CHAPTER III

RESEARCH METHODOLOGY AND THESIS DESIGN

3.1: Meaning of research

Curiosity is a distinctive feature of human beings. Curiosity to know about ourselves, known persons, institutions, environment, planets and the universe is inherent in us. Innumerable questions go on arising in our mind such as what is the shape of our planet earth? How do solar and lunar eclipses arise? Why do day and night alternate? How the air temperature varies at various places on the earth? Is there life on other planets? Why does the performance of similar organizations vary? Why does the behaviour of people differ from person to person? Etc. Whenever we encounter problems, we try to find a solution to them. Seeking answers to questions and finding solutions to problems have been the basis of human progress. In fact, these types of questions are the motives for searching the answers. In the course of searching the answers the obvious steps have been to collect the data, do filtration and examination of the facts collected in the prescribed procedure and codes of making conclusions is called research.

In the context of research, the deepest ocean in the world is the ocean of knowledge and the depth of which is unknown and indefinite. Will we reach the bottom of the ocean? But the research has dived deep to fathom many pearls unseen. Certain findings and the manifestation of our ingenuity, dexterity and determination have led us to known from unknown and hence the sanguinity that we shall strive hard continuously to reach the base of the ocean. With every new experience added, it again needs reinterpretation to get an insight for identification of the truth.

The research process has involved some of the important activities like;

(i) To Explore the of new facts.
(ii) To observe carefully natural and social phenomena.
(iii) To trace the new inter-relationships.
(iv) To re-interpret existing theory.
(v) To propound new theories.
(vi) Extension and further application of existing theories.
(vii) To provide or falsify the old notions.
(viii) Retest old theories in the light of new observations.
(ix) Test the collected human experience by application of research method.
(x) Logical and empirical verification.

3.1.1: Definitions of Research

Professionals have given the meanings of research and research methods:

Many activities are covered in the process of research. According to B.N. Ghosh, “Research is a means to the advancement of the knowledge and of science, but a fruitful research study appears to be almost impossible without the proper understanding of research methodology.”

Encyclopedia of Social Sciences defines research as, “the manipulation of generalizing to extend, correct or verify knowledge.”

According to Plutchick, “Research has its origin in a term which means to go around or to explore .... and it is a combination of Re + Search.” In simple words, it means ‘the repetition of search.’ Kerlinger defines research as a “systematic, controlled, empirical and critical investigation of a hypothetical proposition about the presumed relations among natural phenomena.” Research is in simple terms, “search for facts - answers to questions and solutions to the problems. It is an organized inquiry”.

According to Ijari (2000), “Research is a process when a planned, and the structured investigation has made a specific segment of knowledge either at the macro or micro level. It is a systematic quest for knowledge. New knowledge has created; the investigation is made and added to systematic and scientific knowledge.”

3.2: The Research Methods: Research methods are of two types:

(i) Arbitrary Method: It is also called the unscientific method. This type of research is generally for seeking answers to questions and is based on imagination, opinion, blind faith or impression. It suffers from weaknesses. It is subjective and the findings will vary from person to person depending on impression and imagination. It is vague and inaccurate.

(ii) Scientific Method: This is the rational and systematic approach to seeking the facts. The limitations of the arbitrary method can be eliminated by this method. It is objective, precise and arrives at conclusions by verifiable evidence.
The scientific method is based on the following factors:

3.2.1 **Reliability of evidence**: Conclusion is arrived when it has based on evidence. The validity and reliability of data are checked carefully, and it is analyzed thoroughly using an appropriate method of analysis. The conclusion is reached by the result of the analysis.

3.2.2 **Use of concepts**: Concepts are logical constructs or abstractions created from sense impressions, perception and experience. The researchers use them in their thinking and communication to clarify and correct understanding.

3.2.3 **Ethical neutrality**: Science does not say anything good or bad as it is neutral.

3.2.4 **Generalization**: The research results should be able to generalize.

Hence “Research is a systematic and logical study of an issue or problem or phenomenon through scientific method” (Krishnaswami & Ranganatham, 2013). Multiplication of knowledge has resulted in specializations and appeared as distinct disciplines of gaining knowledge. Many of the disciplines have been able to develop an advanced methodology of research to reach a greater depth of knowledge and also to conclude the results precisely and accurately. But the discipline of social sciences is more complex and cannot be treated as precisely as other sciences. But even then the social scientists have gone a long way to as precise a scientific substance to social research as achievable within the open and accessible frontiers of human knowledge. Since all social sciences are close and intimate with the varied sociological behaviour of a human being a hundred per cent accuracy is difficult to achieve in social science research. However, thanks to human intelligence, the standards of accuracy in social science research have gone as high as hundred per cent in some cases (Khan, 2013). The scientific method of research has played a major role to achieve it.

According to Black and Champion (1976), ‘Scientific research consists of obtaining information through empirical observation, which can use for the systematic development of logically related propositions attempting to establish causal relations among variables.’ The steps of scientific method:

1. Statement of the problem.
2. Review of concepts and theories concerning the previous study.
3. Formulation of hypothesis.
4. Design of research.
5. Data collection.
6. Data analysis.
7. Interpretation of data and reaching generalization and conclusion.

3.3: Library Science and scientific method

Scientific method in library science has been elaborated by Ranganathan (1957) as “Science is the name given to a domain in the Universe of Knowledge whose development has characterized by the never-ending spiral movement known as Scientific Method.” For the convenience of reference, the four cardinal points of the cycle are denoted by the terms:

1. **Nadir**: It marks the accumulation of facts, obtained by observation, experimentation and other similar forms of experience, denoted at the bottom of the spiral circle.
2. **Ascendant**: It marks the accumulation of induced or empirical laws got out of the facts accumulated at the Nadir, by inductive logic including normal equations and other aids from statistical calculus.
3. **Zenith**: It marks the fundamental laws formulated with the aid and intuition of some degree or other so as to comprehend all the inducted or empirical laws accumulated at the ascendants, as compelling implications. Zenith denoted at the top of the spiral.
4. **Descendant**: It marks the accumulation of deduced laws got from the fundamental laws at the Zenith with the aid of deductive logic including general semantics and all kinds of mathematical calculus.

On the spiral shape, four cardinal points give rise to four quadrants in the cycle implied in the spiral. Once a problem has sensed, it is mounted and processed in the spiral of the scientific method and made to pass the following four phases as research methodology speaks. The locations of the quadrants on the spiral are:

Quadrant 1: is between Descendant and Nadir knew for Empirical Phase.

Quadrant 2: is between Nadir and Ascendant knew for Hypothesizing Phase.

Quadrant 3: is between Ascendant and Zenith known for Deductive Phase.

Quadrant 4: is between Zenith and Descendant knew for Verification Phase.

The research may begin from any of the cardinal points and there is no end for the research. The spiral has continuous movement towards next cardinal point. According to Ranganathan (1957), “the cycle is endless, and the researcher can begin its description at any of its points.”
3.4: Classification of research Methods: Research may be classified as pure and applied.

(i) **Pure research:** Pure research or basic research/ theoretical research or scientific research are one and the same primarily aimed at deriving new knowledge irrespective of its applicability. According to Vickery, “scientific research is concerned with elucidating concepts and their relations, hypothesis, and theories but is not necessarily and certainly not directly related to technical and practical problems.”

(ii) **Applied research:** It aims at solving specific problems. It is conducted to find a solution to a real-life problem requiring a remedy or policy decision. Marketing research is an example of applied research. Library research is also its example.

(iii) **Exploratory research:** It is a preliminary study of an unfamiliar problem about which the researcher has little or no knowledge. It incorporates the development of the concept, theory and assumption.

(iv) **Analytical study or statistical method:** It is made systematic by procedures and techniques of analysis applied to quantitative data.

(v) **Diagnostic study:** Similar to descriptive study but with a different focus, it is directed towards discovering what is happening. Why is it happening and what can be done about it? It aims at identifying the causes of problems and their possible solutions.

(vi) **Evaluative study:** It is applied research. It is made for assessing and taking stock of the effectiveness of social or economic programmes, e.g., family planning scheme, irrigation project, etc.

(vii) **Action research:** It is launched for solving the problem and improving existing situation at the earliest possible.

3.5: Classification of research

(i) **Experimental research**

It is designed to assess the effects of particular variables on a phenomenon by keeping the other variables constant or controlled. The above research aims at determining whether and in what manner variables are related to each other? It says, “What will be” when certain variables are carefully controlled and manipulated.
(ii) **Descriptive Research**

The researcher has to present the things which are occurring. It says, “What is it?” It involves description, recording, analysis and interpretation of conditions that exist. It involves the same type of comparison or contrast and attempts to discover relationships between existing non-manipulated variables.

(iii) **Historical Research**

It is a study of past records and other information sources to (or “intending to”) restructuring the source and development of an institution or a movement or system and discovering the trends in the past. It is conducted by scrutinizing the historical facts by available documents (Khan, 2007). It says, “What was.” It involves investigating, recording, analyzing and interpreting the events of the past for the purpose of generalizing facts useful and helpful in approximating our life at present, for future by past happenings, and to a limited extent to carry out a further extension of knowledge by adding new ones. Historical research provides scope for evaluating the present by the past events.

Historical research has many alternative names like documentary research. The Documentary research became synonymous with Archival Research, Historical Research (Hilway, 1964) and Bibliometrics (Connaway and Powell, 2010), (Busha and Harter, 1980). The related terms for bibliometrics are informetrics, scientometrics and informetrics (Venkateswarulu, T., 1989). Historians use documentary research so constantly that sometimes it is called the ‘historical method’ (Hillway, 1964).

3.6: **Documentary Research**

It has received its name from the scholarly activities involved in learning new facts and principles through the study of documents and records. “This method of collecting and analyzing data can probably be considered the oldest form of true research. One of its examples is Aristotle (4th Century B.C.) who had applied method of documentary research when he made his provocative studies of Greek drama and poetry. (Hillway, 1964).

According to Wellington (2007), “Documentary research can be extremely efficient, cost effective and productive; it can provide important historical perspective on any area of the study.” The documentary research consists of putting together in a logical way the evidence derived from documents and records, and that evidence, forming conclusions which
either establish facts hitherto unknown or offers sound generalizations of past or present events, human motives, characteristics, and thoughts.

In this process the researcher studies the records of the past and present first to understand them, second to discover facts from them, third to learn something about their authors or originators, and finally to make generalizations (hypotheses or conclusions) about them.

In documentary research, any one or some or all of the following types of documents can be used for data collection (Hillway, 1964).

(i) Official records.
(ii) Newspapers, magazines and various periodical accounts.
(iii) Eyewitness accounts of events.
(iv) Letters and personal diaries.
(v) Historical writings and studies.
(vi) Descriptive studies made in the past.
(vii) Literary and philosophical writings.
(viii) Archeological and geological remains.
(viii) Miscellaneous.

Limitations in the use of documents

(i) Insufficient data.
(ii) Improper selection of data (Hilway, 1964).

The problems of selecting documents:

(i) External examination: Attempt to determine the genuineness or authenticity of the document.

(ii) Internal examination: Concerned with meaning, accuracy and general trustworthiness of the statements contained in the document.

Conducting research on evaluation of internet sources will be helpful regarding accuracy, authority, objectivity, timeliness, and coverage. Considerations of these factors will weed out many of the problems encountered by the researcher (Pandey and Pillai, 2011).
The above research has used the authentic online database SCOPUS and hence the problem of selection of documents and incompleteness does not arise.

Documentary research is used here to refer to inquiries into the printed tools of librarianship, i.e. the content of 51,382 records (scattered in 1344 journals, 167 conference proceedings, three book series, and one trade publication) in SCOPUS database. The analysis of all those documents under the title, ‘Scientometric study of environmental science research in India’ will be done in this study. The first analytical chapter will analyze at the world level and followed by Indian level analysis.

3.7: Library and Information Science Research

Research activities help to develop the subject and keep abreast of current trends. The LIS research, however, had a late started in India. Dr. S.R. Ranganathan started the Ph.D. Programme in LIS for the first time in 1948 at the University of Delhi. The first candidate who completed his research was Dr. B.D. Krishna Rao in 1957 (Reddy, 2000). Most of the other universities have taken up research activities during the 1970s. The research output in India has not been satisfactory and it could not fulfill the demand of the discipline of the library science in India. The output trend in term of number of candidates completed their doctoral research in LIS shows (Mestri, 2008) that during 1957-1987 (44), 1988-92 (65), 1993-97 (101), 1998-2002 (100) and 2003-2007 (181) work was done.

The problems in LIS research have been identified (Ijari, 2000) as:

(i) Administrative problem,

(iii) Financial problem,

(iv) Thematic problem. and

(v) Problem concerning facilities of literature.

According to Venkateswarulu and Tadiboyina (1989), “Library Science does not have a research methodology of its own; it borrowed already developed in social science like economics, sociology, and political science.” As stated by Karande, (1989) “to evaluate library material or collection on any particular subject, the historical method of research is found useful.”
3.8: Scientometric Study

The scientometrics has been considered by LIS professionals as one of the fascinating fields of study. It has fulfilled the function of scholarly communication. It is also known by alternative terms like bibliometrics and informetrics.

In each and every sector, application of statistics is not only necessary but essential to study the past, present and future. In the library, the sources of statistical data include:

(i) The library staff, (ii) The library document, and (iii) The library administration.

The application of quantitative techniques to the library activities is known with various terms like statistical analysis (Coale and Eale’s, 1917), statistical bibliography, etc. (Hulme, 1923). The term statistical bibliography has been defined by Raising (1962), “The assembling on the interpretation of statistics relating to books and periodicals to demonstrate historical movements, to determine national and universal research use of books and journals, and to ascertain in many local situations the general use of books and journals.” The ‘Librametry’ (Ranganathan 1948) in spite of the early attempt to define it hardly developed until the early 1970s. According to Sen (2015), ‘Librarmety is a branch of knowledge that applies mathematics and statistics to analyze the various components of a library and its resources like building, furniture, equipment, documents, the staff as well as library activities to find solutions to problems and generate local or global indicators.’ The Bibliometrics (Pichard, 1969) is used to describe all the studies which seek to quantify the process of written communication. According to Pichard (1969), “the application of mathematical methods to books and other media of communication has been called bibliometrics.” According to Hawkins (1977), “Bibliometrics is a quantitative analysis of the bibliographic feature of a body of literature.” Further, he extended his writing with the purpose “to shed light on the process of written communication and of the nature and course of development of a descriptive means of counting and analyzing the various facets of written communication.” Fairthorne defined bibliometrics as “the quantitative treatment of properties of recorded discourse and behavior about it.” Recently Potter (1981) defined bibliometrics as “the study and measurement of the publication patterns of all forms of written communication and their authorship.” In Eastern Europe the concept of bibliometrics is known as Scientometrics. Thisterm has coined by V. Nalimov and Z. Mulchnko in their book titled Scientometrics: the investigation of science as the development of information
*process* published in the year 1969). It is a method used to analyze and quantify the bibliographic data and it offers a powerful set of methods and measures for studying the structure and process of scholarly communication. “Scientometrics is the quantitative evaluation and intercomparison of scientific activity, productivity, and progress” (Beck). According to Bookstein, “Scientometrics is the science of measuring science.” The scope of scientometrics is generally centered on quantitative aspects of science, science policy, science administration and particularly of the quantitative studies of “output of science.”

**Application of Scientometrics:** Scientometric studies can be applied in any of the following or all.

1. Sociology of Science.
2. History of Science.
4. Behaviour of Science and Scientists.

The indicators are the tools for evaluating the state of the entire scientific endeavor to identify strength and weakness of the subject, an institution or organization. Science and Technology Indicators are the devices based on some information mechanism or conceptual tools which are amenable for evaluation (Sangam 2011).

**Data Sources:** To perform this study the data has been collected from the following three different sources:

1. SCOPUS Online database.
2. SCIImago Journal Rank (SJR) portal of ELSEVIER (based on SCOPUS).

**3.9: What is SCOPUS? Why is it used in this study?**

The SCOPUS is the largest database of scientific research literature and quality web sources which cover more than 21,000 titles from more than 5,000 publishers. It contains more than 49 million records and more than 376 million scientific indexed web pages. It covers all the journals included in the Thomson Reuters Web of Science (WoS) database and more (Gonzalez-Pereria,). According to the scholars, the SCOPUS has wider coverage of journals from developed and developing countries compared to another international multi-
disciplinary database World of Science (WoS). The use of SCOPUS is expected to generate a better picture than any other (Gupta 2012). According to Majhi and Maharana, “Since coverage of the database is wider than any other database, it goes back to the year 1823. So it can give a clear picture of the research productivity than any other online databases”. On this issue, Ravichandra Rao (1983) has stated that “if sufficient data has collected from machine readable database, results are much more reliable than otherwise.” ‘The SCOPUS has a relatively recent launch in the year 2002; its emergence has constituted competition for the WoS since it incorporates more services and data (Gonzalez-Pereria,).” The statements of various authors on SCOPUS database have been self-explanatory for selecting a data source for this study.

3.10: What is SCImago Journal Ranking (SJR)?

SCImago Journal Ranking (SJR) is a portal prepared by the ELSEVIER based on the information available in the SCOPUS. The SJR provides system computed journal, and country indicators came across in the study. So when a researcher working with SCOPUS data and s/he has to present the journal and country related indicators, the SJR is the only option for such indicators. The researcher has used SJR as a data source for the present study.

3.11: What is Demographic Yearbook (DYB): and why it has opted to use?

The Demographic Yearbook (DYB) is being published by the United Nations annually since 1948. The DYB is an international compendium of national demographic statistics, provided by national statistical authorities to the Statistics Division of the United Nations, Department of Economic and Social Affairs, United Nations, New York, US. For International demographic statistics, DYB is the, is the only authentic statistical data of its member countries in the world. The yearbook gives the unbroken series of demographic data published in a comparable format. The data is readily available for research purposes.

3.12: Tools and software

The researcher has used Microsoft Office Word 2007 for the text and tables, Microsoft Office Excel 2007 for statistical analysis and Microsoft Office Power-Point 2007 for the presentations. Easy availability of these software and their being user-friendly were the important features of MS-WORD, MS-POWERPOINT and MS Excel.
3.13: Coverage and Study Period

The geographic coverage of the present study is India. To compare Indian research output, the world level data regarding the records was the requirement for the present study. The records of scientifically and technically advanced countries have also been downloaded to assess the position of India in the world. The data has been collected for the duration of fifteen years (1999-2013). This period has been grouped into three equal blocks of five years each for the analysis. The three blocks have 1999-2003, 2004-2008, and 2009-2013.

3.14: Data Collection Method

The URL of the SCOPUS [www.scopus.com](http://www.scopus.com) was used to get access on internet explorer. From data search options, Advance Search was selected to prepare a query with Boolean search principle. To retrieve the publication data at world level, SUBAREA (ENVI) AND PUBYEAR> 1998 AND PUBYEAR< 2014 string has been given, it means, a subject collection of environmental science in the world published after 1998 and before 2014. The output of 12,36,114 records was downloaded in the form of refined tables on December 5, 2014 at 2.00 p.m. in MS Excel sheets.

3.15: Sampling Design Phase I: The sampling design has been divided into three phases:

3.15.1: World level records: The entire collection, irrespective of the type of sources, type of documents, geographical area, type of language for the period 1999-2013 published in the world and indexed in SCOPUS (12,35,114) records have been selected as a sample for world level analysis. The main focus of the study has been to analyze Indian research output and citations at Indian level. But the first analytical chapter (iv) of the study has been kept for comparison of Indian research output with the world exclusively for records.

From the refined table the following data has been used for comparative analysis:

- Number of Records.
- Year-wise records.
- Source-type-wise records.
- Country-wise records.
- Document type-wise records.
- Language-wise records.
- Author-wise records.


- Affiliation-wise records
- Source title-wise records.

The following variables (fields) from the refined tables have been used for analysis:

3.15.2: The Records

Number of records published on the subject of environmental science in the world during 1999–2013 (12,36,114) have been retrieved and used at world level analysis. The comparisons between world and India regarding the records, trends, growth, share of Indian records in the world and the Activity Index have been presented in the Table BC4.1 and supported by the graphical presentation. The following scientometric indicators have been used to compare the records:

(i) Activity Index = \( \frac{\text{Share of given field in the publication of given country}}{\text{Share of given field in the world total publications}} \)

Activity Index (AI) = \( \frac{(I_i / I_o) / (W_i / W_o))}{100} \)

Where 
\( I_i \) = Indian output in the year i
\( I_o \) = Total Indian output
\( W_i \) = World output in the year i
\( W_o \) = Total world output

(ii) \( PPR = \frac{\text{Population of a country in a specific year}}{\text{Number of records published in the same country in environmental science}} \)

3.15.3: Table Numbers

Serial numbers of tables have four parts clubbed together. The table number started with the alphabets either BC or C. Further, the table number has extended with a digit representing chapter number; decimal point, sub-chatper number and decimal point and ends with consecutive number represents the table number of a particular chapter and sub-chapter. All the tables in a particular chapter have been assigned consecutive numbers, and those numbers have been assigned a prefix decimal point. The alphabets BC represent for world level or International level data and the C represent country level data. Altogether Table BC 4.1.1 represents the world level data in Chapter 4 of subchapter one and it will be its first table in that particular chapter. This table may contains the world and Indian level data. Another example is Table C 4.3.1 representing the country level data (India), in Chapter 4, subchpater 3 and the first table. In this manner, all the tables in the study are arranged.
Chapter four sub chapter one is exclusively for the comparative analysis of Indian and world data, so the tables contained in Chapter 4 sub-chapter 1 start with BC and the the tables contained in rest of the subchapters such as 4.2, 4.3 and 4.4 start with the alphabet C followed by the consecutive table numbers with prefix of decimal point.

3.15.4: Graph Numbers

Every graph in the thesis has also contains four parts, a capital letter G representing the Graph, continued with a digit representing the chapter number, extended with a dot (.) and digit representing a sub-chapter number further extended with consecutive number of the graph in a particular chapter, for example, G4.1.2 means, the graph contained world level data in chapter four, sub-chapter one, the second graph of a particular subchapter.

3.15.5: Top countries in the world

Presentation of scientific papers of a particular country on a given subject in a defined period provides valuable inputs to assess the research activity performed by that country. The above inputs are useful to compare the research output within countries. From the sample, the top countries have been selected with criteria of minimum > 10000 records published in environmental science during the studied period. Based on the criteria, 30 countries are listed, and their relevant data have been used in the study. The indicator of scientific output has been correlated with other three indicators such as the first indicator is share of research output (in per cent) of the country. The second indicator has used the human population of a country and the third indicator Population Per Record (PPR) used for analysis. The human population of top countries has been taken as variable to present the environmental science research output. In this context, Bertrand and Cote (2006) stated, ‘Very populous countries tend to rank much lower while smaller countries move up in the ranking.’ The detailed presentation of the above indicators has been presented in TableBC4.2. Practically based on the human population (H-L), the top 30 countries have been arranged in ascending order of population and divided into three groups of ten countries each. In a similar manner, based on PPR, (L-H), all the countries have been listed and divided into three groups of ten countries each. With the use of an ordinal scale of measurement, each group has been compared with the other, and the results are presented in chapter four.
3.15.6: Position of India among top countries in the world

From the SCOPUS, top ten countries of every year have been taken and arranged in a column from top to bottom. Every year’s data has been added by columns of fifteen years and analyzed. The 15 X 10 table has been used to present Indian position regarding scientific research output among top ten countries in the world. The Table BC4.14 has mentioned the name of the country in each year at its ranking position. Table BC 4..5 has presented numerical data as a substitute for a particular country.

3.15.7: Source Type

The comparative statements of the source types have been presented in Table BC4.1.6 at world and country (India) levels, the following Source Types are presented and supported by the graph.

The order of source type has been maintained based on the number of records in descending order (H-L). Other source types related to indicators such as the number of records have presented in percentage to the world as well as at Indian level.

Source Types Selected for Analysis at World and Indian Level

<table>
<thead>
<tr>
<th>World</th>
<th>India</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Journal</td>
<td>1. Journal</td>
</tr>
<tr>
<td>6. Report</td>
<td></td>
</tr>
<tr>
<td>7. Undefined</td>
<td></td>
</tr>
</tbody>
</table>

3.15.8: Document Type

The document types have also compared to the world level as well as at Indian level. At world level data, the entire fifteen variables have used whereas at Indian level the eleven variables have used for analysis for the serial numbers 12-15 no records have found at Indian level. The distribution of records among fifteen variables, their ranking at world level and the distribution and ranking of the eleven variables at Indian level have presented. The percentage of each type of document have measured and presented to compare with each other at world level and also at Indian level. In addition to the analysis, the statistics in detail
have presented in Table BC 4.1.7 for reference and supported by the graph. The following variables have been used for presentation with actual records and the percentage at different levels:

**Document types selected for analysis at world and Indian levels**

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>World</th>
<th>India</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Article</td>
<td>Article</td>
</tr>
<tr>
<td>2.</td>
<td>Conference paper</td>
<td>Conference paper</td>
</tr>
<tr>
<td>3.</td>
<td>Review</td>
<td>Review</td>
</tr>
<tr>
<td>4.</td>
<td>Note</td>
<td>Book chapter</td>
</tr>
<tr>
<td>5.</td>
<td>Editorial</td>
<td>Note</td>
</tr>
<tr>
<td>6.</td>
<td>Book chapter</td>
<td>Editorial</td>
</tr>
<tr>
<td>7.</td>
<td>Short survey</td>
<td>Short survey</td>
</tr>
<tr>
<td>8.</td>
<td>Letter</td>
<td>Letter</td>
</tr>
<tr>
<td>9.</td>
<td>Erratum</td>
<td>Erratum</td>
</tr>
<tr>
<td>10.</td>
<td>Article in press</td>
<td>Article in press</td>
</tr>
<tr>
<td>11.</td>
<td>Book</td>
<td>Book</td>
</tr>
<tr>
<td>12.</td>
<td>Conference Review</td>
<td>-----</td>
</tr>
<tr>
<td>13.</td>
<td>Report</td>
<td>-----</td>
</tr>
<tr>
<td>14.</td>
<td>Business Article</td>
<td>-----</td>
</tr>
<tr>
<td>15.</td>
<td>Abstract report</td>
<td>-----</td>
</tr>
</tbody>
</table>

**3.15.9: Language-wise distribution of records**

At the world level, the 33 languages have been observed (Table BC4.1.8), and all of them have been considered in the study. Based on the number of records to rank them, percentages have been calculated and presented. At Indian level, no regional or even national language (Hindi) literature has been found, the entire literature is only in the English language.

**3.15.10: Prolific authors in the world**

The authors who have published more than 200 publications on the subject of environmental science in the world during 1999-2013 have considered as top authors at world level. In this study 32 such authors have been treated as top authors and the following seven indicators are presented in Table BC4.1.9 and analysed in the study.
1. Name of the author
2. Number of records
3. Affiliation of the author
4. Country
5. H-Index
6. Number of citations
7. Number of co-authors

3.15.11: Top Source Titles in the world

Based on the number of records, the source titles (journals) which published more than 5000 records during the studied period have been considered as top source titles (Table BC4.1.10) at world level. From the sample, 20 journals are found in this category, and the list of top 20 source titles and their seven indicators are presented in the study. The journal-related indicators of top source titles used in the study are as given below:

1. Name of the source title: Name of the journal.
2. Number of records: Number of records contained in the source title.
3. SCImago Journal Rank (SJR): SJR has weighted by the prestige of a journal. Subject field, quality and reputation of the journal have a direct effect on the value of citation. SJR is also normalized for the difference in citation behaviour between subject fields.
4. Impact Per Paper (IPP): The ratio of citations per article published in the journal.
5. Source Normalised Impact Per Paper (SNIP): It measures contextual citation impact by weighting citations based on the total number of citations in a subject field.
6. H-Index: It is based on a list of publications ranked in descending order by the number of citations these publications received. The value of h is equal to the number of papers (N) on the list that has N or More citations.
7. Place: Country of publication

3.15.12: Top Institutions in the World

The authors have affiliated themselves with organizations. In the database there is provision and the document published by the author has also been credited in the name of his/her affiliated Institution. The top affiliations in this study are the institutions that have more than 4,000 publications to their credit during 1999-2013. There were 32 organizations which are top affiliated institutions identified and selected for analyses. Name of institution, organization, number of records and country of institution are presented at world level in Table BC 4.1.11 of chapter four. At this stage, comparative statement of world level and
Indian level affiliated organizations would provide limited information. As a result, information regarding records has provided at world level, and the records that are citation related indicators are added and presented at Indian level in an independently at Table C 4.4.3 and analysed in the sub-chapter.

3.16: Sampling Design Phase II - Country (Indian) level records

The SCOPUS has a feature to filter the data by the author, source type, subject, language, year, etc., to get the proper data for research and country option India’ was selected from the filter menu. The list of 51,382 records appeared on the screen, but maximum visible records were 200 at a time. For the purpose of downloading, the maximum of 2000 records could be downloaded at a time. So the data was distributed year by year for the period of 1999-2013. For the period of 1999 – 2002, the records were less than 2000 per year. After 2002, the records were more than that per year. As a result, a different method was used to download the data. From the years 2003-2013, the data was divided into source type and downloaded within the range of downloading capacity. The same method has been adopted till the completion of the data of the year 2013. In the process, there was a possibility to select the fields of the records to be downloaded of which the following 13 fields have been selected most of them are used for analysis in the research.

**Bibliographical fields used for analysis**

<table>
<thead>
<tr>
<th>Sr. no.</th>
<th>Name of the fields</th>
<th>Sr. no.</th>
<th>Name of the field</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Author</td>
<td>2.</td>
<td>Title</td>
</tr>
<tr>
<td>3.</td>
<td>Year</td>
<td>4.</td>
<td>Source title</td>
</tr>
<tr>
<td>5.</td>
<td>Cited by</td>
<td>6.</td>
<td>Affiliation</td>
</tr>
<tr>
<td>7.</td>
<td>Page start</td>
<td>8.</td>
<td>Page end</td>
</tr>
<tr>
<td>9.</td>
<td>Authors with affiliation</td>
<td>10.</td>
<td>Author index</td>
</tr>
<tr>
<td>13.</td>
<td>References</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3.17: Authorship pattern

For the authorship pattern, requirement of the data was year-wise availability of the number of records and number of authors. The data was segregated by the share of contribution of a particular group of authors such as single author, two authors up to nine authors and rest of the authors grouped in more than ten authors. The third requirement was
a number of authors who contributed in each category of authorship pattern. The tables (C 4.2.1 to C 4.2.3) are used to analyze the authorship pattern and supported with Graph G 4.2.1. The distribution of records according to the number of authors in 10 groups from single authored to nine authored publications and ≥ ten authored publications are presented. Further, the year-wise break-up of the entire data is done and presented.

This has involved classification of all the records (51,382) which has been done on the basis of the number of authors. In the database the name of the author is separated with a semi-colon (;). Every author’s name (first, middle and last) is put in a single cell and measured as to how many records have found a single author, two authors, three authors and it has continued up to nine authors, the last category of authorship pattern was of ≥ ten authors.

3.17.1: Block wise authorship pattern

The duration of studied period 1999-2013 was divided into three equal blocks of five years i.e., 1999-2003 first block; 2004-2008 second block and 2009-2013 third block. Finally, to communicate the block summary the block of 15 years was considered in the study and presented. The block-wise information in tabular form has presented in Table C 4.2.4 and to support it the graphical presentation has given in Graph.

The following author-related scientometric indicators are used at this stage of the study

1. \( DC = \frac{NM}{NM+NS} \) Where \( DC \) = Degree of collaboration
   \( NM \) = Number of multi-authored papers
   \( NS \) = Number of single authored papers

2. Average number of authors \( AA = \frac{\text{Total number of papers}}{\text{Total number of authors}} \times 100 \)

3. Average number of papers per author \( AP = \frac{\text{Total Number of Authors}}{\text{Total Number of Papers}} \times 100 \)

4. Co-Authorship Index (CAI) \( = \{ (N_j/N_{io}) / (N_{nj}/N_{oo}) \} \times 100 \), where
   \( N_{ij} \) = number of papers having j co-authors in a particular block;
   \( N_{io} \) = total output in that particular block;
   \( N_{nj} \) = number of papers having j-authors for all blocks;
   \( N_{oo} \) = total output for India
   \( J = 1,2,3,4,5,6,7,8,9 \) and >10

5. Number of pages per author \( PA = \frac{\text{Number of pages}}{\text{Number of authors}} \)
3.17.2: Co-authorship Index (CAI)

In the study, the work has done by calculating the proportional output of a wide range of authors, i.e., single authored papers to ≥ 10 authored papers during different blocks (1999-2003, 2004-2008 and 2009-2013).

CAI = 100 indicates that co-authorship effort for a particular type of authorships corresponds to the Indian average. CAI > 100 indicates higher than average co-authorship efforts and CAI < 100 is lower than average co-authorship effort during a particular block of five years for a given type of authorship pattern. It has also presented in Table C 4.2.9 in detail.

3.17.3: Prolific Indian authors

The authors who have published more than 50 publications during 1999-2013 in environmental science have been listed and the following indicators of all the top authors are presented:

1. Name of author.
2. Number of publications.
3. Number of citations.
4. h-index.
5. Number of co-authors.
6. Affiliation of author.
7. Place of author.

Top world authors on the subject of environmental science have been analyzed in Chapter IV (i) and also presented in Table BC4.1.8 for comparison.

At India level, the criteria for selection of top authors have changed. The authors that have published more than 50 records are selected as top authors. Similar seven variables that have already used at world level have been used for Indian level top authors too. But there is an independent author related analysis has given in Chapter IV (ii) at Table C 4.2.10 at Indian level.
3.17.4: Mega-authored records and their impact

The mega-author records are considered for the record contributed by ten or more authors. It has been discovered from the database that many such mega-authored records and authors are found every year and what is the ratio with total authors and the records? The data is analyzed to find out the relationship of those mega-authored records and the citations received. How the citations are distributed within mega-authored items and how many items have received more than 100 citations? Is there any potentiality to pull the citations to the mega-author records?

3.18: Sampling Design Phase III: Citation Data (at Indian level)

Year-wise distribution of Records and the Citations: The ‘cited by’ was one of the fields downloaded along with all others. This field has been used to count the citations received to the records. There were 3,89,064 citations received for the 32,354 records out of 51,382 records. The statistical techniques like rate, average and percentage are presented (Table 4.3.1) in the context of the citations.

(i) Citation Rate (CR) \[ CR = \frac{\text{Number of papers having at least one citation}}{\text{Number of papers published}} \]

(ii) Not Cited Records (NCR) = Total Records – No of records received minimum one citation

(iii) Percentage of Not Cited Records (PNC)

\[ PNC = \frac{\text{No of papers published – No of papers, at least one citation}}{\text{Total number of papers published}} \times 100 \]

(iv) Average Citation Per Record (ACPP) = Number of Citations / Number of Records

3.18.1: Top cited publications

The publications which have received > 300 citations during the studied period are identified as top cited publications. The following details of such publications have been presented.

1. Name of the author (first author).
2. Year of publication.
3. Name of the journal.
4. Volume no. & issue no.
5. Number of citations.
6. Place of publication of the journal.
There were 21 top cited publications have been listed in Table C 4.3.2 and interpreted, answers:

1. Who was the author of top cited publication?
2. How many citations has he received for top publications?
3. What is the title of that particular publication?
4. In which journal, the top publication has been published?
5. The ranking of the top cited publications?

From the above data, five top cited publications and their characteristics have presented in graph G 4.3.3 to G 4.3.17 by the name of P1 to P5 and presented in Table C4.3.7 and also analysed in detail in Chapter IV (iii).

3.18.2: Citation frequency distribution

It is observed from other citation frequency studies (Garfield, 2005) that few number of citations received more records and higher number of citations received to fewer records. As per the requirement, to investigate the citation frequency distribution pattern, the entire records are categorized into 26 groups. The year-wise distribution of the data has been initiated for a group of records of ‘not cited.’ The second group of records received one citation and their year wise distribution, the third group received two to four and their year wise distribution are done. The work has continued further to the year-wise distribution of the fourth group of records which received five to nine citations followed by the fifth group of records which received 10 to 14 citations. As work proceeds, units in the group have increased as compared with the previous group. The year-wise distribution of the sixth group of records received 15-25 citations followed by the seventh group of records which received 26-50 citations and the eighth group of records which received 51-75 and the ninth group of records received 76-99 citations. From the tenth group onwards the frequency has changed with a group of 50 citations up to 900 citations. More specifically, the following groups have been used to distribute the citation data: A group of 0 (zero) citation, a group of 1 citation, a group of 2-4 citations, 5-9, 10-14, 15-25, 26-50, 51-75, 76-99. Thereafter 100-149, 150-199, 200-249, 250-399, 400-449, 500-549, 550-599, 600-649, 650-699, 700-749, 750-799, 800-849, 850-899 and the last group of > 900 citations. The citation frequency in India has presented in Table C 4.3.8 of Chapter IV (iii).
3.19: Domain-wise distribution of records and the citations

The SCImago Journal Ranking (SJR) has categorized the subject of environmental science into the following twelve categories:

**Domains of Environmental Science**

1. Ecological Modeling
2. Ecology
3. Environmental Chemistry
4. Environmental Engineering
5. Environmental Science (Miscellaneous)
6. Global and Planetary Change
7. Health, Toxicology and Mutagenesis
8. Management, Monitoring, Policy and Law
10. Pollution
11. Waste Management and Disposal
12. Water Science and Technology

Out of the 51,382 records (excluding 37 per cent not cited), 63 per cent records have received 3,89,064 citations. The records and citations their percentage and the Average Citation Per Paper (ACPP) are distributed into twelve sub-categories in the study. It was helpful to identify the thirst, prolific and average sub-categories (domains) for the subject of environmental science in India during 1999-2013. In this part of research each domain is assessed with three ranking positions and presented, i.e., record-based ranking, citation-base ranking, and ACCP-based ranking. The facts have presented in Table C 4.4.1 of Cha. IV (iv).

3.19.1: Special focus on the domain of health, toxicology and mutagenesis

Environmental degradation creates an adverse effect on society (public health). As stated in the introductory chapter, the Indian population has exponential growth and growing population needs more food, goods and services for the survival of growing population. The development has an excessive utilization of resources which results in environmental degradation, affecting public health.

The researcher has purposely included this part in research for the investigation of publications which contribute towards the health-related domain, Health, Toxicology and
Mutagenesis and also the citations received to the above records during the studied period. The Table C 4.4.2 and Graph G 4.4.2 reveal the trends of research output and also the citations for the duration of 1999-2013. The trends have been compared with total research output and the total citations of environmental science research in India. The share of records and the percentage of records and citations have been presented in the research.

The main ranking was considered regarding a number of records (H-L) and accordingly all other indicators have been presented with their ranking in the table.

3.20: Application of Bradford’s Law of Scattering

This law is applied to find out core journals of a specific subject based on the citations. This work will be useful for the development of libraries working on the subject of environmental science and also for researchers for the selection of appropriate information sources for research and reference.

The Law has been applied to the data and a list of 15 source titles has been discovered as core journals of environmental science. Along with each title, important indicators such as the number of articles contained in the journal, SCImago Journal Ranking (SJR), the h-index, Source Normalised Impact Per Paper (SNIP), Impact Per Paper (IPP) and country of publication are presented in this part of the study. The list of journals and relevant information has been presented in table C 4.3.9 of Chapter IV (iii).

3.21: Application of the 80/20 Rule to the citation data

The entire records 51382 have arranged in ascending order of the number of citations they received (H-L) during the study period. About 20 percent records (51382/100 *20 = 10273) from top have taken and citations received to those records have counted, it has measured 315382 about 81 percent of the total citations. The 80/20 rule has matched with minor variation of one percent i.e. 81 percent of use has derived from 20 percent of the titles in environmental science research in India. According to the researcher, the additional one percent of use may be due to the interdisciplinary nature of the subject of environmental science research. The researcher has also analysed the characteristics of top cited publications and found that about nineteen subjects (other than environmental science) have cited to the collection of the environmental science, that effect could be on the additional one per cent citations to the 20 percent records.
3.22: Application of the 80/20 Rule on Journal Articles

The 80/20 rule has also applied to journal article data and presented. The source titles (journals and their number of articles) have already counted at the time of the application of Bradford’s Law of Scattering. The data shows that the collection of articles (44,145) has distributed into 1,028 journals. All the journals have arranged based on the number of articles (H to L). The 20 per cent (1028/100*20) 205 journals have selected and separated from top. The number of articles contained in the selected top 205 journals have counted and presented in table C 4.3.10 in third part of chapter IV.

3.23: Growth of records, authors, pages, references and effect on citations

At the Indian level, the following variables have been distributed by year (1999-2013) and presented the growth of all the variables (Table C 4.3.11) and also supported by graph.

1. Number of records. 2. Number of authors.
3. Number of pages. 4. Number of References.
5. Number of citations.

(i) Records: The database is capable of providing desired results (records) in the desired format in order of consecutive serial numbers. The total number of records have been divided into years of the studied period and used the data for analysis.

(ii) Authors: Classification of all the records (51,382) has been done based on the number of authors.

Data structure in the database: In the author field of the database, the name of the author has been separated with a semi-colon (;). With the help of semi-colon every author’s name (first, middle and last name) has been put in a single cell and measured, how many records were of a single author, two authors, three authors and it was continued up to the maximum authors. All the authors have been measured for analysis.

(iii) Pages: The database provides two options to take the measurement of this field- (i) page start and (ii) page end. Based on these two fields, the number of pages has been calculated and analyzed in the study. The method of measurement of pages has been: (Number of pages = page end – page start).
(iv) **References:** The reference data been has analyzed in the research. The data structure in the SCOPUS database has been observed as the author. For the purposes of research, the reference data has been taken by using the method as it has been used for author data.

(v) **Citations:** There is an independent field in the database as ‘cited by.’ This provides sum of the citations received by that particular record. This field has been used to measure the number of citations and analyzed.

(vi) **Growth:** It has been calculated for records, authors, pages, references and citations.

(Table C 4.3.12) Three types of growth are presented as given below:

1. **Annual Growth Rate (GR)**  
   \[ GR = \frac{\text{Current year total} - \text{Previous year total}}{\text{Previous year total}} \times 100 \]

2. **Average Growth Rate (AGR)**  
   \[ AGR = \frac{\text{Current 5 Year Total} - \text{Previous 5 Year Total}}{\text{Previous 5 Year Total}} \times 100 \div \text{Number of years} \]

   To present the Average Growth Rate, three blocks of five years, namely, the first five-year block (1999-2003), second five-year block (2004-2008) and the third five-year block (2009-2013) have been used. The first five-year block of 1999-2003 has been used here as a base period block to calculate the growth rate.

3. **Annual Average Growth Rate (AAGR)**  
   \[ AAGR = \frac{\text{Growth Rate in Period A} + \text{Growth Rate in Period B}}{\text{Number of Periods}} \times 100 \]

3.24: **Top fifty Institutions in India and their specialization**

Based on the records published on environmental science research in India during 1999-2013, the list of top institutions have been presented in the descending order (H – L) of publications. The following data regarding the top institutions are included for analysis.

1. Name of the affiliated organization.
2. Number of records.
3. Number of citations.
4. Number of not cited records.
5. Percentage of not cited records.
6. Average citations per paper.
With the help of above mentioned six variables the top 50 institutions have been analyzed. The first three variables have been used to find out the specialization of the affiliations in the following way:

1. Converted the source titles of the records into domains from SJR Report.
2. SD1 = Specialized Subject Domain one (domain having highest number of journals).
3. Identified top cited source titles/journals of each organization.
4. Domain of highly cited source title (SJR) upper quartile.

Under each domain (1-12) publication-based specializations have been identified and presented in the list. Maximum citations received domain has been assigned to the organization as its specialization. It has been observed that some of the organizations have been listed in top 50 based on the number of records but do not receive single citation during the studied period. Such affiliations are assigned subject domain one only. The citations received database has also used in the similar manner and two specializations have presented for each of the institution. The domain-wise lists of specialised institutions have been presented in Table C4.4.3 of the thesis.

3.25: Thesis organisation

The thesis will have five chapters, including the fifth chapter for findings. The preliminary pages will be as per Research Manual of the Tata Institute of Social Sciences, Mumbai.

CHAPTER I: Introduction
CHAPTER II: Review of Literature
CHAPTER III: Research Methodology and Design
CHAPTER IV: Analysis and Interpretation of data
   IV (i) : Comparison of Indian Research Records with the World Record
   IV (ii) : Authorship Pattern in Environmental Science Research in India
   IV (iii) : Citation Analysis
   IV (iv) : Domain-wise distribution of Records and Citations
CHAPTER V: FINDINGS
   GLOSSARY
   BIBLIOGRAPHY