all the areas of aquaculture as the values of contributions of multiple authors ranged from 57.10 per cent to 90.80

per cent in different aspects of aquaculture. The degree of collaboration was found to be 0.85 for all the three years and it ranged from 0.83 (1991) to 0.86 (1996 and 2001).

Anuradha and Urs (2007)¹⁹¹ analysed international collaborative patterns as indicated in the Indian publications by tracking out multi-author publications as given in Science Citation Index (SCI) database. Correspondence analysis is used for analysis and interpretation of the results. According to correspondence analysis of the data set, physics, chemistry and clinical medicine are the first, second and third largest subjects having international collaboration. USA, Italy, Germany, France, England are the top five countries with which India is collaborating. The data set shows an association between physics and Italy, Switzerland, Algeria, Finland, South Korea, Russia and The Netherlands contrasting an association between biology & biochemistry, immunology, ecology & environment, geosciences, Multidisciplinary subjects and England, Japan, Canada. It also shows an association between agriculture and Philippines, Canada and Denmark in contrast to an association between chemistry and Malaysia, Germany and France. An association between clinical medicine and astrophysics and England, Sweden, USA and New Zealand in contrast to an association between agriculture and Canada, Philippines and Denmark is shown. An association between engineering, mathematics, computer science, neuroscience and Singapore, Canada and USA in contrast to an association between chemistry and astrophysics and Malaysia and Spain is shown. This association of collaborating countries and disciplines almost tallies with the publication productivity of these countries in different disciplines.

Kumar and Kumar (2008)¹⁹² studied the collaboration in research in five major oil seed research institutions in our country. Results found that only 21.33 per cent of publications are single authored papers and the collaboration coefficient ranges from 0.709 to 0.845.

Ramanujan and Nerur (2009)¹⁹³ carried out an author co-citation analysis involving authors who have made seminal contributions to the field of software maintenance. The data for the study were obtained from the Science Citation Index and the Social Sciences Citation Index. The results indicate that most of the software maintenance research has focused on eight areas: program logic characteristics, quality of processes/metrics, effort and productivity issues, cognitive issues in repair

maintenance, organizational issues: strategies for software evolution/maintenance, object-oriented maintenance, domain specific language issues and program construction and design. Some of the limitations of this study include: exclusion of data after 2003, giving equal weight to all citations, and implicit assumption that a relationship exists between the citing and cited documents.

Patil (2010)¹⁹⁴ examined articles published in the journal *Herald of Library Science* for authorship pattern, degree of collaboration and geographical distribution of papers. The degree of collaboration is found to be 0.30.

Kumbar and Girish Kumar (2011)¹⁹⁵ studied the authorship trend and collaborative research in genetics and plant breeding based on the data collected from the *Indian Journal of Genetics and Plant Breeding* published during 1998-2002. The study reveals that two author papers are maximum (44.24%). The degree of collaboration in research is 0.87 in genetics and plant breeding as a whole and ranged between 0.86 to 0.89 during 1998-2002. The contribution from research institutions and laboratories i.e., 44.08 per cent is vividly ahead of other segments such as universities and colleges.

Baskaran and Sadik Batcha (2012)¹⁹⁶ studied the authorship pattern and research collaboration in the field of cardiology research by retrieving the related records from the MEDLINE database for the period 1991- 2010. The study shows that the maximum number of records i.e. 829 was during 2000 followed by 826 in 2003 and 789 in 2002. The result shows that the degree of collaboration mean score is 0.70 and highest score is 0.88 in 1991.

Chinchilla-Rodriguez and others (2012)¹⁹⁷ studied the use of block modeling in the micro-level study of the internal structure of co-authorship networks over time. Variations in scientific productivity and researcher or research group visibility were determined by observing authors' role in the core-periphery structure and crossing this information with bibliometric data. Three techniques were applied to represent the structure of collaborative science: (1) the block modeling; (2) the Kamada-Kawai algorithm based on the similarities in co-authorships present in the documents analysed; (3) bibliometrics to determine output volume, impact and degree of collaboration from the bibliographic data drawn from publications. The paper

describes certain features of Pajek software and how it can be used to study research group composition, structure and dynamics. The approach combines bibliometric and social network analysis to explore scientific collaboration networks and monitor individual and group careers from new perspectives. Its application on a small-scale case study is intended as an example and can be used in other disciplines. (Authorship Pattern)

Baskaran (2013)¹⁹⁸ studied the Relative Growth Rate (RGR), Doubling time (D_t) and institution-wise collaboration and ranking of authors in research contribution of Alagappa University during 1999-2011. The study highlighted the fact that the RGR was showing a fluctuating trend during the study period. The doubling time has shown increased and decreased trend during the period of study. Degree of collaboration and its mean is found to be 0.963. The top three institutions having collaboration with Alagappa University are Central Electro Chemical Research Institute, National Cheng King University and Anna University.

Prakasan (2014)¹⁹⁹ and others explain that science and technology research at international level is significant in the present information communication technology age. The study focused on India's strengths and weaknesses in collaborative research at the international level. The study analysed collaborative fields at their macro and micro level. The main objective of the study is to depict the international research collaborative trend of Indian science. A total of 4,92,403 bibliographic records were extracted from the Web of Science database for the present study. The findings reported in this study could be of interest to those who are involved in the collaborative research programmes.

Tunga (2014)²⁰⁰ presented a case study of the authorship pattern and degree of collaboration in the field of horticulture based on the sample of 8,437 journal articles and 1,327 book citations appended to eighty doctoral dissertations of Bidhan Chandra Krishi Viswavidyalaya (BCKV) and Uttar Banga Krishi Viswavidyalaya (UBKV), West Bengal during 1991-2010. The study reveals that out of the 8,437 references cited, 1,763 (20.695%) are single authored papers and 6,665 (78.997%) are multi authored papers. Papers with two authors (37.039%) are the highest in the cited journals followed by papers with three authors (25.116%), single authored papers (20.896%) and papers with four authors (11.332%).

Sameer Kumar (2015)²⁰¹ provided an exhaustive review of the growing literature on co-authorship networks and the gaps in research. An in-depth analysis of search knowledge networks provides an opportunity to investigate its structure. Patterns of these relationships could reveal the mechanism that shapes our scientific community.

Chuang and Ho (2015)²⁰² conducted bibliometric analysis of highly cited papers from Taiwan. Data used in the study was extracted from the SCI-expanded database of the Web of Science. Authorship, collaboration pattern and *Y*-index were studied. Results showed that highly cited papers might not have high citations in early years and may be published in journals with low impact factors. International collaboration was responsible for the increasing number of highly cited papers over the years. Institutions can be categorized into three phenotypes and majority of the institutions are characterized with high dependency and low leadership in the collaboration. The United States was the leading choice for international collaboration, while National Taiwan University was the leading choice of institutions for domestic collaboration.

2.5 Self-Citations

Citations are an important component of research communication. Through self-citing, authors convey the relationship and continuity between their present work and their previous work. According to Tagliacozzo (1977)²⁰³ “self-citing is a common and fundamental attribute of scientific articles and has a function which essentially is not different from other forms of citing”. The extent of self-citing varies considerably in different research papers within a discipline and also amongst disciplines. Generally two methods are employed to assess self-citation behaviour. The first method involves tallying all citations as well as all self-citations and calculating the ratio of self-citations to all citations. The second method involves analyzing the citations and tallying articles that contain one or more self-citations and comparing this figure with the total number of articles in the sample. This is called the self-citation rate.

Kundu (1981)²⁰⁴ studied the citing pattern of Indian library scientists by analysing the citations appended to the journal *Annals of Library Science and Documentation* during 1954-1975 and found that 14.90 per cent of citations were self-citations. Lawani (1982)²⁰⁵ in his study discussed the heterogeneity of author self-citations by grouping them under synchronous self-citations and presented a systematic scheme for their classification by identifying four categories within each group. Sridhar (1985)²⁰⁶ studied the citing pattern of Indian space engineers and found the overall self-citation rate to be thirty five per cent and the average number of self-citations per article was 3.44.

Snyder and Bonzi (1989)²⁰⁷ examined the motivation of authors in citing themselves and others. They observed that there were relatively few significant differences in motivation between the reasons for which authors cite themselves and the reasons for which they cite others. Bonzi and Snyder (1990)²⁰⁸ compared the self-citation pattern in the physical sciences of chemistry and geology to those in the social sciences of economics and sociology. Raptis (1992)²⁰⁹ studied the authorship characteristics in five international library and information science journals and found a self-citation rate of 27.60 per cent.

Dimitroff and Arlitsch (1995)²¹⁰ found that the rate of self-citation was fifty per cent and the percentage of self-citations was 6.60 per cent in library and information science literature through an analysis of 1,058 articles collected from twenty eight core library and information science journals. Jose (2008)²¹¹ carried out citation analysis of 3,040 citations that appeared in the articles of five volumes of *Journal of Genetics* for the years 1997-2001. The result reveals that the percentage of author self-citation for the years 1997, 1998, 1999, 2000 and 2001 is 8.38 per cent, 12.41 per cent, 16.12 per cent, 4.39 per cent and 10.86 per cent respectively.

Zuccala (2010)²¹² studied a set of journal articles (369) published in singularity theory (1974-2003) and the mathematicians who wrote editorial reviews for these articles, and the number of citations each reviewed article received within a five year period. The results indicate that singularity theorists of lower status (junior researchers) have reviewed slightly more well-cited articles (2-5 citations, excluding author self-citations) than their higher status counterparts (senior researchers).

Juan Miguel (2011)²¹³ studied the aspects like citations, self-citations and number of articles that influenced large changes in only one year in the impact factors (IFs) of journals. A set of 360 instances of journals with large increases or decreases in their IFs from a given year to the following was selected from journals in the Journal Citation Reports for the period 1998-2007 (40 journals each year). The main factor influencing large changes was the change in the number of citations. About fifty four per cent of the increases and forty two per cent of the decreases in the journal IFs were associated with changes in the journal self-citations.

Larcombe and Voss (2011)²¹⁴ investigated the incidence of self-citation (authors citing their own work) for scholarly articles in ten journals published by the American Physiological Society. The study analysed authorship and referencing practices of all original research articles published in the first ordinary issue of each journal in both 2000 and 2010, comprising 271 and 212 articles, respectively. Self-citation is common in these journals and represents a total of 17.75 per cent of all citations. Only nine (1.86%) of the articles analysed did not self-cite. Author position significantly influenced the rate of self-citation with last authors being self-cited significantly more than any other author. This was likely a result of the cumulative nature of scientific research within a specific discipline and the necessary desire to promote one's own work for associated academic benefit. The country in which the work was conducted also influenced the rate of self-citation, with last authors based in North America self-citing more than last authors from Asian countries. A comparison of self-citation rates between decades (2000 and 2010) revealed an increase in the number of authors and number of citations per article between 2000 and 2010. However the mean percentage of self-cited articles did not differ between the years. Finally, there were no differences in the percentage of self-citation between the different journals analysed.

According to Hartley (2012)²¹⁵ author self-citations are another factor that affects the impact factor of a journal. Typically these self-citations are just counted as such. But to be more meaningful the study suggested that when examining the contribution of authors' self-citations to impact factors one should first count the number of citations in the text rather than in the reference list and then discriminate

between different kinds of author self-citations - from those that are informative to those that are self-enhancing - if these data are to be more credible.

Leblond (2012)²¹⁶ analysed 643 articles from nine different ecology journals of various impact factors for synchronous (i.e., within reference lists) and diachronous (i.e., following publication) self-citations, using the Web of Science online database. The study assessed the effect of the number of authors, pages, and references/citations, the proportion of diachronous/synchronous self-citations, and the impact factor, on the proportion of synchronous and diachronous self-citations separately. And compared various candidate models made of these covariates using Akaike's Information Criterion. On an average, ecologists made 6.0 synchronous self-citations (12.8% of references), and 2.5 diachronous self-citations (25.5% of citations received 2.8 to 4.5 years after publication) per article. The best predictor of the proportion of synchronous self-citations was the number of authors. The proportion of self-citations also increased with the number of pages and the impact factor of ecology journals and decreased with the number of references/citations.

Allik (2013)²¹⁷ carried out bibliometric analysis of research articles published in the *Journal of Cross-Cultural Psychology* (JCCP) during the first ten years (2001-2010) of the new millennium. There were 457 original research articles, which were cited 6,187 times in 4,227 citing papers. Although the largest number of articles were authored by researchers from the United States (52.3%), Canada (12.0%), and People's Republic of China (11.6%), the highest impact articles were written by Israeli (30.5 citations per article), Estonian (29.5), and Swiss (23.6) psychologists. The country self-citation rates or biases were highest in the United States (+22.9%), The Netherlands (+20.7%) and People's Republic of China (+20.5%), showing that the small-world networks operate most strongly in these three countries. As revealed by a cross-journal citation pattern, JCCP had the strongest influence on personality and social psychology research and negligible on intelligence and cognitive research. The impact of the research articles published in JCCP on the core psychology journals remained at the same (modest) level, while the journal self-citation bias demonstrated a slight increase during the last ten years.

2.6 Ranking and Scattering of Journals

The problem of exponential growth of literature is complicated by the scatter phenomenon. The literature on a given subject field is scattered over a wide range of journals. Citation studies have revealed that in any given subject field, a substantial portion of the references, i.e., around two thirds of the total are found to be concentrated in a relatively small number of journals and the rest of the references are scattered in a very large number of journals which are peripheral to the subject field. Citation counts provide an excellent method for preparing ranked lists of journals arranged in the order of decreasing frequency to identify core journals in that subject field.

The phenomenon of scattering of journal literature was first studied by Bradford (1934)²¹⁸ He studied the references in two bibliographies on applied geophysics and lubrication and deduced the Law of Scattering of papers on a given subject in scientific periodicals. The graphical formulation of the law is generally expressed by:

$$Y = A + B \cdot \log X$$

Where Y is the proportion of the cumulative number of articles contained in the proportion X of the first most productive journals: A and B are constants.

The Verbal formulation of Bradford's Law of Scattering is that "if scientific journals are arranged in order of decreasing productivity of articles on a given subject, they may be divided into a nucleus of periodicals more particularly devoted to the subject and several groups or zones containing the same number of articles as the nucleus, when the number of periodicals in the nucleus and succeeding zones will be as 1 : n : n²".

Vickery (1948)²¹⁹ was the first to point out the Bradford's verbal formulation of the law of scattering and graphical representation were not mathematically identical. He pointed out that the verbal formulation only corresponds to the upper straight line portion of the bibliograph, but not the entire graph with its initial raising curve. He also showed that the relation should hold for any number of zones of equal productivity, not just for three zones as proposed by Bradford.

A significant study prior to the publication of Science Citation Index was by Fussler²²⁰ in 1949. He Studied the characteristics of literature used by chemists and physicists of American origin and ranked the journals according to their use.

Another significant study reported by Brown (1956)²²¹ was an attempt to ascertain what conclusions and inferences can be drawn from a study of lists of most frequently cited journals in different fields of science.

Since the enunciation of Bradford's Law, many different models have been provided by several researchers. Kendall (1960)²²² analysed 1,763 references in 370 journals devoted to operations research and 1,465 references devoted to statistical methodology covering the period 1925-1939 and confirmed the linear logarithmic approximation of Bradford's graphical formulation. He also suggested that Bradford's Law and Zipf's Law were identical.

Leimkuhler (1967)²²³ developed the following model to predict the distribution of references based on Bradford's verbal formulation:

$$F(x) = \frac{\log(1 + \beta * X)}{\log(1 + \beta)}$$

Where F(x) is the relative total number of references contained in the proportion X of the most productive journals; and β is the constant related to the subject field and the completeness of the collection.

In 1968, Brookes (1968)²²⁴ provided the following model for the "exact Bradford distribution function":

$$R(n) = K \log n$$

Where R(n) is the cumulative total of papers found in the first n journals when the journals are ranked according to decreasing order of productivity; and K is a constant which depends on the document collection. He also showed that the Bradford distribution was closely related to the Zipf distribution.

Groos (1967)²²⁵ observed a droop when he plotted the data collected by Keenan and Atherton on the journal literature of physics. The droop refers to the shape of some Bradford's curves at their tail ends. The curve shows a downward

deviation at the end of the log-linear portion. This phenomenon was known as *Groos Droop*. Goffman and Warren (1969)²²⁶ showed the applicability of Bradford's Law to the literature of mast cells and schistosomiasis in the field of medicine. Goffman and Morris (1970)²²⁷ showed that Bradford's Law held good for literature dispersion in the field of transplantation-immunology for the years 1965-68, as well as periodical circulation in a medical library.

Singh (1974)²²⁸ prepared a ranked list of 219 journals in chemistry by analysing the citations in *Indian Journal of Chemistry* for the year 1970. Garfield (1976)²²⁹ analysed more than five million citations in journal articles indexed by the *Science Citation Index* in 1974. And he prepared the list of highly cited journals in 1974, journals with high impact factor for 1974 and significant journals in the field of botany, astronomy/astrophysics and mathematics.

Sengupta and others (1980)²³⁰ prepared a ranked list of forty seven journals in neuroscience based on the analysis of citations in *Annual Review of Neuroscience* for the year 1979. They compared the list with those previously prepared on medicine, biochemistry, physiology and pharmacology. Sengupta (1984)²³¹ proposed a new formula for ranking biochemical journals taking into account not only the number of citations but also the number of years of publication of each journal. He also prepared ranked lists of journals in the field of biophysics, biochemistry and microbiology (1985, 1986, 1989)^{232, 233, 234}

The study by Egghe and Rousseau (1988)²³⁵ revealed that the Groos droop may be expected in interdisciplinary bibliographies. Lockett (1989)²³⁶ reviewed the major and significant studies of Bradford's Law of Scatter related to the appropriate formulation of Bradford's Law, the parameters of the Bradford distribution and the Bradford distribution's relationship with other distributions, which were published during the period 1934-1987.

Qiu and Tague (1990)²³⁷ conducted a computer simulation to study the phenomenon of the Groos droop. Based on the results of 400 runs the study indicated that the Groos droop was not primarily caused by incomplete data sets. Coleman (1994)²³⁸ studied the different aspects which influence the shape of the Bradford's bibliograph causing the Groos droop. The findings revealed that humanities and non-

laboratory social science literature displayed convexity in their bibliographs, with curvature values of about four or more; technical specialties exhibited a small amount of convexity, with curvature values less than about four; and very compact (“narrow”) technical specialties exhibited linearity of concavity in their bibliographs, with curvature values of zero or less. The study also demonstrated that bibliographies covering very short periods showed more convexity than comprehensive bibliographies on the same subject.

Mahendra and Deshmukh (1996)²³⁹ applied Bradford’s Law to the citations in the journal *Annals of Library Science and Documentation* and confirmed its validity. Ravichandra Rao (1998)²⁴⁰ has made an analysis of Bradford multipliers to identify a suitable model to explain the Law of Scattering. Bandyopadhyay (2000)²⁴¹ studied the scatter of journal literature in different disciplines for the period 1981-1990.

Mittal and others (2006)²⁴² carried out an analysis of 536 papers published in library and information science education during the period 1995-2004. 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.

Sevukan and others (2007)²⁴³ analysed the publications in plant sciences by faculty members of central universities of India. A total of 348 bibliographic records of plant sciences was retrieved from Science Citation Index – Extended (SCIE) for a period of ten years from 1997 to 2006. The output of plant sciences literature has been analysed by year, document type, authorship pattern and collaboration pattern at different levels viz., international, national and local. The laws of Bradford and Lotka have also been tested. Results of the study reveal that: the plant sciences literature has grown steadily during the study period except for 1997 and 2002; articles are a predominant source of publications of plant sciences literature; the plant sciences research in central universities of India is fairly collaborative; and the productivity of authors fits Lotka’s distribution while scattering of journal articles does not fit into Bradford’s distribution.

Sevukan and Sharma (2008)²⁴⁴ present a detailed analysis of research performance of biotechnology faculty members in central universities of India from 1997-2006. The data used for the study were retrieved from two database sources, namely, PubMed, NCBI (National Centre for Biotechnology Information); and ISI Web of Science database-Science Citation Index Expanded (SCIE). Bibliometric techniques have been employed to analyse the data. The results indicate that the growth of literature in biotechnology has steadily increased from fifteen articles in 1997 to forty three articles in 2006; two-authored publications predominate amongst the pattern of authorship; applicability of Lotka's law is validated from the values $n = 2.12$, $C = 0.669$, and $D = 0.027$ obtained using least square method. However, the application of Bradford's Law does not the literature analysed.

Krishnamoorthy and others (2009)²⁴⁵ undertaken the bibliometric analysis of diabetes literature indexed in the MEDLINE database for the period 1995-2004. The result shows that maximum number of records (13,244) was during 2003, followed by 12,690 in 2002 and 11,061 in 2001. Relative growth rate was found to be decreasing year wise. Ranking of the journals based on the quantum of research output on diabetes during 1995-2004 shows that USA occupies the first place by contributing the highest number of publications. The research productivity of diabetes conforms to Bradford's Law of Scattering.

According to Nash-Stewart and others (2012)²⁴⁶ the validity of Bradford's law for systematic reviews has not been addressed in literature. They have examined whether Bradford's law was valid for the Cochrane Review identified literature on acute otitis media and pneumonia, conditions that are reported in a wide variety of clinical and health journals.

Dutta and Rath (2013)²⁴⁷ carried out a scientometric study of 834 articles on carbon nanotube research in India spanning over the years 1999 to 2012 downloaded from Web of Science. The study analysed literature growth trends, which shows an initiation of potential growth of research in this subject since 2008. It also examines collaborations with different countries. The authorship pattern documents types involved and active Indian institutions co-coordinating research in this subject have also been studied. Bradford Law of Scattering was applied to identify the core journals and Lotka's Law was applied to study the author's productivity pattern.

2.6 Obsolescence of Literature

Obsolescence is one of the characteristics of scientific and technical literature. Studies of ageing or decay or obsolescence of documents usually assess the decline in the use of a representative set of documents over time. Obsolescence may be ascertained through studies of library use or by citation analysis. These studies guide the librarians in deciding which items are to be stored or which to be discarded in order to make room for new acquisitions. Generally two methods viz., synchronous studies and diachronous studies are widely practiced to measure obsolescence factors. In the former method, records of uses or references at one point of time are analysed by comparing them against the age distribution of the material cited or used. In the latter method, use of particular item is analysed through successive observations at different time periods. In this method, the rate at which citations decline with the age of the items is studied for a sample of items with the help of citation indexes.

In 1960, Burton and Kebler²⁴⁸ drew an analogy between the decrease in use of scientific literature and the decay of radioactive material. They applied the term, “Half-Life”, to the decrease in use of scientific literature in the same way in which the decay of radioactive materials is referred to. Line (1970)²⁴⁹ discussed apparent and real obsolescence taking into consideration the rate of growth of literature. According to him the half-life, or true half-life is the time (actual or expected), during which half the total use of individual items constituting a literature has been, or is expected to be, made. Apparent half-life or median citation age is the time within which half the citations in a citation study occur.

Brookes (1970)²⁵⁰ developed an equation to show that the growth in the number of contributors to the literature on the same subject field will cancel the effect of the rate of growth of literature if both the growth rates are equal and disputed the need to correct for literature growth in obsolescence studies. Chen (1972)²⁵¹ studied the use of 138 journals in physics at Massachusetts Institute of Technology Science Library and observed a rapid decrease in use as the journal aged. Seymour (1972)^{252,253} published two comprehensive review articles about weeding one devoted to monographs and the other to serials. The most comprehensive review was published by Line and Sandison (1974)²⁵⁴ covering the concept of obsolescence,

patterns of document use, synchronous and diachronous studies; the relationship between citations and actual use; and practical value of obsolescence studies.

Ravichandra Rao (1974)²⁵⁵ studied the obsolescence of literature in sociology by analysing the citations in the *American Journal of Sociology*. The results showed half-life values of 9.2 years, 5.85 years, 5.8 years and 5.8 years for the years 1950, 1969, 1970 and 1972-73 respectively.

Longyear (1977)²⁵⁶ analysed 1,374 citations in six major journals in musicology for the period 1973 to 1975, and found that journal articles in musicology do not show any obsolescence pattern as does scientific literature.

Griffith and others (1979)²⁵⁷ studied the ageing of scientific literature and observed that ageing depends not merely on the material itself, but also on its users; a single journal may start aging very differently by different user communities; and ageing rates vary among journals.

Brown (1980)²⁵⁸ studied the half-life of chemical literature using the poisson frequency distribution and found it to be 9.3 years.

Gupta (1985)²⁵⁹ studied age distributions of citations received by the *American Association of Petroleum Geologist Bulletin* for the years 1960, 1970 and 1979. Citation distributions were statistically tested by applying K-S Test and found to be negative exponential. Obsolescence factors were determined. The average half-life for 1960 data was found to be 7.6 years while 6.2 and 6.1 years for 1970 and 1979 respectively. The year 1970 receives comparatively more citations than others which shows increased research activity in seventies and more visibility and use of literature in these years. Percentage of citations for the first decades have increased from sixty per cent to seventy per cent from 1960 to 1970 and 1979 which indicates greater use of recent literature.

Stinson and Lancaster (1987)²⁶⁰ compared the results of a synchronous citation study of obsolescence over a nineteen year period, with the results of a diachronous citation study using the literature of human and medical genetics. They found that if the first two years of synchronous data was excluded, the rate of obsolescence

measured synchronously was statistically equivalent to the rate of obsolescence measured diachronously.

Gupta (1990)²⁶¹ carried out a synchronous citation study of fifteen leading journals in physics to determine the obsolescence of articles in *Physical Review*, with age. He found that the density of citations to physical review decreased exponentially with a half-life of approximately 4.9 years.

Gupta (1997)²⁶² studied the characteristics of theoretical population genetics in terms of obsolescence measures such as half-life and price index, and found that the age of references cited in source papers of theoretical population genetics, irrespective of the period studied, was found to be best modeled according to a simple lognormal probability density function.

Jagannath (1999)^{263,264} discusses in her paper how reading materials have become obsolete over the years due to changes in thought content, language, style of presentation and usage of new terminologies and deterioration in physical body or document carrier. In another paper she discusses the changes in research project/programmes, in different fields of science and technology and their impact on collection development and management.

Gupta and Karisiddappa (2000)²⁶⁵ used different approaches for studying the growth of scientific knowledge, as reflected in publications and authors. They applied selected growth models to the cumulative growth of publications and authors in theoretical population genetics from 1907 to 1980. They concluded that among the models studied, the power model is the one which best explains the cumulative growth of publication and author counts in theoretical population genetics.

Kannappanavar and Vijayakumar (2001)²⁶⁶ carried out citation study of periodical literature of *Plant and Cell Physiology* to determine the obsolescence factors and patterns of the periodicals.

Biradar and Sampath Kumar (2003)²⁶⁷ examined the obsolescence in the field of Zoology literature, its annual aging factors, mean life and utility factor.

Hazarika (2005)²⁶⁸ studied the citation pattern of research papers published during 2000 to 2002 in the *Indian Journal of Forestry*. Of the total 3,798 citations appended to 252 research papers, the highest of sixty per cent citations are from journals followed by books (28.00%) and technical reports (5.00%). The obsolescence factor of forestry literature is found to be 17-18 years. Forestry literature complies with the Bradford's Law of Scattering.

Vallmitjana (Nuria) and Sabate (2008)²⁶⁹ carried out a bibliometric study on the citations within the chemistry field PhD dissertations to ascertain what types of documents are the most frequently used in the research process, what are the most frequently consulted journals and obsolescence rate of the journals. The analysis covered forty six doctoral theses presented at the Institut Quimic de Sarria (IQS) from 1995 to 2003. The results obtained from the 4,203 citations revealed that the most frequently used documents were scientific papers, which accounted for seventy nine percent of the total; thirty three journals met fifty percent of the informational needs; and the age of fifty percent of the citations was no older than nine years.

Sangam and Mogali (2013)²⁷⁰ examined obsolescence of literature in social science. Three journals viz., *Journal of Social and Economic Development*, the *Journal of Polity and Society* and the *Journal of Social Change* were selected to collect the data for the period 2006-2010. These journals together contributed 283 articles with 11,271 citations. It is observed that the citation frequency follows a negative exponential pattern. The half-life of literature is found to be 9.04, AF=0.9262, utility factor=13.55 and corrected obsolescence=0.9482.

Mulla and others (2013)²⁷¹ studied the obsolescence of engineering literature cited in 137 doctoral dissertations of engineering and technology awarded by six universities of Karnataka (Bangalore University, University of Mysore, Mangalore University, Karnataka University, Gulbarga University and Kuvempu University) during 1961 to 2008. The study found that 71.60 per cent of total journal citations relate to thirty seven years old publications. The engineers and technologists prefer to cite current as well as old literature in their PhD theses.

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