CHAPTER – 2

REVIEW OF RELATED LITERATURE

2.1 Introduction

It is necessary and useful to review the available literature in order to know the areas that have invited the attention of the researcher so far, and the areas that seek the attention of the future researchers. Hence, a brief review of related literature and theories of the study under consideration is presented in this chapter.

The review of literature is an important component of any research study and process. It is a source from where research ideas are drawn and further developed into concepts, and, finally, into theories. It also provides the researcher a bird’s eye view of the research done so far in that area. Review of literature suggests new avenues of approach to the solution of a chosen problem.

According to Newman et al (1997) and Mauch and Birch (1998), a literature review performs four main functions:

i. Firstly, the literature review of a thesis is primarily focused on what has been done before and is designed to highlight how the study will fill in the current knowledge ‘gap’;

ii. The review outlines the instruments which the researcher will use, and why he should use them;

iii. The review points out why it is necessary to conduct the research; and

iv. Finally the review sets the boundaries for the research study (called delimitations).
For this purpose, a retrospective search of literature was carried out by using SCOPUS Database, Web of Science database (Science Citation Index), Social Science Citation Index, JCCC@infonet, Emerald, Springer e-journals full-text database. Attempts were also made to trace and collect the relevant research papers and related documents such as journal articles, conference papers, books, etc.

Attempts were also made to trace and collect the original articles and the same have been used for review.

In this chapter, an attempt has been made to review the published literature under the following sub-headings:

- Growth and Publication Productivity;
- Scientometric analysis of different subjects and sources;
- Scientific Productivity of institutions or organizations;
- Ranking of Universities and Research & Development Organizations;
- Collaborative works (Individual level, Institutional level and Country level);
- Citation Analysis of individual scientists.

2.2 Growth and Publication Productivity

Jain & Garg (1992) who have worked in the field of laser research indicate that Indian output comprises almost 4 % of the total world literature output in laser research and the majority of publications are published in foreign journals. The international collaboration is found to be less. A mathematical model for growth similar to Bass model shows that laser research literature may get marginalized by 1995.

Growth and scientific productivity in the field of earth sciences is studied by Parvathamma & Gunjal (1993). It indicates that the relative growth rate is declining from 0.35 to 0.11 and the growth pattern follows the logistic pattern. The productivity of authors is fairly close to Lotka’s Law as
63% of the authors contribute single paper and it follows the negative binomial distribution.

Growth study of research literature in scientific specialties is done by Gupta et al. (1997) by using three well established diffusion laws: Bass, Mansfield and exponential logistic. The results show that the fit statistics value in terms of R and F value are not quite good, while the modified Bass, Mansfield and Exponential-logistic model fits the data in the field of physics, chemistry, engineering and genetics. The most appropriate model generally seems to be the modified exponential logistic model.

A scientometric study of laser patent literature is conducted by Garg & Padhi (1998) based on the papers published in the journal of Current Laser Abstract (JCLA) for the period 1967-1995. It indicates that innovative activity in laser science is at its peak in the early 1970s. A shift in emphasis from application of laser to experimental laser research and to theoretical laser research has been observed. The USA and the Japan are the leading countries in laser research with an emphasis on spectroscopy of laser out communication, application of laser research.

Seetharam & Rao (1999) study the growth of Food Science and Technology (FST) based on the CFTRI publication output between 1950 and 1999. It traces and compares the trends in Food Science and Technology literature – books, reports, patents etc., produced by CFTRI and world output. The findings reveal that world’s FST literature growth has been seven times since 1950 while Indian FST literature is 35 times. For this study Gompertz model followed by logistic are the best fitted models for both world as well as Indian FST literature.

Sangam (1999) in his obsolescence study on psychology literature, has observed that the higher the growth rates of literature, the higher the obsolescence and higher the half life. The study shows that history (AAF=981,
HL=37.91, ML=54.69, UF=SS.19, OF=0.98) followed by political science (AAF=968, HL=21.45, UF=31.46, OF=0.977) and anthropology (AAF=0.959, HL=16.30; UF=24.11, OF = 0.971) has higher growth and higher obsolescence value.

**Sharma & Garg (1999)** studied the structure and dynamics of mathematics discipline and found that out of 37 subfields of mathematics, 14 subfields output is more than 57% compared to others. The growth rate of mathematics as well as of its subfields follows the logistics growth pattern, and growth rate is found to be declining in mathematics.

**Gupta et al. (1999)** has applied this methodology in the application of selected growth models to the growth of world and Indian physics literature during 1898-1950. They observed that growth of Indian physics literature follows a logistic growth model, while the growth of world physics literature can be explained by the combination of logistic and power models.

**Karki et al. (2000)** have studied the activity and growth of organic chemistry research in India during the years of 1971 – 1989 by using Chemical Abstract as source database. The study reveals that the activity index of India is quite lower. However, the activity picked up speed and matched with world during the 1980s. The growth trend of world and India follow the same pattern which shows that the output in three subfields such as amino acids, alkaloids and general organic chemistry is not going to saturate in near future. For the data exponential model has been found to be best fitted.

**Egghe & Rao (2002)** observed that an exponential model was never the best fit. Indeed, they have shown that such a model could never have been expected to provide the best fit, given that the rate of growth in every database declined steadily over the years studied. They also found that a power model fitted best in cases of convex growth and that Gompertz model generally fitted best in cases of S-shaped growth. They suggested that, in modeling the growth
of literature, the choice between an exponential and a logistic function may have always been a false one, and that we should instead be asking whether growth is best described by a power law or a Gompertz function.

**Gupta et al. (2002)** has made study on modeling the growth of world social science literature. The study shows that power model followed by logistics model is best fitted on cumulative growth of publications in all subfields of social sciences.

**Kundra (2002)** has done a quantitative analysis of medical science literature in India, and found that Power model is the only model which best growth model describes the cumulative growth of medical literature. Lotka’s and bionomial distribution is found to be fitted to the author productivity and collaborative measures depict increase in collaborative research.

A scientometric study of laser research in India is done by **Garg & Padhi (2002)** for the year 1970-1999. The findings show that research in this area has improved a lot during 1985-1994. This is because of impact indicators such as citation per paper proportion of high quality papers and publication effective index. India’s citation rate per paper for highly productive authors is at par with the world’s citation rate per paper. It indicates that international collaboration mainly with the USA and activity index and attractive profile of the prolific institutions are quite similar.

**Sharma et al. (2002)** examined the growth of world literature as reflected in three data sets, namely, Physics Abstracts, Chemical Abstracts and Electrical and Electronics Abstracts from 1907-1994. They found that the power model describes best the growth of literature as reflected in the three data sets.
Sangam & Keshava (2003) have studied the growth of world Social Science literature in the six sub disciplines, viz., Anthropology, Economics, History, Psychology, Political Science and Sociology for which the information was derived from the CD-Rom version of the Wilson Social Science Abstracts for the period 1983–1998, and it determines the rate of growth of the Social Science literature by calculating relative growth rates and doubling time for publications. Also it fits the modified exponential curve and logistic curve for the original publications.

Sangam & Kadi (2003) have studied the growth of research and priorities of demography research in different countries of the world, i.e., USA, UK, India and China for the period 1986 to 2000. For the study they have employed appropriate growth model to fit the time series data in order to study the trend of growth of subject for each country. The results show that over a period of time there is an increase in publication of literature.

Pouris (2003) analyzes the publication output of South Africa as covered in the ISI web of science database. The results show that South Africa’s publication growth is losing ground to scientifically emerging countries like Singapore, China, Taiwan, etc. The growth rate of South African Publication output is found to be 2.4% per annum, while world’s output is growing at the rate of 3.7% per annum.

Matia et al. (2005) analyzed a set of three databases at different levels of aggregation: (a) a database of approximately 10(6) publications published from 1980-2001, (b) a database of 508 academic institutions from the European Union (EU) and 408 institutes from the United States for the 11-year period of 1991-2001, and (c) a database of 2330 Flemish authors published during the period 1980-2000. At all levels of aggregation, they found that the mean annual growth rate of publications is independent of the number of publications of the various units involved.
Tsay & Yang (2005) studied the randomized controlled trial (RCT) literature and observed that it plays a fundamental role in developing Evidence-based Medicine (EBM). They found that the literature growth rate, from 1965 to 2001, was steadily rising, and followed an exponential model.

Literature growth, journal characteristics and author productivity in the field of library and information science is conducted by Tsay (2004). The study shows that logistic growth model fits well to the LIS literature for the period 1977 to 2000. Journals distribution is according to Bradford Zipf S-Shaped curve. Author productivity follows the Lotka’s low distribution, as 76.7% papers are contributed by a single author.

Kaliyaperumal & Natarajan (2009) study the growth pattern as well as overall trend in literature output on retina during 2002-2007. The results indicate variability in the authorship pattern, and English language as the major medium in literature output for retina. The contribution of the USA is higher compared to that of other countries. The study emphasizes the need for more research in retina and its allied subjects.

2.3 Scientometric Analysis of different Subjects and Sources

Scientometric Analysis is a well-established tool in information research. It is an application of quantitative methods to the history of science. Quantitative approaches to the description of documents and examination of services have been gaining importance both in research and in practice.

Monitoring and evaluating the various facets of the scientific enterprise is a necessary and integral part of science policy. Rising costs of research and development and competing disciplinary claims for financial resources require intelligent allocation of resources, which presupposes the necessary knowledge of the activities and performance of the innovation system. The development of Science, Technology and Innovation (STI) indicators have grown substantially during the last twenty years across the globe.
Nagpal et al. (1985) have analyzed the S & T organization in the field of Indian Organic Chemistry and found that universities (77.86) followed by the government departments (14.09) are most productive organizations.

Rajeshwari (1985) studies in detail the conceptual and methodological problems related to the use of science indicators. The paper mainly focuses on financial, manpower and output indicators and the problems in their application for scientific measurement.

Garfield & Doroff (1992) study the use of citation data as a quantitative indicator for S & T evaluation and policy making. They are of the view that publication and citation data offers potential to develop new quantitative objective indicators of S&T performance. The study highlights the use and limitations of citations as indicators and concludes that they provide valuable and revealing additions to conventional methods of S&T evaluation.

In another study in the field of economics, Sangam (1999) found that AFF of journals is 0.92944903 and for books 986828913 while the half life for Journals and book found to be 9.47 and 15.7 years respectively. Another study in the field of petroleum geology to find out the AAF and half life is done by Gupta and Gupta (1983) and the results show that half life for Journals is 5.7.

The use of macro, meso and micro level science indicators to map the scientific output in the field of condensed matter physics is studied and applied by Bhattacharya (2001). The author has used different multivariate techniques co-words analysis to study.

Jeevan & Gupta (2002, 2001) found out that 75 % of literature output covered in SCI data base is from chemistry department having longest impact as their normalized impact factor is 2.76. Based on the quality of chemistry papers the PEL value is highest among other subjects.
Schloegl et al. (2004) have done a scientometric analysis of international and German languages – LIS journals. Over 90,000 citations from Social Science Citation Index are analyzed in terms of impact factor, citing half life, average references and rate of self-citation like indicators.

Singh et al. (2004) have studied the scientific output of Indian Institute of Technology, Roorkee, India in the field of chemistry and chemical engineering. All the departments of the institutes are analyzed. Findings of the study show that chemistry is the most productive field after engineering and technology followed by physics and earth sciences. Physics has got the highest rank in terms of quality papers (2 impact factor), and chemistry stands fifth.

Rajendran et al. (2005) analyzed the global output covered in Ei-tech index database covering the period from 1999 to 2003 and found that 88% paper, are written in collaboration. The USA (27.8%) is found to be the most productive country, and periodicals ranking has also been done.

Frandsen (2005) studied the bibliometric analysis of economics journals to understand some hidden structures within the science of economics resultant form citation analysis. The analysis indicates several underlying factors within citation pattern in economics that should be accounted for when doing citation analysis for evolution purpose.

Pallubny (2005) has compared the scientific impact expressed by the number of citations in the field of chemistry, physics, mathematics and clinical medicine by applying the law of constant ratio. The study reveals that the ratio of the total number of citation of any two broad fields of sciences remain close to the constant over a period of time. The law of constant ratio can be used in average as micro criteria for comparing the scientific input of research institutions belonging to different sciences.
Leydesdorff (2005) has studied the use of science indicators for evaluation of research and evolution of indicators. The paper focuses on the output indicators, methodological limitations, multivariate and dynamic analysis, cyber metrics and webometrics, reflexive scientometrics in detail.

Kaur & Gupta (2009) examine the India’s performance based on its publication output in Immunology and Microbiology during 1999-2008, based on several parameters, including the country’s annual average growth rate, global publications share and rank, institutional profile of top 15 institutions, international collaboration profile and major collaborative partners, patterns of communication in national and international journals, and characteristics of its top 15 most productive authors. The study uses 10 years publications data in Immunology and Microbiology from Scopus International Multidisciplinary Bibliographical Database.

Suluimanov, Frolova & Khasenova (2009) analyses the foreign publications of Kazakh authors by SCOPUS Database during 1991–2008. The publication activity is expressed in 3883 documents. The average share of Kazakh publications in the total worldwide flow is equal to 0.017%. The citation rate of publications was revealed to have significantly grown since the 1996. It is shown that most articles were written in English and published in periodical editions. The main themes of publications are represented by physics and chemistry. The leading foreign partners of Kazakhstan in the scientific sphere were determined.

Ping & Wolfgang (2009) have studied the data from the Science Citation Index Expanded (SCIE), and conducted a systematic analysis of Chinese regional contributions and international collaboration in terms of scientific publications, publication activity, and citation impact by using scientometric methods. They found that regional contributions are highly skewed. The top positions measured by the number of publications or citations, share of publications or citations are taken by almost the same set of regions.
Lalitha Kumari (2009) analyses the research output and impact in Synthetic Organic Chemistry (SOC) during 1998–2004, applying standardized scientometric indicators. Volume of research publications and their citations presented as percentage world share is illustrative of the trend pattern against time. Adopting relative indicators - Absolute Citation Impact (ACI) and Relative Citation Impact (RCI), a cross national comparison is attempted at three levels of aggregations - global, Asian and Indian. Based on this analysis, it is concluded that G7 nations, being leaders in respect of the volume of literature published, and citations attracted are showing a decreasing trend over the years probably due to shifting and diversification of their research efforts to other emerging research fronts.

Schöffel et al. (2010) focuses strongly on therapeutic and diagnostic methods during recent years. So far, there is no scientometric approach of the topic rheumatoid arthritis available, although there is an increased need to evaluate quality and quantity of scientific research. Density-equalizing algorithms, scientometric methods and large scale data analysis were applied to evaluate the quality and quantity of scientific efforts in the field of rheumatoid arthritis. Data were compared with Pubmed and ISI-Web. During the period 1901-2007, 78,128 items were published by 129 countries, including the USA, UK and Germany being the most productive suppliers, representing 45.7% of all publications. Other countries (23) published more than 100 items. In terms of international cooperation the USA proved to be the most successful partner.

Buylova & Osipov (2010) state that scientometric data on the participants, their origin by region and research center and analysis of advancements and problems of Russian studies on nanotechnology are discussed.
Bala & Gupta (2010) attempt to analyse the research profile of biochemistry, genetics and molecular biology research in India during 1998-2007, country’s performance based on its research output, its publication share and rank in global context, and annual publication growth rate. Also analyses the share of international collaborative papers in India’s research output, the characteristics of research output of major Indian institutions, authors, and highly-cited papers. The patterns of research communication by Indian scientists in most productive journals in this discipline have also been evaluated.

Singh (2010) studies scientific productivity of Nano Science and Technology (NST). The author provides a brief historical background of the development of Nano Science and Technology in the world in general and in India in particular. ISI Web of Knowledge source was used to collect and analyse the data in order to find out scattering of the subject over last twenty years (1988-2007).

Suleimenov (2010) studies the Kazakhstan publication citation indicator that has been developed in Kazakhstan since 2005 is to carry out scientometric analysis of scientific publications to determine their citation rate. The bibliographic database (BDB) on citation includes information on the publication activities and citation index of approximately 30000 Kazakh scientists and specialists. They had over 18000 scientific papers published in over 500 domestic and foreign journals. The total quantity of references to papers by Kazakh scientists were more than 28000. The Kazakh analogue of the science citation index determination system is an efficient tool for analytical work with the BDB of scientific publications, which makes it possible to calculate publication activities and citation parameters, which are used to define the value and demand for the results of scientific work in various fields of domestic science.
Yanning et al. (2011) point out that the citation count is an indication of the influence of specific articles. Further, they investigate the highly-cited articles in physics (1979-2008), using citation data from the ISI Web of Science. In the study, 15, 44,205 articles were examined. The results reveal that the USA is the world leading country in physics, and Japan has maintained the highest growth rate in the field of physics research since 1990.

Karpagam et al. (2011) have studied the growth pattern of Nanoscience and Nanotechnology literature in India during 1990–2009 (20 years), using Scopus International Multidisciplinary Bibliographical Database. The study identifies the Indian contributions in the field of nanoscience and nanotechnology. Further, the authors measured in terms of country annual growth rate, authorship pattern, collaborative index, collaborative coefficient, modified collaborative coefficient, subject profile, etc. Also examine the national publication output and impact in terms of average citations per paper, international collaboration output and share, contribution and impact of Indian Institutions and impact of Indian journals.

Sagar et al. (2010) have made an attempt to study the research publication on Tsunami during 1997-08 by referring Scopus database. 4,338 publications and 21,107 citations were analyzed and the growth of publications, country-wise distribution of publications, and activity index of countries, most-frequently cited publications, authorship pattern, co-authorship index and distribution of keywords were traced. Out of the total publications of Tsunami, 54.20% has been contributed by USA, Japan, UK, India, and Australia. The incident of Indonesia’s tsunami on 26 December 2009 paved the way for a large number of publications.

Kaur & Gupta (2010) have focused on the study of dental science research in India. The study was done with an objective to analyze the status, publication share, rank and growth of India’s research output. For the study, Scopus database for the period 1999-2008 was referred. Out of the four
branches of Science and Technology literature only health sciences were selected, which comprises dentistry. In addition, the citation data for measuring quality impact and visibility of Indian research output was used.

**Sangam & Meera (2011)** have studied the chemical science research in India, and prepared a map based on publication and citation data. In the study, the quantification of research and growth in the different subfields of chemical science literature has been done. The identification of inter and multidisciplinary characters was also done. The investigation in the changes in the patterns of collaborative research was successfully done. The study was extended even to identify the research institutions which are leading in publishing a large number of papers and journals. It was possible to earmark highly productive academic institutions, who contributed a large number of Indian research papers in the field of Indian Chemical Sciences.

**Gupta, Bala & Kaur (2011)** have made an attempt to study the research publication on AIDS/HIV during 1999-08 by referring to Scopus database. The data was analyzed on the aspects such as the growth rank, global publication share, citation impact, share of international collaborative papers, contribution of major collaborative partner countries, contribution of various subject fields and by type of tuberculosis and patterns of research communication in most productive journals. According to the study, India ranks 12th in the top 20 countries, and its global publication share is higher than that of Brazil. The inference of the study is that India needs to increase its output and to bring about improvement in the quality of its research efforts.

**Gupta et al. (2011)** have made an analysis of the research output of India in Computer Science during the period 1999-2008. The parameters such as 1) total research output 2) its growth, 3) its rank and global publication share 4) Citation impact 5) Share of international collaborative papers and major collaborative partner countries and lastly partners of research communication in productive journals were considered. A comparative study of publication
output and impact of India in comparison with China, Taiwan and Brazil was done.

**Balasubramani & Murugan (2011)** have taken up the study of the research performance of India in Tapioca. The extent of study extends to entire globe, and the period chosen was 1997 -2010. The main focus of the study in research of tapioca is its growth, share and impact in global publication, the patterns of international and major collaborative partners, the publication productivity and impact of leading institutions of India, the characteristics of most prolific authors and high-cited papers and patterns of research communication in the productivity journals. For the study SCI through Web of Science provided by Thomson Reuters. Totally 447 records were used and analyzed by using histcite software application in order to fulfil the objective of the study.

**Choudhury & Sarkhel (2011)** have made an attempt to study the research publication on Agriculture research in West Bengal for the period 1993-2007 by referring CAB Abstracts. According to the study, 303 institutions have 10417 author papers in 1178 journals, published from 53 countries. Only 8 foreign journals were from the top 50 journals with 30 papers. The institutions which produce high quality papers were noticed. The collaborative research trend was found among the authors.

**Gupta & Bala (2011)** have made an attempt to study the research publication on Tuberculosis during 1998-09 by referring to Scopus database. The data was retrieved on the following aspects, the growth, rank and global publication share, citation impact, share of international collaborative papers, contribution of major collaborative partner countries, contribution of various subject fields and by type of tuberculosis and patterns of research communication in most productive journals. According to the study, India ranks 3rd in the top 21 countries, and global publication share is higher in
China. The inference of the study is that India needs to increase its output and bring about improvement in the quality of its research efforts.

**Gupta et al. (2011)** analyzed the Indian research output in diabetes during 1999-2008. By referring to Scopus database, the data was retrieved on the following parameters its growth, rank of global publications share, citation impact, overall share of international collaborative papers, and share of major collaborative partners. The most productive institutions, authors, and highly-cited papers were analyzed. The publication share of India was also compared with China, South Korea and Brazil.

**Rita et al. (2011)** have conducted study on publication productivity and career advancement by female and male psychology faculty. The study was concentrated on 511 university psychology professors of which 250 were women. The period of the study was from 1998 to 2004 and the database referred was PsycINFO. The result of the study reveals that overall women published less than men, especially in international journals and as senior authors. Further studies also show that the scientific productivity of women is slower when compared to men.

**Sudhier & Abhila (2011)** have done analytical study of the research productivity of the social scientist at the centre for development studies, Thiruvananthapur during 1998-2008. For the study, totally 599 research publications by CDS researchers have been considered. This includes 38.32 journal articles, 23.54 chapters in books and 15.03 working papers. The studies reveal that majority of contribution is found to be 0.43%. 66% of articles were published in Indian Journals, while 33.19% were published in foreign journals. Economic and Political Weekly contributed the highest number of articles (79) i.e. 34.50%), followed by Indian Journal of Labour Economics with (7) i.e.3.06%.
Zafrunnisha (2012) has made a study of the application of Bradford’s law. For the study, 141 Ph. D theses were considered. An analysis was made to identify Bradford’s Zones and productivity of journals cited in theses. The journals were divided into four equal groups in order to measure the productivity of journals. It is observed that the average rate of productivity of journals in the first group was 254 articles whereas it has come down to 10.73 articles in the fourth group. The journal distribution ratio in psychology has been worked out and dispersion of journal titles in psychology does not fit the Bradford’s law of Scattering.

Sangam (2012) has tried in his study to investigate the pattern of authorship and Collaborative studies in the field of demography. The data was made available from the population index for the time span 1988 -1999. The span of three years period was considered for assessment. The results of the study show that the collaborative index increases from 1.47 during 1988 and 1990 to 1.79 during 1997 and 1999. It is found that the growth in the proportion of collaborated publication shows decreasing value. The computed value of CI and DC show a consistent trend, reflecting the growing collaboration.

2.4 Scientific Productivity of Institutions or Organisations

Scientific Productivity of individual author/Scholarly productivity of individual authors is measured by the number of publications produced by item in a particular period of time. In this authors’ productivity study, the publications brought out by the authors are analysed to know their impact on research and also to determine the rank of authors as regards to their individual productivity. Most of the authors, contributing to a specific field of literature, in fact, contribute very little, and the number of highly productive authors is too small. The phenomenon is popularly referred to as ‘Lotka’s law of inverse square law’. The law is summarized as “the number of authors making two contributions is about one-fourth, of those making one; the number making ‘n’
contributions is about 1/n2 of those making one; and the proportion of all contributions who make a single contribution is about 60 percent”. So the highly productive authors form a very small proportion of the total. The Lotka’s law distribution is applicable only under certain limited conditions, and not all data collected on authorship in a field confirm exactly the inverse square relationship (Mahapatra, 2009).

Evaluating of the productivity of institutional research and developmental activities highlights the contribution of the institution and the individual scientists engaged in research.

Glanzel (1996) undertook the study of National Research Performance in the six selected fields of Social Sciences for the period of 1990-1992. In the present study, the bibliometric methods, which were used for the evaluation of National Research Performance of hard and Life Sciences, were used. The data is made available from SCI and SSCI of ISI. The result of the study shows that SCI and SSCI appear to be identical or similar but there is difference in coverage of bibliometric data. The SSCI covers journals, fully but selectively while SCI covers the publication in any journal. Though the difference seems to be insignificant but it has serious consequences while doing bibliometric macro trend analysis, particularly during subject classification.

Bordons et al. (2003) made a study of the productivity of the Spanish Council for Scientific Research scientists in Natural Resources and Chemistry during 1994-1999. A total of 260 Natural Resources scientists (24% of females) and 219 Chemistry scientists (38% of females) were studied. The results of the study show that the productivity tended to increase as professional category improved in two areas. Within each category no significant differences in productivity were found between genders, but the outlines with the highest production were mostly males. Distribution of females by professional categories and number of years at the institution were analyzed to detect possible gender discrimination in the promotion system. A positive
picture emerges more in Chemistry than in Natural Resources, since a process of feminization of that area has started in the lowest professional categories, and females’ progression to the upper ranks is expected in the near future.

**Khan et al. (1998)** observed LIS literature in Bangladesh for the period 1966-1997. The literature was retrieved from 37 periodicals, originating from 14 countries containing 308 articles, which were written by 116 librarians. The observation reveals that 256 articles (83%) were published from Bangladesh alone, whereas only 21 articles (6.82%) were from India. Out of the total articles published 92% were single author papers and only 25 articles were multi author papers.

**Angadi et al. (2006)** conducted scientometric study by analyzing 358 publication published by different social scientists working in Tata Institute of Social Science during 2001-2004, in order to study authorship pattern and collaboration trend. The result of the study indicates that 90.22% of papers were by single author, 5.86% were by two authors, and 3.35% were by three authors.

**Katy et al. (2006)** have collected publication data sets and analyzed them to identify 500 most cited research institutions with spatio temporal changes in their inter-citation patterns. The approach is novel in analysis of the dual role of institutions as producers and consumers of scholarly knowledge and studying the diffusion of knowledge among them. A geographic visualization metaphor has been used to visually depict the production and consumption of knowledge. Finally, the maps showing highest producers and their consumers and highest consumers and their producers have been prepared.

**Frizo et al. (2006)** have chosen the combination of full text analysis and traditional bibliometrics methods to map the research papers appeared in journal “Scientometrics”. The objective of the study was to develop appropriate
techniques for full text analysis and to improve the efficiency of individual methods in the mapping of Science. The study was made with regard to 5 journals in the field of LIS covering 1000 articles and notes published during 2002-2004. The combination of different mapping techniques, applied to full text of scientific publications, resulted in a characteristic tripod pattern. Totally, six clusters were identified in LIS, two from bibliometrics, one relating to information retrieval and one each from general issues, webometrics and patent studies as small but emerging clusters within LIS.

Gupta et al. (2003) have examined the performance of five state universities of Karnataka (India) in seven broad fields: physics, chemistry, engineering technology, clinical medicine, biomedical research, biology and earth and space science during the period 1996-2000. The study reveals that Mysore University, followed by Karnataka University, has reported maximum literature, and chemistry and physics are the areas where maximum research has been done. Karnataka and Mysore University have high activity index in chemistry.

Gupta, Kaur & Bala (2011) analyse the research output in diabetes during 1999-2008 on several parameters, including its growth, rank and global publications share, citation impact, overall share of international collaborative papers, and share of major collaborative partners. They also analyse the characteristics of most productive institutions, authors, and highly-cited papers. The publications output, impact and collaborative publication share of India is also compared with that of China, South Korea and Brazil.

Pradhan, Panda & Chandrakar (2011) presents the trends in authorship pattern and author’s collaborative research in Indian chemistry literature with a sample of 53,977 articles downloaded from SCI-Expanded database in Web of Science during the period 2000-2009. The average number of authors per article is 3.55 %. In the study, the degree of collaboration (C) during the overall 10 years (2000-2009) is 0.03. In the 10 years period, the
multi-authorship articles are higher, and single authorship is predominant. The study found that the researchers in chemistry are keen on team research or group research rather than solo research.

**Gupta & et al. (2011)** have made analysis of the research output of India in Computer Science during the period 1999-2008. They have considered a number of parameters such as 1) total research output 2) its growth, 3) its rank and global publication share 4) Citation impact 5) Share of international collaborative papers and major collaborative partner countries, and lastly, partners of research communication in productive journals. Further they have done a comparative study of publication output and impact of India in comparison with China, Taiwan and Brazil.

**Balasubramani & Murugan (2011)** have taken up the study of the research performance of India in Tapioca. The extent of study covers to entire globe, and the period they have chosen is 1997 -2010. The main focus of the study is research of tapioca, its growth, share and impact in global publication. The patterns of international and major collaborative partners. The publication productivity and impact of leading institutions of India. The characteristics of most prolific authors and high-cited papers and patterns of research communication in the productivity journals. For their study they have gone through SCI through Web of Science provided by Thomson Reuters. Totally, they have obtained 447 records and analyzed them by using histcite software application in order to fulfil the objective of the study.

**Gupta & Bala (2011)** have made an attempt to study the research publication on Tuberculosis during 1998-09 by referring to Scopus database. They have gone through and analyzed the growth, rank and global publication share, citation impact, share of international collaborative papers, contribution of major collaborative partner countries, contribution of various subject fields and by type of tuberculosis and patterns of research communication in most productive journals. According to the study, India ranks 3rd in the top 21
countries, and global publication share is higher in China. The inference of the study is that India needs to increase its output and to bring about improvement in the quality of its research efforts.

**Sangam & Bagalkoti (2012)** undertook a study of research output of top eight Asian countries under various indicators. To determine the ranks, the total articles, citations, subject areas, authors, institutional collaborations, international collaboration and H-index are taken into account. In this article, all the indicators which measure quantifiable aspects of the application of science and technology. For this, data has been collected from the SCOPUS international multidisciplinary bibliographical database.

**Gunasekaran & Balasubramani (2012)** analyse the artificial intelligence research output carried out during the year 1973 – 2011. The different parameters, including authorship pattern, growth, rank with global publication, institutions contribution, most productivity journals were analysed. Scoups citation database has been used to retrieve the data. The authors compared the profile of India’s research output with other countries with help of scientometrics technique. The study shows that India ranks 1st among the top 17 countries with 219 (96.05%) papers. The Indian research output slightly decreased in the year 1973, but later gradually increased every year.

**Korzhavykh (2012)** discussed the importance and potential of scientometric assessment of the progress of innovative pharmacy. The author also described the Scientometric publications are analyzed and forecast new domestic drug R&D in historical perspective, the role of systemic informational analysis of science as a new methodological tool for research metrics is described.
2.5 Ranking of Universities and Research & Development Organizations

Ranking is the process during which items are sorted by relevance (from the most to the least pertinent). It is performed by calculating a relevancy score (in percentage), using a series of parameters called ranking factors. Rank is the relationship between units that refer to different values of some variable underlying property such as the following: Degree, Grade, Relative position, Social position, Stratum.

A ranking is a relationship between a set of items such that, for any two items, the first is either 'ranked higher than', 'ranked lower than' or 'ranked equal to' the second. In mathematics, this is known as a weak order or total preorder of objects. It is not necessarily a total order of objects, because two different objects can have the same ranking. The rankings themselves are totally ordered. For example, materials are totally preordered by hardness, while degrees of hardness are totally ordered (Sangam, 2012).

Gupta & Karisiddappa (1997) have studied the productivity of authors by duration and speed of their paper publication in the field of theoretical population genetics. Their findings show that duration of the reading participation of authors increase while skewness in the author productivity distribution is close to Lotka’s distribution and negative binomial distribution. The distribution obtained for the speed of publication is not found to be close to Lotka’s distribution.

Sen et al. (1998) have used a modified formula for ranking authors, using citation and self citation. The study indicates that a small number of papers receive a large number of citations. Papers in biochemistry and molecular biology usually generate a large number of ranking citations and the mean citation score in mathematics is usually found to be less than papers in physics, chemistry, biology and medicine.
Gauffriau & Larsen (2005) have explained the fractional and total count method of publication for ranking the universities and countries. The analysis shows that fractional count method is the best method for ranking national, regional and institutional level. Collaboration study is also done, showing high degree of collaboration.

Braun et al. (2007) use normal gatekeeper indicator to rank the universities of the world, Europe, and 29 countries of the world. The first 20 universities, except 3 UK universities, are from the USA. A rank correlation study is done between Times’ Shangai and ISSRU ranking, Shangahai and this ranking shows a close relation while there is variation in ranks of ISSRU vs. Shangahai and Times’ vs. ISSRU, while Florian (2007) has critically examined the problem found, reproducing the Shanghai study.

Buela-Casal et al. (2007) compare an international ranking of universities based on five selection criteria using four international rankings. The results show that indicators referred to research and scientific productivity from academic staff has a prominent role across all approaches.

Kivinen & Hedman (2008) discussed the Academic World Ranking of Universities by re-sampling and reanalyzing the ARWU (Academic World Ranking of Universities) data. The authors propose an input-output analysis for measuring universities' scientific productivity with special emphasis on those universities which meet the productivity in a certain group of universities. The productivity analysis of Scandinavian universities evaluates multidisciplinary and specialized universities on their own terms; consequently, the ranking based on scientific productivity deviates significantly from the Academic World Ranking of Universities.

Medina (2008) presents the bibliometric characteristics of the 386 most frequently publishing universities and of a (partly overlapping) set of 529 European universities and presents a statistical analysis of ranking data,
focusing on more general patterns. Also compares US universities with European institutions; countries with a strong concentration of academic research activities; a ranking of universities based on indicators calculated for all research fields combined with one compiled for a single field (oncology); general with specialized universities; and rankings based on a single indicator with maps combining social network analysis and a series of indicators. Further highlights important factors that can be taken into account in the interpretation of rankings of research universities based on bibliometric indicators.

**Prathap & Gupta (2009)** point out the ranking of top 25 universities based on the number of research papers published from 1999 to 2008. Sanjay Gandhi Postgraduate Institute of Medical Sciences (SGPIMS) is among the top 10 universities as per SCOPUS database. All the listed universities have a number of departments, including arts and science.

**Markusova et al. (2009)** says that the structure of domestic science significantly differs from the structure of science in other countries of the world, where science is carried out predominately at Universities. The increasing necessity for domestic Universities to find place in global ratings imposes a number of new tasks on the librarian and scientific-information service of teaching staffs.

**Prathap & Gupta (2009)** assessed both the quantity and quality of scientific research and presented the ranking of research performance based on quantum of output and quality of research of various Indian universities, using from SCOPUS database. The publication share of these 25 universities to the total output by India showed some increase from 17.48% (22,173 papers) in 1999–03 to 18.31% (37,512 papers) in 2004–08.

**Gupta (2010)** describes the type and growth of higher education in India and its priorities as listed in the current 11th Five-Year Plan of Government of India. The study stresses the need for ranking of Indian universities and focuses
on new methodology of ranking of top 50 productive Indian universities, using publications, citations and international collaborative publication data.

Billal (2010) criticizes the ranking process and the negative impacts it forecasts due to its exploitation for other gains. Ranking of universities is viewed from a different angle by the developing countries. Further he emphasizes that the ranking of the universities have received more prominence, and consulted frequently for a variety of factors, though it never remains the sole factor in decision making.

Gupta (2011) uses a new methodology of ranking of top 50 productive Indian universities based on publications, citations and international collaborative publications. The factors affecting productivity and quality of research in Indian universities were also identified by the author. The study indicates the various methods employed for ranking universities in India.

Carmen & Moed (2011) opine that a bibliometric analysis of the 50 most frequently publishing Spanish universities shows large differences in the publication activity and citation impact among research disciplines within an institution. Gini Index is a useful measure of an institution’s disciplinary specialization and can roughly categorize universities in terms of general versus specialized. A study of the Spanish academic system reveals that the assessment of a university’s research performance must take into account the disciplinary breadth of its publication activity and citation impact. It proposes to use graphs for showing not only a university’s article production and citation impact, but also its disciplinary specialization. Such graphs constitute both a warning and a remedy against one-dimensional approaches to the assessment of institutional research performance.

Gupta (2011) analyses the ranking of India’s productive institutions in agricultural sciences, based on various quantitative indicators such as the total number of papers, international collaborative papers and qualitative indicators,
which combine quantitative and qualitative aspects. There is a gradual change in their ranking positions, when their ranking is calculated on the basis of mean citation rate. H-index was compared with their ranking on the basis of the composite indicator.

Sangam & Bagalkoti (2012) examines India’s performance on the basis of its publication output in Science and Technology during 2001-2010. Also identifies the international collaboration, h-index and the National Assessment and Accreditation Council grade (NAAC) of top 50 productive universities. The study uses 10 years publications data from Scopus international multidisciplinary bibliographical database. 50 universities contributed 1,08,666 papers and received 3,36,027 citations during 2001-10, with the average citation per paper as 3.09. The study also indicates various criteria for ranking universities.

2.6 Citation Analysis of Individual Scientists

Citation analysis is a convenient tool for identifying outstanding authors or articles. Its interest is to take note of those which are being heavily cited as shown in the Science Citation Index (SCI).

Effective access to information is an essential requirement for the success of any information systems and for researchers/scholars, journal are the most dependable sources of information (Aina and Mabawonku, 1997). Although journals from major part of the literature consulted by researchers/scholars, rising cost of journals and the increasing number of journals are making it more difficult for libraries to provide researchers with all the information they need. Citation analysis is a useful tool for evaluating the use of library collections.

Citation analysis is the examination of the frequency, patterns and graphs of citations in articles and books (Garfield, 1983 and Rubin, 2004). Citation analysis is one of the well-known methods used in a university library
environment. Not only do citations play an important part in the scholarly communication process, but ‘citation and the composition of bibliographies reflect changes in the information seeking behavior of academics’, as well (Naude and Du Toit, 2005). In this regard, thesis and dissertations have proved to be particularly appealing to use for assessing library collections because they serve as a convenient source of in-house research. Furthermore, Zipp (1996) found that ‘the most heavily cited journal titles in theses and dissertations can be used as a surrogate for the titles most heavily used by faculty in their publication’. This is because the research interests of graduate students often reflect the research interests of the faculty advisers.

**Garfield (1977)** conducted the Citation Analysis study on Lester R Aronson during the Anti-visection Controversy. **Garfield (1984)**, in his series of two essays in Current Contents dedicated to Dr. S. R. Ranganathan, the Father of Indian Library Science highlighted in detail life and works in the first part and his contribution to Indian and International library science in the second part of the essay.

**Cawkell & Garfield (1980)** have made a study of citation analysis to assess Einstein's impact on today’s science by considering citing articles from 1974-77. Einstein’s major contributions in the fields: the special and general theories of relativity; Brownian movement and statistical theories; development of quantum theory (from photoelectric research) for which he received the Nobel Prize in 1921, and developments in wave mechanics (the Bose-Einstein Statistics). The results indicate that there is a definite subject connection between most cited and citing articles. In the year 1977, Einstein received 452 citations in all. Out of his 11 early articles, most have been heavily cited today. The impact of Einstein’s work is evident in a variety of disciplines. His direct influence and on-going interest in his work are quite extraordinary.

Citation analysis is the examination of the frequency, patterns and graphs of citations in articles and books (**Garfield, 1983 & Rubin, 2004**).
Citation analysis is one of the well-known methods used in a university library environment. Not only do citations play an important part in the scholarly communication process, but ‘citations and the composition of bibliographies reflect changes in the information seeking behavior of academics’, as well (Naude & Du Toit, 2005). In this regard, theses and dissertations have proved to be particularly appealing to use for assessing library collections because they serve as a convenient source of in-house research.

Gupta & Chandrasekhar (1983) conducted a citation analysis study on S. Chandrasekhar, the winner of the 1983 Nobel Prize for physics, using Science Citation Index (SCI). A total of 401 works were cited 10,359 times during 1965-1980, out of which six were identified as citation classics for receiving 53% of all the citations. The author concluded that there was a high correlation in quantity, quality of works, citedness and receipt of honors and awards for S. Chandrashekhar.

Folly et al. (1991) carried out a citation analysis study of 80 Hungarian scientists, authors or co-authors of a total number of 6273 papers published between 1930 and 1976. The results reveal that the first three parameters seem to be applicable in measuring the utility of the individual's scientific contribution with a slightly different emphasis on different aspects.

Mahapatra (1992) measured the degree of influence of Ranganathan’s works on Indian Library and Information Science literature. She analyzed the references appended in journal articles and found that even after his death, Ranganathan continues to be cited frequently, especially for his works on classification and cataloguing.

Gupta (1993) analyzed the citations for all the publications of Xavier LePichon pertaining to sea floor spreading for the period 1965-1979. Out of the 127 cited publications, 13 papers were consistently cited. However, the most
The cited article is “Sea-floor spreading and continental drift” published in *Journal of Geophysical Research* (1968) which received 642 citations in all.

Sinha & Ullah (1993) attempted a citation analysis to determine the citation characteristics of periodical articles and books published by Ramachandran in the field of cement and concrete chemistry. The authors found that he was a highly quoted/cited scientist, and that his books were more cited than his articles.

Lancaster et al. (1993) analyzed publications of Manfred Kochen, a well-known information scientist. Kochen earned 456 citations as reflected in the Science Citation Index and in the Social Sciences Citation Index. The authors observed that the citations are not concentrated on a few items, but are scattered over his entire corpus of writings.

Bibliometric profile of internationally recognized top-scientists in chemical engineering was analyzed by Peters & Van (1994). The authors have developed a method to compare bibliometric characteristics of top-scientists with an 'average scientist' in chemical engineering. The method includes citation-analysis of books and proceedings. The results show a very clear 'bibliometric profile'; top-scientists reach the maximum of their received citations about a year earlier; second, they are cited significantly more than the average scientist; third, top-scientists' references are more numerous, they are concerned with more recent literature, and the fifth finding was that the journals used by top-scientists for their publications are representative in the field in chemical engineering as a whole.

Plomp (1994) analyzed in two parts the highly cited papers of professors as an indicator of a research group’s scientific performance. In the first part of the paper, the citations in 1986 and 1987 of 3938 papers published in 1985 by 324 research groups in the faculties of science and medicine, of eight universities in the Netherlands are analyzed.
Furthermore, Zipp (1996) found that ‘the most heavily cited journal titles in theses and dissertations can be used as a surrogate for the titles most heavily used by faculty in their publications’. This is because of the research interests of the faculty advisers.

Informetrics study of M. N. Srinivas, a well known sociologist, widely recognized as an architect of modern Indian sociology and social anthropology was made by Devarai et al. (1998). The author has 132 publications all with single authored publications have been analyzed by year, domain, and authorship pattern. Channels of communication used, key words, etc. The results indicate that the papers published by the scientist reveal that his papers are of high caliber and qualify him to be a 'role model' for the younger generations to emulate.

Tiew (1999) analyzed the publication productivity, authorship pattern, channels of communication, journal preference and language preference of Professor Dato’ Khoo Kay Kim, Professor of Malaysian History in the University of Malaya, Kuala Lumpur. He has published 205 papers during 1963-1998 with the total productive age of 36 years. The average publication output per annum is 5.7, the highest productive year being 1992.

Kamble (2001) presented a detailed scientometric analysis of the publication output of Indian leading astrophysicist J. V. Narlikar by authorship credits to collaborators, Lotka’s Law, and Bradford’s Law and growth of his publications in his highly preferred journals. It was found that Narlikar had excellent collaboration with 45 researchers. The prominent collaborators were F. Hoyle (54), G.R. Burbidge (19), etc. Bradford's multiplier for second zone was 9.37. His productivity follows Lotka’s Law of author productivity in a research group.
Sen & Karanjai (2003) analyse publications and citation pattern of the publications of Biman Bagchi, a renowned physical chemist from India, who published 226 papers during 1981 - 2002. His contributions reached their peak in 1999 and 2002 when they reached 19. The author is highly productive in as much as on an average the author has produced 10 papers per annum. In the beeline of authorship, Bagchi occupies the first authorship position in 69 cases. His collaborator A Chandra occupies the first authorship position in 30 papers, thus becoming Bagchi's closest collaborator. The journal has been the most preferred channel of communication the author with 220 papers, out of 226. Journal Chem Phys is found to be the most preferred journal that carried 91 papers of the author, followed by Chem Phys Lett (21 papers). Of the total papers, 179 received 4030 citations, and 47 received no citations. Three papers of the author have received more than 200 citations each, and another three received between 100-200 citations each.

Swarna et al. (2003) studied the Classic-Author Synchronous Self-References (C-ASS-R) of H. J. Bhabha the C-ASS-R as recommended by Aksnes (2003) by considering only the first-author in self-references. The quantitative analysis of the events of synchronous references in the research papers followed throughout the publishing career of an individual scientist revealed interesting highlights on the knowledge generating system.

A scientometric analysis of publications of Leland H. Hartwell, a Nobel laureate in Physiology/Medicine (2001) was carried out by Angadi et al. (2004). The study revealed that Hartwell had 108 publications during 1961–2001 in different domains, with 101 collaborators, most active collaborators being Weinert, T.A. (10), Garvik, B. M. (8), etc. His productivity coefficient is 0.76, which clearly indicates that his productivity increased after 50 percentile age. Highest collaboration coefficient is one. 96 papers out of 108 have been published in journals. The core journals publishing his papers were: Cell (14), Genetics (12), etc. The authors suggest that it would be interesting if one
attempts to study the sociological aspects and citation studies on Leland H. Hartwell, which may give many new insights into his scientific career.

Cardona & Marx (2006) analyzed the impact of the works and citations of Vitaly L. Ginzburg, one of the pioneers of solid-state physics and received the physics Nobel Prize 2003. Ginzburg had published 424 articles with an average number of almost 10 articles per annum from 1955 until present, which is indeed very impressive. The authors have also investigated the informal citations, the citations involving mentions of Ginzburg’s name without a specific formal citation. The authors expressed that because of Ginzburg's long scientific life, it is an excellent subject for learning the capabilities and shortcomings of citation analysis. It was found from the study that Ginzburg was among the most prominent and influential Russian physicists. According to the Hirsch number (h-index = 40), Ginzburg is one of the most influential Russian Nobel Laureates, and he occupies the sixth place based on the total number of citations.

Cardona & Marx (2006a) analyzed the work of Georg(e) Placzek with the aim of illustrating the power and virtues of bibliometric techniques and their pitfalls.

Sangam et al. (2006a) analyzed publications of N. Rudraiah, a leading mathematician, from India. He has collaborated with 102 colleagues and students in his 43 years of productive life. He has published 271 papers scattered in five different research domains during 1962-2004. His collaboration co-efficient was 0.51. Highest collaborators were M. Venkatachalappa (31) and B. C. Chandrasekhara (21). The core journals publishing his papers were: Indian Journal of Pure and Applied Mathematics, Current Science, International Journal of Heat and Mass Transfer, etc.

In the same year, Sangam et al. (2006b) analyzed 337 publications of Peter John Wyllie, an American geologist during 1951-2004. Of these papers,
144 (42.72%) were single-authored and 193 (57.28%) multi-authored papers. The results indicate that the highest productivity was in 1983 with the output of 13 papers (age 54); the highest collaboration coefficient (0.64) was during 1970–1974; during the 54 years span of scientific career, Prof. Wyllie has collaborated with 75 researchers. Huang was the main collaborator with 25 papers during 1973–2000. Of 337 papers, 241 were published in 68 different channels of communication, and his most preferred journals were: American Mineralogy (24) and Journal of Geology (23).

A scientometric study on communication and collaborative research pattern of G. N. Ramachandran, a pioneer in molecular biophysics from India, has been analyzed by Sangam et al. (2006c). It is interesting to note that in his 49 years of productive life, he has collaborated with 81 colleagues and students and has published 304 papers during 1942-1990. The highest collaboration coefficient is 0.86. He has the highest collaboration with V. Sasishekaran (18) and R. Srinivasan (15). The core journals, which published his papers were: Proceedings of the Indian Academy of Sciences, Acta Crystallographica, Current Science, Nature and Biopolymers. Bradford Multiplier was found three. Prof. Ramachandran has established a remarkable scientific tradition that thrives in the world. Ramachandran was in fact one of the most outstanding scientists of post-Independent India.

The analysis of 251 publications by B. N. Koley, an eminent physiologist of India, published during 1958-2001, was examined by Koley & Sen (2006). The authors examine year-wise distribution of papers, research group of the scientist and scattering of papers in different communication channels. In addition, they find out author productivity, spectrum of research activity through analysis of the title keywords, and productivity of Koley's research group. Finally, it shows that the data set does not follow Bradford distribution. The authors felt that these studies may prove to be of great value.
to the concerned scientist, and might help him to pinpoint his position amongst his fellow professionals.

**Sangam et al. (2007)** analyzed 178 papers published by S. Ramaseshan during 1944–2000. The scientist S. Ramaseshan was a leading crystallographer from India. His publications were analyzed and classified into four domains. The work done by S. Ramaseshan has made a mark on the various areas he dealt with earnestly for the encouragement of science in India. No doubt, he helped science in the nascent years of the birth of modern physics in India.

Similarly, the biobibliometric study was conducted by **Parvathamma & Gabbur (2008)** on T. M. Aminabhavi. In his 36 years of teaching and 28 years of research experience in various fields of polymer science, he has published 521 research articles, 57 popular articles and 94 conference papers in eight domains of polymer science. He has three US patents to his credit. Collaboration Coefficient (CC) was ranged between 0.9 and 1.0 indicating the interdisciplinary nature of his research. The year 2006 has been the most productive year in his research career wherein he has published 96 research papers. The period of international collaboration is significant with W.E. Rudzinski (22 years), Patrick E. Cassidy (15 years), J.D. Ortego (12 years) and T.H.S. Phayde (05 years). The authors expressed that the study of Prof. T. M. Aminabhavi’s research output proves that long time commitment and sustaining efforts are necessary to achieve excellence in one’s area of research. Through high degree of collaboration at national and international levels, he has shown the importance of team work to younger generation of polymer scientists.

The scientometric portrait study on Nayana Nanada Borthakur, an eminent biometeorologist, was carreid out by **Hazarika et al. (2010)**. It was confined to 106 papers published during 1963-2005. The noteworthy results of this study are as follows: Collaborative authorship pattern is found to be in the team size of 2.5. Collaborative coefficient was 0.76 and productivity
coefficient was 0.65, and 54 channels of communication were used to publish his research results of which International Journal of Biometeorology (15) top the list. The publication concentration was 18.5, and publication density was 2.

The scientometric study undertaken by Varaprasad et al. (2010) highlights the growth and development of chemical science research by J.S.Yadav during 1986-2009. During this period he has published 722 papers (702 research articles) in various domains. His papers have been scattered in 56 high impact factor scientific journals. The percentage of collaborative work (99.7) was very high. The highest degree of collaboration, i.e. 0.1925 was found during 2002-2003. His h-index was 41 after 24 years of scientific activity is a clear indication of his consistent publication productivity behaviour.

The scietometric portrait study carried out by Keshava et al. (2010) to know the scientific work done by Prof. Kubakaddi and his role in the achievement of science in India especially in the field of physics. The result of the study shows that Kubakaddi had 85 papers to his credit during 1974-2008. Highest productivity was in 1987 with the output of nine publications (age 36) and the highest collaboration coefficient (0.71) of Prof. Kubakaddi is found at the age of 44-48 (1995-1999). Kubakaddi’s h–index was 7.

2.7 Collaborative works (Individual level, Institutional level and Country level)

Research collaboration could be defined as a working together of researchers to achieve the common goal of producing new scientific knowledge. Collaboration plugs the researcher into a wider contact network in the scientific community, and it enhances the potential visibility of the work. Thus, collaboration helps speed up problem solving, stimulates creativity and enables inter-disciplinary boundary crossing which in turn enriches knowledge development and transfer. Collaboration also organizes multidisciplinary research networks in a variety of ways.
Library and Information Science (LIS) is a multidisciplinary subject. It is closely interconnected with computer science, education, sociology, cognitive psychology, mathematics, management, philosophy and engineering. New information technologies brought into LIS school such topics as human-computer interaction, computer-mediated communications, information literacy, and social informatics, which further brought into play several other disciplines. Thus the demand for research collaboration in LIS is increasing.

The multiple-author publication, frequently referred to as a co-authored publication, has been used as basic counting unit to measure collaborative activity. Smith was one of the first researchers to observe an increase in the incidence of multiple-author papers, and to suggest that such papers could be used as a proxy measure for collaboration among groups of researchers. K. Subramanyam has taken this argument further. He opined that bibliometric methods offer a convenient and non-reactive tool for studying collaboration in research. Finally it can be said, despite the limitations of co-authorship measures, many studies have used this technique to investigate collaboration. For example, de Solla Price was an early advocate of the use of multiple-author papers as a measure of changes in collaboration.

Kundra (1996) has studied the collaboration pattern in the field of medical sciences, using different collaborative measures. The study reveals that there is a perceptible increase in the collaborative research from 12.4% to 66.36%. It has been observed that there is three times increase in the basic research, and the average authorship per paper is found to be 1.2.

Gupta, Suresh Kumar & Karisiddappa (1997) examine collaborative pattern by using different collaborative measures. About 72% of authors have collaborated, and it is observed that the average author per paper is 1.86, and there is consistent increase in collaborative coefficient, and the productivity and collaboration count is found to be 2.34 and 2.08, using normal count and straight count method. Correlation between the number of publication/papers
and average number of collaboration per author as 0.6944 (0=0.002) seems to be strong.

Cronin & Atkins (1997) have conducted a comparative analysis of authors in monographic and journal literature in the field of sociology. The findings show that in relative ranking of authors on both, the format is almost the same for specified period and lack of correlation suggests that there may be two distinct populations of highly cited authors.

Rousseau (1997) investigates the distribution of domain names and the distribution of links between websites. The study shows that Lotka’s function provides an adequate description and the self citation in half of the total citation studied.

Vinkler (2000) has used GF term credit share indexes, total publication score, total relative publication and potential indicators to evaluate the publication output quantitatively as well as qualitatively. The result shows that biochemistry and molecular biology are having higher mean GF (2.897); and credit share of 0.55.

Osarch & Wilson (2002) studied the Iranian scientific publication by using SCI Index. The results show the average annual growth rate of 2.6%, and a number of collaborative links indicates the average annual growth rate of 11.1% at the international level of collaboration. Different factors affecting the growth and collaboration are also highlighted.

Another study by Kundra & Srinivasan (2004) reveals the productivity pattern and collaboration pattern of Indian institutions, which shows that there is a steady growth in publication and in collaborative output. The degree of collaboration is observed to be between 94.98%, which reflects the high professionalism in the field of chemistry for the period 1993-2003.
Kretschmer & Aguillo (2004) have made a study on collaboration in the field of science and technology by using COLNET member data. It reveals that 78% of the multi authored publications become visible through the web/search engines, and they are being used by authors for references.

Glanzel & Schubert (2004) have analyzed the scientific collaboration through co-authorship. The authors have given an overview of the development and application of co-authorship based indicators, their methodological background and their use in research. The review of co-authorship analysis focusing on relevant issues at individual, national and international level is also given.

Gupta & Jha’s (2004) study on Indian collaboration with East Asian countries shows that 56% of papers are co-authored and 44% are multilateral and Indian collaboration with Japan is strongly bilateral. The most preferred area of research is Chemistry, Physics and Engineering & Technology, contributing more than 60% of the total output. In multilateral collaboration, physics accounts for about 55% of the total multilateral papers, and the USA has the largest participation with 419 papers, followed by France with 263 papers, Russia with 296 papers and Germany, with 168 papers.

Similarly, Munshi & Pant (2004) studied the collaboration pattern in the field of nuclear science, and found that more than 66% of papers are the results of collaborative efforts, and the USA, Germany and Japan secure the top positions among collaborating countries.

Rana (2004) studies the field of wildlife science. The author found that the growth rate is 37.85 articles per year, and the growth rate of authors varied from 28.80 to 46.70 per year. The 65% of the total authors have contributed only single article, upholding the applicability of Lotka’s law and 50% of the total literature is contributed by 10% of the total authors. The highest number
of contributions (articles) is 456 in 41 years with an average of 3.8 articles per year. Average of all productive authors is 156 articles per year.

Sangam (2004) conducted a study on the collaborative pattern in the field of demography and found that there is an increasing trend of collaboration in two-authorship, three-authorship and five-authorship papers. Collaborative measures show that there is an increasing trend from 1.47 to 1.79 in Collaboration Index.

Cholin (2005) conducted a comprehensive collaborative analysis of the sociology literature. The study has been done for the 15 major fields of sociology using the three collaborative measures as: Collaborative Index (CI) Collaborative Coefficient (CC) and Degree of Collaboration (DC) and found that there is an increasing trend towards collaboration in these fields.

Vijay (2005) in his paper, found that the collaborative research in Food Science and Technology literature is being preferred to solo research as Degree of Collaboration(DC) is found to be 0.91 and Collaborative Index has also shown an upward trend as it increases from 4.89 in 1994 to 8.2 in 2003.

Anuradha & Urs (2007) have studied the international collaboration pattern in the selected field of physical sciences by using SCI database data. The correspondence analysis of the data indicates that physics, chemistry and clinical medicine are the first three disciplines, having international collaboration with the USA, Italy, Germany, France and England which are top five countries having high collaborative output.

Harirchi et al. (2007) have done an exploratory study of the features of Iranian co-authorship in biology, chemistry and physics, which show that only 5% of the Iranian literature output in these fields is a result of collaboration. The motive behind the collaboration among the scientists is: sharing laboratories, accessing knowledge and increased efficiency of the study.
Sangam & Meera (2012) have studied the analysis of citations received by two journals, viz., *Indian journal of Experimental Biology* and *Asian journal of Chemistry*. These journals have received 30,142 references for 3,027 articles at the rate of 9.95 references per article for year data. The authors found that the value Annual Ageing Factor (AAF) = "a” as calculated from the graph is found to be A A F =0.948687. The value of half life as observed from the graph is 15 years and calculated value is = 13.15865 years which is almost near to the observed value. The value of Utility factor (U) was found to be U = 19.48831 and the value of the mean (m) is = 18.98392 which confirms the exponential nature of the distribution and also justifies the correctness of the average value of ‘a’. Citation frequency distribution in chemical science journals follows exponential pattern. The Corrected Obsolescence Factor (a) was found to be = 0.504389.

The analysis of the reviewed articles reveals that, with the help of scientometric measures the numbers of the studies have been done. The application of scientometric techniques on scientific literature shows that exponential, Bass model are best fitted model to the scientific literature. It has been observed that the collaboration is gradually increasing in the scientific publications. Considerable number of the article has been reported on journal productivity. It has been found that a number of scientometric studies have been done in science at the micro level. Indian Chemistry literature has been found to be more investigated research area in science and technology.
References


38. Garfield, E. (1978b). The 300 most-cited authors, 1961-1976, including co-authors. 3A. Their most-cited papers-introduction and journal analysis. *Current Contents*, 47, 5-16


47. Garfield, E., & Malin, M. V. (1968), *Can Nobel Prize winners be predicted?* 135th Annual Meeting, American Association for the Advancement of Science, Dallas, TX.


112. Moed, H. F. et al. (1985). The application of bibliometric indicators: important field-and time-dependent factors to be considered, *Scientometrics, 8* (3-4), 177-203.


