Project Completion Report

Design of a Computational Framework for Discipline-wise and Thematic Mapping of Research Performance of Indian Higher Educational Institutions

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About NSTMIS:

The National Science and Technology Management Information System (NSTMIS), a division of the Department of Science and Technology (DST) has been entrusted with the task of building the information base on a continuous basis on resources devoted to scientific and technological activities for policy planning in the country.

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Disclaimer:

Every care has been taken to provide the authenticated information. However, the onus of authenticity of data rests with the PI of the project.

Preface

This report presents the design, observations and outcomes of the research study instituted by the NSTMIS Division of the Department of Science & Technology, Ministry of Science & Technology, Government of India and executed at the Department of Computer Science in Banaras Hindu University.

The report focuses on assessment of research output of Indian Higher Education Institutions (including research intensive institutions) in various subject and thematic areas. A computational framework is developed for mapping research competencies of Indian institutions in specific thematic areas and to assess their overall thematic research strength in the given area. A new measure called x-index is proposed and demonstrated. The computational framework designed, and the data analysed is also used to create a web portal called Indian Science Reports hosted at www.indianscience.net.

In addition, a set of supporting annexures are attached to demonstrate the various outputs and deliverables of the project. The report is organised into six chapters covering the various components of the study. An Executive summary in the beginning of the report presents a quick but detailed outline of the report and a Research summary provides a summary of project outcomes and deliverables.

The first chapter covers the background, motivation, key objectives and the limitations of the study. It has explored the existing ranking frameworks in order to draw from the gaps in the university ranking frameworks.

In the second chapter, the review of the literature on the research performance assessment and ranking of higher education and research institutions is covered.

Following the literature review and understanding of existing ranking frameworks, the methodology for the study is presented in the third chapter. This chapter presents insights into the sampling design, data sources, tools for data analysis and visualisation used in the study.

Chapter four contains the description of data and data analysis results obtained. This includes the description of data from Web of Science and Dimensions databases, its analysis and development of institutional performance reports.

Chapter five presents the results and discussion from the study. This chapter contains a descriptive account of India's scientific output, and institutional performance reports presented on the web portal (Indian Science Reports).

Chapter six contains the findings, summary of results and recommendations for future work and policy purposes.

Acknowledgements

The Project Investigator and the Project Team extend their gratitude towards the members of the assessment committee for their valuable inputs and guidance during the term of the project. The team thanks the Department of Science and Technology (DST)-NSTMIS division for providing the financial support to undertake this project.

The project team also acknowledges the data sources used in the study, these include, Dimensions and Web of Science databases for Publication Metadata, Altmetrics for Social media trends in research, Gender API for determining the gender of authors of the publications, Wikipedia and University websites for other external information on universities and media files.

Indian Science Reports (ISR) Team consisted of Prof. Vivek Kumar Singh, Ms. Prashasti Singh, Ms. Mousumi Karmarkar, Mr. Abhirup Nandy, Mr. Aakash Singh, Mr. Satya Swarup Srichandan Dr. Hiran H. Lathabai, and Dr. Anurag Kanaujia.

The project was carried out at the Department of Computer Science, Banaras Hindu University which supported the project with infrastructural and administrative support.

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Executive Summary

This NSTMIS supported project entitled *Design of a Computational Framework for Discipline-wise and Thematic Mapping of Research Performance of Indian Higher Educational Institutions*, has been carried out during the period of 2020-2022. The project has been undertaken at the Department of Computer Science, Banaras Hindu University, Varanasi, Uttar Pradesh.

It had been motivated by the observation that the existing university ranking frameworks provide a broad indicator-based overview of higher education institutions, formulated with a commercial perspective. The requirement of a detailed information platform for research, development and education institutions has been felt by the scientometrics community in India. This study has attempted to fill this gap by developing a framework and a platform for collecting, computing and providing information on some of the specific indicators of research activity. Using the publication data of Indian institutions, a web-based portal for documenting and disseminating results from the computation of indicators on the research performance of selected institutions has been developed and hosted.

The outcomes from the study can be beneficial for various stakeholders, namely, researchers, policy makers, ranking agencies, students and the general public. It will augment existing ranking platforms, and Higher Education Institutions (HEI) listings (such as NIRF, DST India Science and Technology Portal), by providing institution specific indicators of scientific performance. The portal developed under this project will provide assistance to prospective research students in finding best research places on specific topics of interest; ranking agencies (national and international) as it will enable them to find top performing institutions on a specific research topic, as the research performance parameters computed on the detailed topics can be used to identify best research places/ institutions in a specific area and also produce discipline-wise rankings of Indian Institutions.

This project aims to meet the gap of design of "an accurate article-level fine-grained thematic area classification system" and propose applications by utilizing this knowledge. The project has led to the formulation of: (a) an article-level classification methodology, (b) an automated web-based computational system for research performance assessment, (c) Research Papers and technical reports, and (d) Research Performance assessment reports of 1000 Indian institutions. The project has produced technical reports, a website and other documentary output. The project team also aspires to utilise available computational tools for translation and make all project outputs available in Hindi language too in future.

The project has been completed in two stages. The first stage involved the development of a new computational framework for assessment of thematic performance of institutions on the basis of sample data from the Web of Science Database. Two indices to rank the institutions, named x-index and x(g)-index were developed for this purpose. The working of this framework was demonstrated using data of 195 Indian institutions in the area of Computer Science. IIT Kharagpur and Thapar institute of engineering and technology had highest x-index and x(g)-index, and were placed on the top most position. Thematic research strengths and core competencies of the 195 institutions were also identified.

In the second stage of the project, the study covered data from all the disciplines indexed on the Dimensions database for a period of 10 years. The access to the database was acquired by using Dimension's API. A total of 1000 Indian organisations (Higher Education Institutions, Government hospitals and laboratories, and R&D firms) were assessed under the project. Detailed reports on scientific productivity of India and the performance of selected 1000 Indian Institutions were developed using the conceptual framework. These reports were thereafter used to show visualisations on the web portal.

India's research output was also mapped and compared with some of the leading countries in S&T research. Indian Research Output in the 2010 to 2019 period grew from 60,250 to 148,724 publications and it moved from 10th to 6th position in terms of global productivity. The publications during this period had received a total of 11,805,480 citations. It was observed that India's contribution to the top 1% of highly cited papers has grown from 1.85% in 2010 to 4.3% in 2019. Comparatively, the top contributions were from China (33.2%) and U.S. (36.96%). The subject wise output was also estimated for 22 major subjects. The overall research output is dominated by publications in subjects like Medical & Health Sciences, Engineering, Chemical Sciences and Information & Computing Sciences. Approximately 20% of the research output involved collaboration at international level. United States of America (33.09%), United Kingdom (12.42%), Germany (9.19%), China (8.87%), South Korea (7.72%) and Australia (7.06%) were the major contributing partner countries. These publications also received higher citations at 18.65 (average citations per paper) compared to domestic papers at 7.95. The volume of research funding to Indian Institutions was estimated as 4.6 billion USD, placing India at the 15th spot in terms of research grants. It is about 100 orders of magnitude lesser as compared to the United States, and 27 times less as compared to the United Kingdom and Germany.

It was observed that only 29.3% of Indian papers are Female 1st authored, as compared to 70.7% Male 1st authored papers. Subject areas like History & Archaeology, Built Environment & Design and Law & Legal studies have a slightly higher percentage of Female 1st authored papers. India is placed on the Lower side of Open Access availability level, with only 33.61% papers available in Open Access. Out of the total funded research output during 2010-2019, 71% is Closed Access, 12% Gold Open Access, 9% Green Open Access, 5% Bronze Open Access and 3% Hybrid Open Access. The social media coverage of a research output in different subject areas vary significantly, ranging from coverage percentage of 40.18% for Biological Sciences, to 9.47% in Information & Computing Sciences. It is observed that out of the total research output in 2010, 13.7% of the research output gets some social media attention. This level has continuously increased during the period, reaching to 25.2% in 2017 and settling down to 23.3% in 2019.

The study has developed a thematic-area based article classification system; a set of detailed reports on research performance of Indian Higher Education Institutions in different detailed topics; and a fully automated web-based portal for documenting and disseminating results from the computation of indicators on the research performance of selected institutions. These outputs in addition to being useful research and consultation tools for the various stakeholders also provide a proof of concept for the possibility of a larger national information platform with granular information about the research and development. It has the following direct benefits.

1. A fully automated Web-based portal for disseminating results about computed indicators of different institutions.
2. The results generated from the study can be of great interest to ranking agencies, national and International, as it would allow them to find top performing institutions on a specific research topic.
3. Help prospective research students in finding best research places on specific topics of interest.
4. The results also provide a mechanism for institutional collaboration recommendation.
5. Produced reports and documents on research performance of Indian Institutions, something which was largely missing till date.

This project is novel in many respects with many interesting outputs and benefits. However, at the moment, the project is limited to data of Indian research Institutions only. Though the developed system has the capability of seamless extension to data for the whole world, currently only data for Indian institutions has been populated. Collection of full data for the whole world will take a lot of effort and huge memory requirements will be there. However, it is proposed to cover the data for the whole world as a future extension of the project.

Chapter 1

Introduction, Objectives, Limitations

This chapter covers the background, motivation, key objectives and the limitations of the study. This study is an exercise in designing an expertise mapping framework which can be useful for assessment of the research and development activities and the resulting outputs from them. This chapter looks at some of the importance of performance assessment and the use of performance indicators for these purposes. Existing university ranking frameworks are explored in order to draw from the gaps in these frameworks for the refinement of the project objectives. It presents the specific objectives of the study and its motivation. The study is limited by the number of variables which are considered for assessment and further work is required to develop a more robust methodology.

Background of the project

Assessment of institutional performance has an instrumental role in the current education and research ecosystem. Stakeholders rely on various available measures of institutional performance for purposes of decision making in varied situations. For instance, students refer to the ranking when choosing their study destinations, researchers for possible future collaborations, and governance and funding agencies in order to choose financial support to the institutions and their research and development activities. Scientific performance is a multidimensional process with several different facets. In the past few decades, the aspects of research performance assessment, institutional rankings, policy implication studies and other topics of societal implication of Scientometrics have drawn the attention of researchers in the area of Scientometrics and Informetrics, who have contributed to this purpose through the development of measures for quantitative aspects of scientific research activities. However, traditional research performance assessment exercises are based either on overall performance of institutions or in some broad categories (say Arts & Humanities, Social Science, Science etc.). While, for purposes of evaluation it is sometimes required by administrators or directors of institutions that the institutions be arranged in order of merit in a ranked list. This requires the creation of composite indicators based on measurable parameters (Vinkler 2006; Torres Salinas et al. 2011) which reflect merit in accordance with human judgement. Traditionally, this STI data is collected by international agencies, such as OECD, World Bank, United Nations etc. OECD's STI statistics (https://www.oecd.org/innovation/inno/stistatistics.htm), provides country specific information on the STI indicators related to Human and financial resources devoted to R&D. These indicators are provided at a country level and do not provide the finer details for each country i.e., at the level of institutions, or even the research focus and activity areas of a country. Another popular platform is a web application called Excellence Maps (https://www.excellencemapping.net/), which is developed with the aim to visualise the performance of universities and research institutions on an overall level and in some selected subject areas. This application uses publication data available from Scopus in order to rank the institutions on the basis of their performance. The platform, however, uses four variables only, including proportion of papers from one institution and three non-S&T indicators (Bornmann,

et al., 2014). The research done at the national level is largely left out of the assessment criteria in both the platforms.

Ranking platforms such as the Global Innovativeness Index (https://www.wipo.int/global_innovation_index/en/), Times Higher Education (THE) University rankings (https://www.timeshighereducation.com/), Academic Ranking of World Universities and Quacquarelli Symonds (QS) World University Rankings (https://www.topuniversities.com/), Centre for Science and Technology Studies (CWTS) Leiden Rankings (https://www.leidenranking.com/) have also been using various strategies for measurement of organisational performance of universities, research institutions and other higher education institutions. However, most of these platforms/ portals provide limited data analytics and often suffer from underrepresentation of institutions in developing countries like India. Recently, few international rankings have introduced discipline-specific rankings wherein they provide ranking on research performance of institutions in some broader disciplinary categories.

Subject classification of an article being used currently

Most of the academic databases like Web of Science, Scopus, Dimensions, Academic Search (EBSCO), JSTOR, SciELO, etc., maintain information about research articles published in journals indexed by them and this indexing is dependent on factors such as journal quality, publication scope, editorial board and policies, level of publishing professionalization, archiving policy etc[1]. Depending on the changes that happen to the journals and the level of the change which is reflected in the indexing databases, the indexed properties of the journals in databases also get modified. It is found that most of the databases assign an article a subject category based on the journal (which in turn is determined by the interest and focus of the editorial board) it is published in (for instance, WoS has about 250+ subject categories[2]). This practice of indexing databases is not the best practice because the changes in journal's characteristics affect article's classification also. It may be better if some basic information from the article text (such as title, abstract, keywords etc.) can be used for the purpose. This would not only significantly improve the article classification but will also help in any consequent subject/ discipline-wise analysis. Some of the previous works in this direction are discussed here; a more detailed discussion can be found in chapter 2.

A three-step methodology that involved in creation of citation networks of publications, clustering and assigning a cluster label by Waltman and Eck (2012) and journal level classification (Zhang et al. 2010; Janssens et al. 2009; Rafols and Leydesdorff, 2009), DBLP (DataBase systems and Logic Programming) publication classification using concept lattices (Alwahaishi et al., 2011), subject clustering analysis based on Clarivate WOS' subject category classification (Zhang et al., 2010) are some of the approaches used in existing studies. Other than these, a hybrid text/citation-based method to cluster journals covered by the WoS database, content-based and algorithmic classification of journals, automated subject

[1] Journal Indexing: Core standards and why they matter | Impact of Social Sciences (lse.ac.uk)

[2] Web of Science: List of Subject Classifications for All Databases (clarivate.com)

classification of textual Web pages, etc., are also there. Most of this previous work however did not deal with a fine-grained thematic area classification, something which we need for our thematic area classification task. Few other previous works (Singh et al. 2015; Gupta et al. 2011) tried a fine-grained classification of CS domain research output in different thematic areas. The thematic areas in these works, however, are not well distinguished and exhaustive.

Challenges in developing the topic-based classification system

As discussed earlier, the current subject classification schemes are limited to classifying research articles into a broad discipline (say Physics or Chemistry etc.) and not into fine-grained (specific) thematic areas (sub-disciplines of a subject). Therefore, at the moment any research performance assessment exercise done subject-wise can only tell which institutions are doing good in a given discipline. In case we need to know the best research places on a specific topic (say Nanotechnology or NMR), it is not possible with the current state of the art. This is the gap we are attempting to address with the proposed approach. Recently some databases (for eg., Dimensions Field of Research[3]) have started using classification systems based on the content of research articles. This goal, however, has its own challenges. It requires automated processing of a large amount of data of articles. Fortunately, the current state of the art in Machine Learning, especially NLP and the readily available computing power makes it addressable. In this study, we are trying to explore this potential of NLP for addressing the identified gap in combination with an efficient and established network Scientometrics approach.

Proposed Work

The existing scheme of subject classification of an article is based on publication source (the journal in which it is published). The text matter of the research article is not used to identify its subject area. For example, given two research articles, one on NMR and other on Nanotechnology, they will both be classified to belong to Physics, if the publications source belongs to Physics. There exists no way to differentiate between these two articles taking into account the topic covered in them. Design of an article-level subject classification system is therefore an important requirement. It is however only possible by following a computational approach and appropriate machine learning techniques. Fortunately, the state of the art in computational sciences allows us to design such computational frameworks. One early example of such systems is a Sciento-text system developed by Uddin et al. (2016). The system allows to assess research strengths of institutions at finer thematic area level and accordingly identify top performing institutions on any topic (say Nanotechnology, Molecular Biology or Spectroscopy etc.).

Objectives

This project has tried to meet the gap of design of an accurate article-level fine-grained thematic area classification system and propose applications by utilizing this knowledge. The expected project deliverables will include: (a) an article-level classification methodology, (b) an

[3] Browse Fields of Research for Publications - Dimensions

automated web-based computational system for research performance assessment, (c) Research Papers and technical reports, and (d) Research Performance assessment reports of Indian institutions. The project will aim to produce technical reports, website and other documentary output in Hindi language as well. It will be our effort to make all project outputs available in both English and Hindi languages.

The project aims to design and implement a new computational framework for classification of research articles into fine-grained thematic areas (topics) by processing its textual content and using this knowledge for discipline-specific research performance assessment of Higher Education Institutions (HEIs). The broad objectives can be summarized as follows:

- To design a computational framework for thematic area-based classification/ tagging of research articles,
- To develop an automated system for research performance assessment of Indian HEIs in different research themes/ topics,
- To identify top performing research centres/ groups in a specific thematic area/ topic, and
- To produce outputs in the form of research papers, technical reports and web-based documents on topic-based research performance assessment of Indian institutions.

This finer thematic area classification model can be used not only for discipline-specific research performance assessment but also for other applied tasks like: (a) finding best research centres/ places in a specific topic, (b) finding most productive researchers in a specific thematic area, and (c) finding best journals for reporting results in a specific topic. Some direct applications may include finding reviewers for grant applications on a topic or finding best research places in an area. The theme specific thrust area-based funding decisions can also use the developed method. The developed system is thus expected to garner a varied user base including researchers, policy makers as well as students.

Chapter 2

Review of Literature

This chapter contains the review of the literature on the research performance assessment and ranking of higher education and research institutions. During the last few decades, the prominence and use of ranking frameworks has gained importance due to the ease of assessment it provides. Ranking frameworks such as ARWU, Leiden, THE, QS, Shanghai, URAP have developed different methodologies and become popular among the stakeholders. These however are disproportionate in representing institutions from developing countries and hence are of limited relevance to them. The local ranking systems such as NIRF in India are being developed based on similar overall performance parameters.

Introduction

The researchers in the area of Scientometrics and Informetrics have been working on several important aspects of scientific productivity. Research performance assessment, Institutional rankings based on performance, policy and other societal implications have active scholarship in the past few decades. This project deals primarily with two aspects of the discipline, namely, development of a method for classification of research publication according to specific subject/thematic areas, and assessment of research performance of institutions in the selected thematic areas. For this purpose, it is important to first understand the existing systems of thematic classification and performance ranking and draw from the observations to improve upon them. In the following sections, previous work done by researchers in these two areas is presented and analysed, providing a summary of the state of art in them. Thereafter, a short proposal about the direction for the research paper is presented.

Subject/ thematic classifications

The academic databases (Web of Science, Scopus, Dimensions, Academic Search (EBSCO), JSTOR, SciELO etc.) maintain information about research articles published in journals indexed by them. This indexing is dependent on factors such as journal quality, publication scope, editorial board and policies, Level of publishing professionalization, archiving policy etc[4]. As journals get upgraded or downgraded in scientific indexing (SCI, eSCI, Scopus, SSCI etc.) the database indexes are updated and improved. These also categorise journal articles based on subject categories assigned to the journals by their editors (for instance, WoS has about 250+ subject categories[5]). Most of the databases, however, assign an article a subject category based on the journal it is published in. This is truly not the best way to assign a subject category to a research article. It may be better if some basic information from the article text (such as title, abstract, keywords etc.) can be used for the purpose. This would not only significantly improve the article classification but will also help in any consequent subject/

[4] Journal Indexing: Core standards and why they matter | Impact of Social Sciences (lse.ac.uk)

[5] Web of Science: List of Subject Classifications for All Databases (clarivate.com)

discipline-wise analysis. Recently some databases (for e.g., Dimensions Field of Research[6]) have started using classification systems based on the content of research articles. This goal, however, has its own challenges. It requires automated processing of a large amount of data of articles. Fortunately, the current state of the art in Machine Learning and the readily available computing power makes it possible. In the next paragraph we look at some past works that have somewhat similar subject classification goals.

Some of the previous works have performed individual level classification (Waltman and Eck 2012) and journal level classification (Alwahaishi et al. 2011; Zhang et al. 2010; Janssens et al. 2009; Rafols and Leydesdorff, 2009). Waltman and Eck (2012) proposed a three-step methodology for constructing a publication-level classification system of science. This involves determining the relatedness of publications based on direct citation relations between publications, clustering publications into research areas and labelling research areas based on the information in titles and abstracts. The study by Alwahaishi et al. (2011) did an analysis of the DBLP publication classification using concept lattices. Here a journal is represented as a list of topics and the topics are the disciplines being covered by all journals, based on the extracted data from their aims and scopes. Zhang et al. (2010) implemented subject clustering analysis based on International Scientific Indexing (ISI) category classification (Web of Science subject categories). The study focused on the analysis of the information flow among the ISI subject categories and aimed at finding an appropriate field structure of the WoS using the subject clustering algorithm. Unlike the other studies, Janssens et al. (2009) used a hybrid text/citation-based method to cluster journals covered by the WoS database. Rafols and Leydesdorff (2009) proposed a content-based and algorithmic classification of journals. In another somewhat related work, Golub (2006) used an automated subject classification of textual Web pages, based on a controlled vocabulary, something conceptually similar to our proposal. Most of this previous work however did not deal with a fine-grained thematic area classification, something which we need for our thematic area classification task. Few other previous works (Singh et al. 2015; Gupta et al. 2011) tried a fine-grained classification of CS domain research output in different thematic areas. The thematic areas in these works, however, are not well distinguished and exhaustive.

Popular Institutional Ranking systems

Research performance assessment has remained a key objective in Scientometrics. Different ranking or assessment exercises use data from different sources and sometimes use different academic databases too. Several agencies in the world are now interested in research performance assessment of institutions across the world.

Methodologies used by popular ranking systems

The *Academic Ranking of World Universities (ARWU)* considers the number of Nobel prizes, Fields medals, highly cited researchers variables which are relevant mainly for some prestigious universities. In fact, in the ARWU ranking, the top 500 institutions are found in

[6] Browse Fields of Research for Publications - Dimensions

only 35 countries. In the initial exercise of the Shanghai ranking, *only 3 institutions from India found a place in the list* (Liu et al., 2005). ARWU considers over 1000 institutions and produces a list of 500. Recently, Subject-based rankings have also been introduced in ARWU based on broad subject categories of Web of Science data. Thematic area-based rankings are still not there. However, at the moment overall rankings of ARWU are being popularly used.

The *Leiden Ranking* is another exercise based exclusively on bibliometric indicators and uses field normalization and normalization with respect to year. The Leiden Ranking uses papers, citations and collaboration, and offers separate ranked lists for each of these. It offers both size-dependent and size independent ranking based on different criteria (Waltman and Van Eck, 2012; Waltman et al., 2012). When it comes to Indian institutions, *only four institutions appear in the recent Leiden ranking*. This ranking is also not producing any thematic area-wise maps of research.

The *Webometrics* or Web Ranking is based entirely on Web visibility (Aguillo et al., 2008).

Since 2009, *SCIMago Institution Ranking (SIR)* has been publishing ranks for worldwide institutes based on different research indicators such as research output, international collaboration and impact etc. from the Scopus database. This ranking is published by a group of researchers in a Spain-based research organization, consisting of researchers from different institutions such as University of Granada, Spanish National Research Council (CSIC), Charles III University of Madrid. At present SCIMago ranks over 5000 institutions. However, access to the results are not easily obtainable, and this too does not provide any thematic area-based research performance assessment.

The *Times Higher Education* and *QS* Ranking use other data on internationalization and reputation surveys as part of the ranking exercise, which would need time-consuming and expensive surveys. They both use perceptual scores, which in addition to being highly subjective are not necessarily representative of demographic and cultural variations of responders.

A relatively recent entrant into the global ranking exercises is *URAP*, which was started in 2009 in Turkey. *University Ranking by Academic Performance (URAP)* Research Laboratory was established at Informatics Institute of Middle East Technical University in 2009. The main objective of URAP was to develop a ranking system for the world universities based on academic performance determined by quality and quantity of scholarly publications. Its coverage is much larger than the earlier ranking and it also offers assessment on some broad subject categories but not on thematic areas.

Some of the published works which try to assess the ranking systems and also suggest alternative methods and improvements for ranking research competence of institutions. Some of these exercises include Jeremic et al. (2011), Molinari and Molinari (2008), Garcı´a et al. (2012), Matthews (2012), Geraci and Esposti (2011), Lazaridis (2010), Liu and Liu (2005), Billaut et al. (2010) and Torres Salinas et al. (2011). Despite the above mentioned and other

studies, the problem of developing countries whose universities do not find representation in the global ranking exercises has not been given enough attention. Further, there is very little attempt made to do research performance assessment at finer granular level of thematic areas.

Ranking platforms such as the Global Innovativeness Index (https://www.wipo.int/global_innovation_index/en/), Times Higher Education (THE) University rankings (https://www.timeshighereducation.com/), Academic Ranking of World Universities and Quacquarelli Symonds (QS) World University Rankings (https://www.topuniversities.com/), Centre for Science and Technology Studies (CWTS) Leiden Rankings (https://www.leidenranking.com/) have also been using various strategies for measurement of organisational performance of universities, research institutions and other higher education institutions. However, most of these platforms/ portals provide limited data analytics and often suffer from underrepresentation of institutions in developing countries like India. Recently, few international rankings have introduced discipline-specific rankings wherein they provide ranking on research performance of institutions in some broader disciplinary categories. However, the current subject classification schemes are limited to classifying research articles into a broad discipline (say Physics or Chemistry etc.) and not into fine-grained (specific) thematic areas (sub-disciplines of a subject). Therefore, at the moment any research performance assessment exercise done subject-wise can only tell which institutions are doing good in a given discipline. In case we need to know the best research places on a specific topic (say Nanotechnology or NMR), it is not possible with the current state of the art.

Designing the framework for identification of thematic areas and assessment of research performance

To identify thematic areas in a discipline is a difficult task and requires proper understanding of the domain as well as a system to map research papers in different thematic areas. A suitable machine learning algorithm will be required for the purpose along with appropriate amount of domain knowledge (training data) to train the machine learning based classification model. The model closest to this objective is by Uddin *et al.* (2016). The proposed project aims to develop a suitable model for thematic area-based classification of a research article. Once this model is developed and trained, it can be used to categorize research output of different institutions in different thematic areas. Once this categorization is achieved, the standard procedures of research performance ranking can be followed to identify top performing institutions in any thematic area. More analytical results like top publication sources in a thematic area or top performing researchers in a thematic area can also be identified. Such classification can be used for thrust-area based funding decisions.

Chapter 3

Methodology – Sampling Design, Data Sources, etc.

The project has been completed in two stages. The first stage involved the development of a new computational framework for assessment of thematic performance of institutions on the basis of sample data from the Web of Science Database. Two indices to rank the institutions, named x-index and x(g)-index have been developed for this purpose. This computational framework for thematic mapping is explained in two publications (Lathabai, Nandy and Singh, 2021a and 2021b).

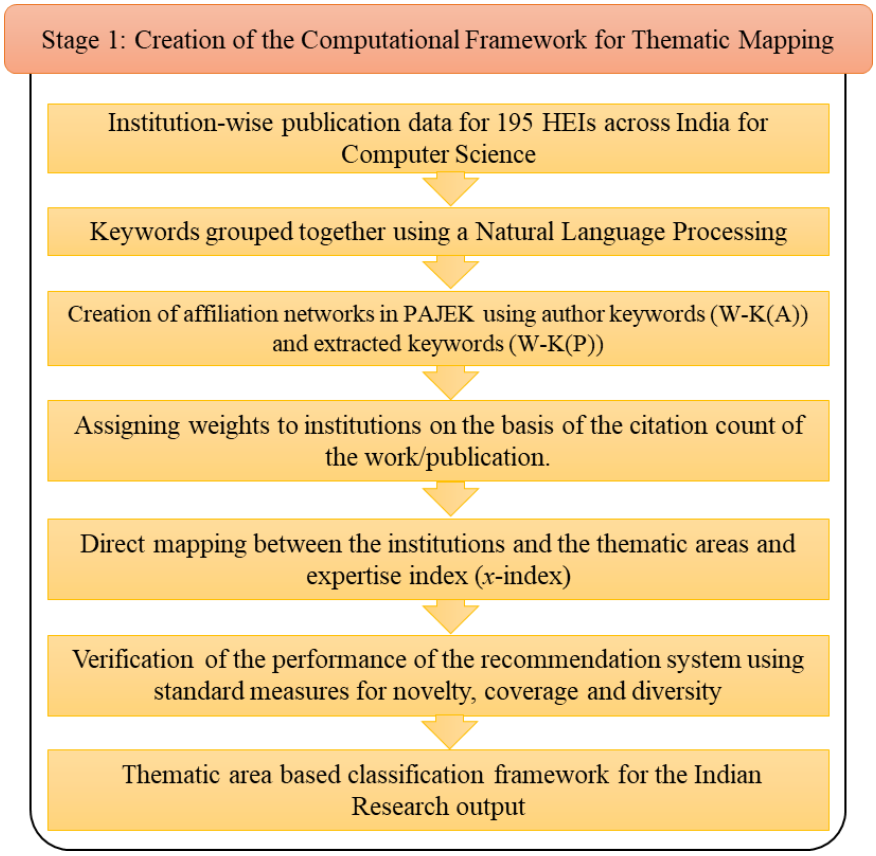
In the second stage of the project, detailed reports on scientific productivity of India and the performance of selected 1000 Indian Institutions were developed using the conceptual framework. These reports are thereafter used to show visualisations of these reports on the web portal. The study has covered data from all the disciplines indexed on the Dimensions database for a period of 10 years. A total of 1000 Indian organisations (Higher Education Institutions, Government hospitals and laboratories, and R&D firms) have been assessed under the project. The access to the database was acquired by using Dimension's API. A paper about the web portal has been published in Scientometrics journal (Singh et al., 2022).

Introduction

The research methodology for this project has been designed keeping in mind the type of data and information available on the scientometric outputs of institutions. The study has utilised quantitative methods for the purpose of designing an analytical framework and has used it for development of the institutional performance reports. The overall methodology of the study is divided into two sections, and involves first developing a framework to assess institutions on certain thematic areas and later to scale up the framework to include a larger dataset of publications from more institutions across the country **(Figure 3.1)**. The following sections provide detailed accounts of each stage of the project, present the data sources used and data processing approaches used.

Stage 1: Creation of the computational framework for thematic mapping

For the first stage of the project, a scientometric analysis framework has been designed to rank institutions based on their research performance and strength in a thematic area. This study proposes a performance indicator named "*x*-index", which considers the citation weighted affiliation networks to assign performance ratings to institutions.



***x*-index**

This index uses the publication data of institutions on a given subject and uses machine learning algorithms to assign performance ratings to them. A multi-step process (data collection, data pre-processing, grouping keywords and development of W-K affiliation network), has been followed in order to compute the *x*-index for the selected institutions. First, institution-wise publication data for 195 HEIs across India was collected for a time period of 10 years i.e., 2010-2019 for the field 'Computer Science'. The data was downloaded from WoS using an automated data extraction tool "UI Vision (based on selenium library". The pre-processing of publication data involved manual curation to remove improper/incorrectly encoded entries. A WoS file with publication details and other field tags is almost similar to an adjacency list representation where entries associated with tags like authors, keywords, etc., are separated by delimiters like ';', ',', '[' and ']'. For the final pre-processing step keywords were grouped together using a Natural Language Processing (NLP) module **Figure 3.2**. For creating a Work-Keyword (W-K) affiliation network, ';' or ',' separated keywords have to be split and represented in edge-list format for the creation of affiliation networks in PAJEK (Batagelj & Mrvar, 1998) compatible format. After the pre-processing step, the resulting keywords were used to create the W-K(A) network and corresponding W-K(P) network. K(A) indicates author keywords and K(P) indicates keyword plus extracted keywords. The Injection Methodology was used for obtaining a weighted network (Lathabai, Prabhakaran, & Changat, 2017), where the weights were assigned on the basis of the citation count of the work/publication. An in-degree analysis helped to provide the publication count of an institution, with respect to certain themes or keywords. This resulted in a direct mapping between the institutions and the thematic

areas, and provided an expertise index, called *x*-index, for each institution based on the thematic areas they worked on the most. Overall expertise indices (*x* and *x(g)* indices) of institutions was obtained with the adaptation of *h* and *g* indices to the thematic area performance of institutions. For instance, an institution's *x*-index will be *x* if it has published in at least *x* thematic areas and received more than *x* citations in all these *x* thematic areas. It provides information about core research thematic areas of an institution and may aid in institutional research portfolio management. Similarly, an institution's *x(g)*-index is *x(g)* if it has been published in at least *x(g)* thematic areas and the citations from these *x(g)* areas averages to *x(g)*. Since, top *x* areas in the *x(g)* core represents the core competency areas, rest of the (*x(g)*-*x*) areas can be treated as potential core competency areas of an institution. **Figure 3.1** demonstrates how the *x*-index is calculated for each institution, based on the number of publications and citations.

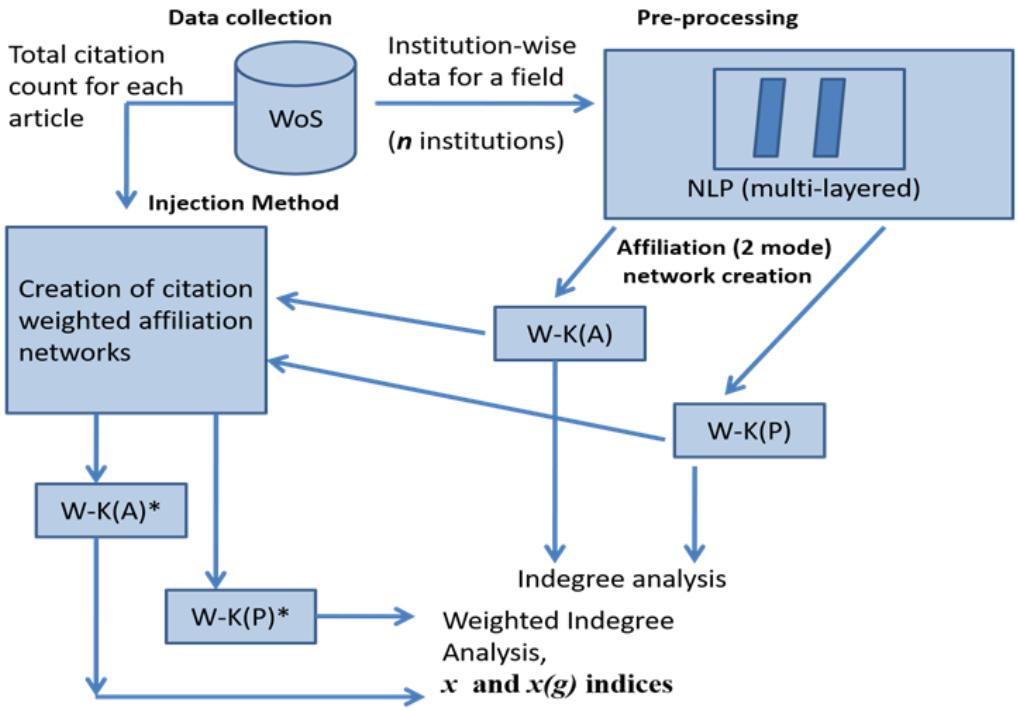


Fig 3.1. Schematic diagram of the network based computational framework for thematic mapping.

Calculating *x*-index

To show how the *x*-index was calculated, '*Dr. Mahalingam college of engineering and technology (DMCET), Pollachi, Tamil Nadu*' is taken as an example. For this institute, the *x*-index value was 11, which means it has 11 strong research areas. This was calculated using the ratio $\frac{Rank\ of\ the\ keyword}{Strength\ of\ the\ keyword}$. The rank where the ratio became less than 1 was taken as the threshold and the corresponding rank value was determined to be the *x*-index of the institution. Similarly, *x(g)*-index was calculated using the ratio $\frac{Squared\ Rank\ of\ the\ keyword}{Cumulative\ Strength\ of\ the\ keyword}$. Table 3-1 shows how the *x*-index and *x(g)*-index was calculated in the study for the mentioned institution. We see after Rank 11, the ratio of $\frac{Rank\ of\ the\ keyword}{Strength\ of\ the\ keyword}$ becomes less than 1, so *x*-

index is taken to be 11. Similarly, *x(g)*-index is seen to be 18. This process was iterated for all the 195 institutions and they were all provided with both an *x*-index and an *x(g)*-index.

Table 3.1. Demonstration of computation of *x* and *x(g)* indices of the institution DMCET

Rank		**Thematic areas**	**Strength (weighted in-degree)**	**Squared rank**	**Cumulative strength**
	1	support vector machine	38	1	38
	2	wavelet transformation	35	4	73
	3	eeg classification	35	9	108
	4	machine learning	32	16	140
	5	epileptic seizures	32	25	172
	6	feature selection	17	36	189
	7	cascaded multilevel inverter	15	49	204
	8	anfis	15	64	219
	9	control voltage	15	81	234
	10	grid voltage	15	100	249
***x*-index =**	**11**	pv	15	121	264
	12	image texture	11	144	275
	13	matrix algebra	11	169	286
	14	feature extraction	11	196	297
	15	image segmentation	11	225	308
	16	active contour segmentation technique	10	256	318
	17	ultrasound images	10	289	328
***x(g)*-index =**	**18**	segmented region	10	324	338
	19	wavelet features	10	361	348

The institutions were then ranked according to their *x*-index scores if they had strong or weak research expertise in the thematic area.

The rationale behind the framework is that (i) by maximization of strengths in areas of core competency of institution through suitable collaborations with institutions that are also having core competency in such areas (strategy 1) and (ii) by enhancing strengths in areas of potential core competency of an institution through suitable collaborations with institutions that have (a) core competency in such thematic areas or (b) potential core competency in such thematic areas. Upon verification of the performance of the recommendation system using standard measures for novelty, coverage and diversity (Brandão et al., 2013; Gunawardana & Shani, 2015), the framework is found to be having reasonable coverage and capable of tossing novel and diverse recommendations.

Result Stage 1: W-K(A) network analysis

An example weighted network, for the institute "*Indian Institute of Technology, Kharagpur (IITKGP)*", from the Stage 1 framework is shown below (Figure 3.2) -

Description of the network:

- Number of Vertices = 5874 vertices where,
  - i. 1205 are publication works (1st mode)
  - ii. 4669 are keywords (2nd mode)
- Number of Arcs/Edges = 6127.

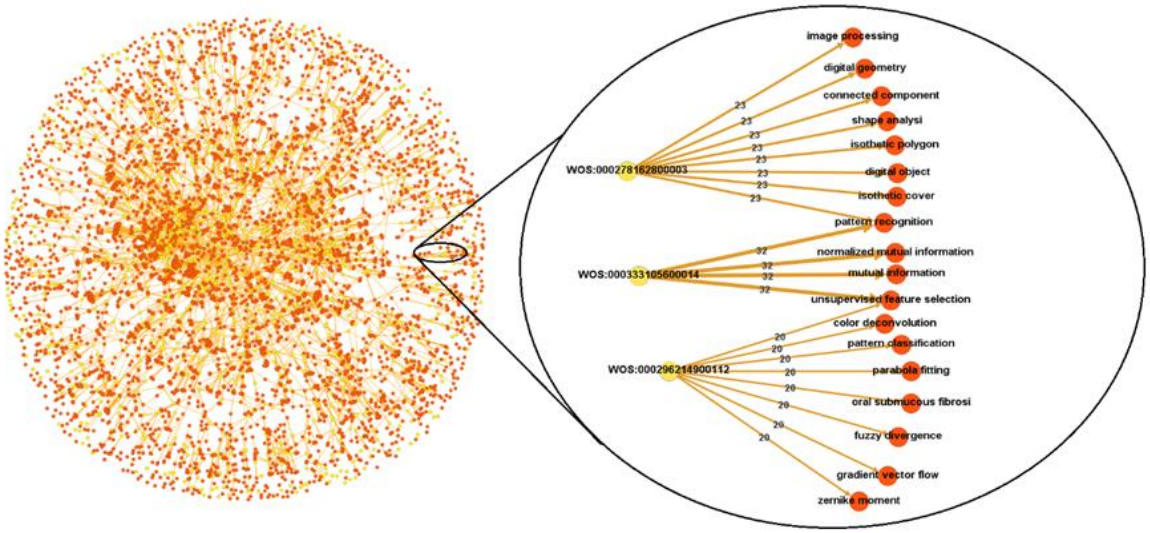


Fig. 3.2. Citation weighted W-K(A) network of IIT Kharagpur, highlighting a subnetwork

In the above figure, yellow vertices are the individual publications and red vertices are the keywords. The lines/edges connecting the two represent the link between the two components, where the weight value is determined from the number of citations the publication has received and hence the keyword (through that unique publication) has received. A similar network was created for each of the 195 institutions, which provided weighted links between keywords and publications, and hence the institutions themselves.

The output from the first stage was a ranked set of institutions which has been used as a thematic area based ranking framework. The ranking system was compared with some of the most prevalent ranking frameworks in the academic world, namely the Times Higher Education rankings (THE), the QS rankings, the ARWU rankings and the CWTS rankings. For the comparison, Spearman's Rank Correlation was used, which provided an assessment between the rankings and the significance of the relation between them. Firstly, the comparison for x-indices computed using author keywords is conducted. For ARWU, 7 institutions are common and Spearman's ρ= 0.571. For THE, 17 institutions are common and ρ is found to be 0.678. For QS, 16 institutions are common and ρ obtained is 0.496. In the case of CWTS Leiden, results are available only in a format where fields 'Mathematics' and 'Computer Science' are combined. For CWTS, 31 common institutions were found and ρ= 0.801. In case of Keyword plus keywords, Spearman's ρ values obtained for ARWU, THE, QS and CWTS are 0.393, 0.698, 0.568 and 0.766, respectively. In case of x(g)-indices, the Spearman's ρ for relative

rankings of common institutions are 0.75, 0.665, 0.404 and 0.76 with respect to ARWU, THE, QS and CWTS rankings, according to author keywords. For keyword plus keywords, ρ scores are 0.295, 0.659, 0.501 and 0.676 respectively for ARWU, THE, QS and CWTS rankings.

From the above results, it can be inferred that our ranking framework generates essentially different rankings from most of the existing ranking systems. Thus, an expertise-based ranking framework is capable of assigning ranks of institutions in a novel/non-trivial way. Though slightly higher correlation of expertise-based rankings is observed especially with CWTS ranking (where CWTS considers mainly the research publication data for ranking, though it includes Mathematics too with Computer Science), the limitations of CWTS Leiden for thematic area-based ranking (such as usage of broad subject categories, and under-representation of developing countries etc.), make the proposed framework a worthy choice for thematic area-based rankings. The framework not only determines the core competency of institutions in a given subject but also allows identifying research strength of institutions in specific thematic areas. One may even combine multiple thematic areas together, to determine the research strength in the given multiple thematic areas. A list of all the institutions and their corresponding *x*-index is listed below **(table 3.2)** –

Table 3.2: List of institutions and their x-index values

Institute	**x-index**	**Institute**	**x-index**
Thapar Institute of Engineering Technology	116	Indian Institute of Technology (IIT) Kharagpur	115
Indian Institute of Technology (IIT) Delhi	104	Indian Statistical Institute (ISI) Kolkata	101
Indian Institute of Technology (IIT) Roorkee	95	Vellore Institute of Technology (VIT)	84
Indian Institute of Technology (IIT) Kanpur	77	Indian Institute of Science (IISc) Bangalore	74
National Institute of Technology (NIT) Rourkela	70	International Institute of Information Technology (IIIT) Hyderabad	65
Anna University	65	Indian Institute of Technology (IIT) Bombay	65
Shanmugha Arts Science Technology Research Academy Sastra	64	Indian Institute of Technology (IIT) Indore	63
Indian Institute of Technology (IIT) Guwahati	63	Indian Institute of Information Technology (IIIT) Allahabad	62
Indian Institute of Technology (IIT) Madras	61	Indian Institute of Technology Indian School Of Mines (IIT-ISM) Dhanbad	60
National Institute of Technology (NIT) Kurukshetra	58	National Institute of Technology (NIT) Tiruchirappalli	57
Bharathiar University	57	Chaudhary Charan Singh University	56
Sardar Vallabhbhai National Institute of Technology	56	University of Delhi	56
National Institute of Technology (NIT) Durgapur	55	Malaviya National Institute of Technology (MNIT) Jaipur	54
Manipal Academy of Higher Education Mahe	52	Tezpur University	52
University of Hyderabad	51	Veer Surendra Sai University of Technology	49
Delhi Technological University	49	Siksha O Anusandhan University	48
Thiagarajar College of Engineering	48	Gandhigram Rural Institute	48
Jawaharlal Nehru University, New Delhi	47	Indraprastha Institute of Information Technology Delhi	47
University of Calcutta	47	Indian Institute of Technology (IIT) Patna	46
Indian Institute of Information Technology Design Manufacturing Jabalpur	46	Vidyasagar University	46

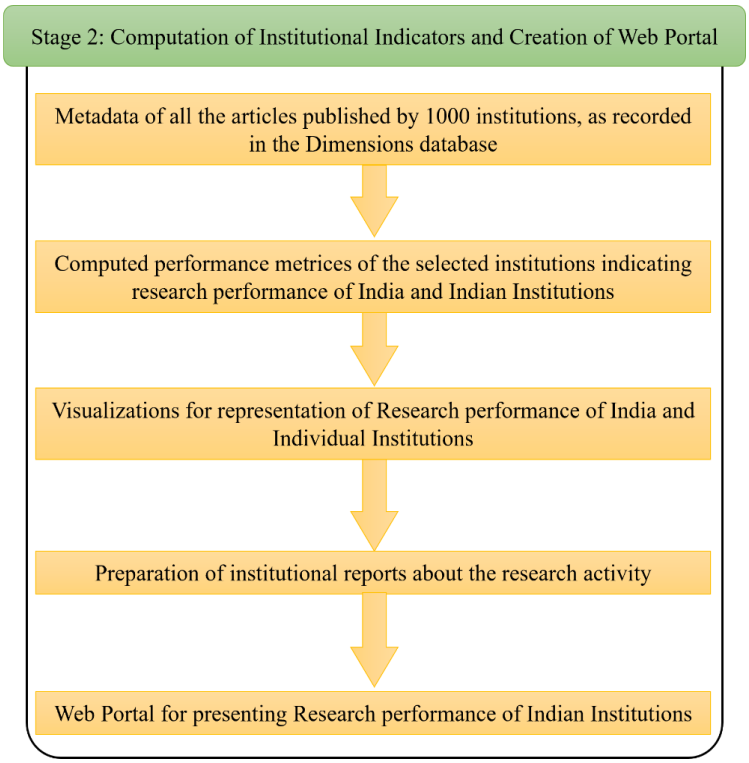
Motilal Nehru National Institute of Technology	46	Indian Institute of Technology (IIT) Bhubaneswar	46
Amrita Vishwa Vidyapeetham	45	Birla Institute Of Technology Science Pilani Bits Pilani	45
Indian Institute of Engineering Science Technology Shibpur IIEST	44	Dr B C Roy Engineering College	43
Panjab University	42	PSG College Technology	42
Kalasalingam Academy of Research Education	42	Jaypee University of Information Technology	42
Indian Institute of Technology IIT BHU Varanasi	42	Netaji Subhas University of Technology	41
Thiruvalluvar University	41	Birla Institute of Technology Mesra	40
Banaras Hindu University	40	National Institute of Technology Calicut	39
National Institute of Technology Karnataka	39	National Institute of Technology Raipur	39
Pondicherry University	39	National Institute of Technology Silchar	38
South Asian University SAU	37	Maulana Azad National Institute of Technology Bhopal	37
Indian Institute of Technology (IIT) Hyderabad	37	Annamalai University	37
National Institute of Standards and Technology	36	Indian Institute of Technology (IIT) Ropar	36
LNM Institute of Information Technology	35	KIIT University	35
Indian Institute of Management Calcutta	35	Periyar University	34
Maulana Abul Kalam Azad University of Technology	34	Aligarh Muslim University	34
Visvesvaraya National Institute of Technology Nagpur	34	Alagappa University	33
Indian Institute of Management Ahmedabad	33	I K Gujral Punjab Technical University	33
GGS Indraprastha University	32	SRM Institute of Science Technology	32
Institute Of Mathematical Sciences IMSC India	32	The Northcap University	31
Shri Mata Vaishno Devi University	31	National Engineering College India	31
Mepco Schlenk Engineering College	30	Karunya Institute of Technology Sciences	30
Nirma University	30	SSN College of Engineering	30
National Institute of Technology Warangal	30	RCC Institute of Information Technology RCCIIT	30
Amity University	30	Sant Longowal Institute of Engineering Technology SLIET	29
Jamia Millia Islamia	29	University Of Allahabad	29
Symbiosis International University	29	University Of Burdwan	29
National Institute of Technology Patna	29	Jaypee Univ Engn Technol	28
Tata Institute of Fundamental Research TIFR	28	B S Abdur Rahman Crescent Institute of Science Technology	28
Chandigarh University	28	Visva Bharati University	28
Manonmaniam Sundaranar University	27	Dr B R Ambedkar National Institute of Technology Jalandhar	27
Kamaraj Coll Engn Technol	27	Karpagam Academy of Higher Education KAHE	27
Sri Ramakrishna Inst Technol	27	Kalyani University	27
National Institute of Technology Hamirpur	26	Deenbandhu Chhotu Ram University of Science Technology	26
Bhabha Atomic Research Center BARC	26	Indian Institute of Technology (IIT) Jodhpur	26
Techno India Coll Technol	26	National Institute of Technology Jamshedpur	26
Punjabi University	26	College Of Engineering Guindy	25
PSNA College of Engineering Technology	25	Bharathidasan University	25

Shri Guru Gobind Singhji Institute of Engineering Technology	25	Lovely Professional University	25
Andhra University	25	CSIR Central Scientific Instruments Organisation CSIO	24
Reva University	24	University Of Kashmir	24
Sathyabama Institute of Science Technology	24	Indian Institute of Technology (IIT) Mandi	24
Int Inst Informat Technol	24	Indian Institute of Management Lucknow	24
Jaypee Inst Informat Technol	24	Jawaharlal Nehru Technological University Hyderabad	24
Haldia Institute of Technology	23	CSIR National Institute of Science Communication Information Resources NISCAIR	23
Dayalbagh Educational Institute DEI	23	University of Mysore	23
Indian Statistical Institute Bangalore	23	Indian Institute of Space Science Technology	23
Indian Institute of Technology (IIT) Gandhinagar	23	Guru Ghasidas Vishwavidyalaya	23
Bannari Amman Institute of Technology	22	Pondicherry Engineering College	22
Centre For Development of Advanced Computing C-DAC	22	K L University	22
Sri Krishna College of Engineering Technology	22	National Institute of Technology Delhi	22
Savitribai Phule Pune University	22	National Institute of Technology Agartala	21
Maharishi Markandeshwar University	21	National Institute of Pharmaceutical Education Research NIPER	21
CSIR Indian Institute of Chemical Technology IICT	21	Chennai Mathematical Institute	21
National Institute of Technical Teachers Training Research Chandigarh	20	North Eastern Hill University	20
National Institute of Technology Meghalaya	20	Gautam Buddha University	20
Guru Nanak Dev Univ	19	Institute Of Engineering Management IEM Kolkata	19
National Institute of Pharmaceutical Education Research S A S Nagar Mohali	19	CSIR Structural Engineering Research Center SERC	19
Heritage Inst Technol	19	CSIR Academy of Scientific Innovative Research AcSIR	19
Madras Institute of Technology	19	Jawaharlal Nehru Technological University Kakinada	18
National Institute of Technology Goa	18	Cochin University Science Technology	18
Kongu Engn Coll	18	Kumaraguru College of Technology	18
Galgotias University	18	Sona College of Technology	18
CSIR Central Drug Research Institute CDRI	18	Vel Tech Rangarajan Dr Sagunthala R D Institute Of Science And Technology	18
PES University	18	Punjab Engineering College Deemed University	18
Dhirubhai Ambani Institute of Information and Communication Technology	18	Velammal Engineering College	17
Banasthali Vidyapith	17	University Of Kerala	17
Gandhi Institute of Technology Management Gitam	17	North Eastern Regional Institute of Science Technology	16
K S Rangasamy College of Technology	16	KSR Coll Engn	15
GLA University	15	Karpagam Coll Engn	15
Manipal University Jaipur	15	Bharati Vidyapeeth Deemed University	15
St Josephs Coll Engn	15	Indian Institute of Science Education Research IISER Kolkata	15
Madanapalle Institute of Technology Science	15	Rmd Engn Coll	14

Univ Coll Engn	14	Jawaharlal Nehru Technological University Anantapur	14
Homi Bhabha National Institute	13	Govt Coll Technol	13
Coimbatore Institute Of Technology	13	Dr Mahalingam Coll Engn Technol	11
CSIR Central Electronics Engineering Research Institute CEERI	10	Assam University	9
RMK Engn Coll	9		

Stage 2: Computation of Institutional Indicators and Creation of Web Portal

The final aim of the project was to provide a thematic area-based classification framework for the Indian Research output from the top 1000 organisations involved with research in India. Thus, for the second stage of the project, we have scaled up the framework developed in the previous stage, and applied the mapping of institution - thematic areas to these 1000 Higher Education Institutions HEIs. The research data collected involved all the articles published by these institutions, as recorded in the Dimensions database[7], during the time period of 2010 to 2019. The study at this stage, presents an analytical study of these higher education institutions, along with the computational framework from the previous stage.



The primary data source for the study is the Dimensions database, which provides publication meta-data. A list of top 1000 higher education institutions was formed, based on the order of the total number of publications the institution produced. The time period selected for filtering the article records was 2010 to 2019. Based on the data provided by the database, the keywords and/or concepts for each of the individual articles provided for the base data for our thematic

[7] Dimensions - https://app.dimensions.ai/discover/publication

area-based classification. These concepts were substituted as thematic areas, after being curated using an NLP based module. A detailed description of the NLP module is provided in **Fig 3.3**.

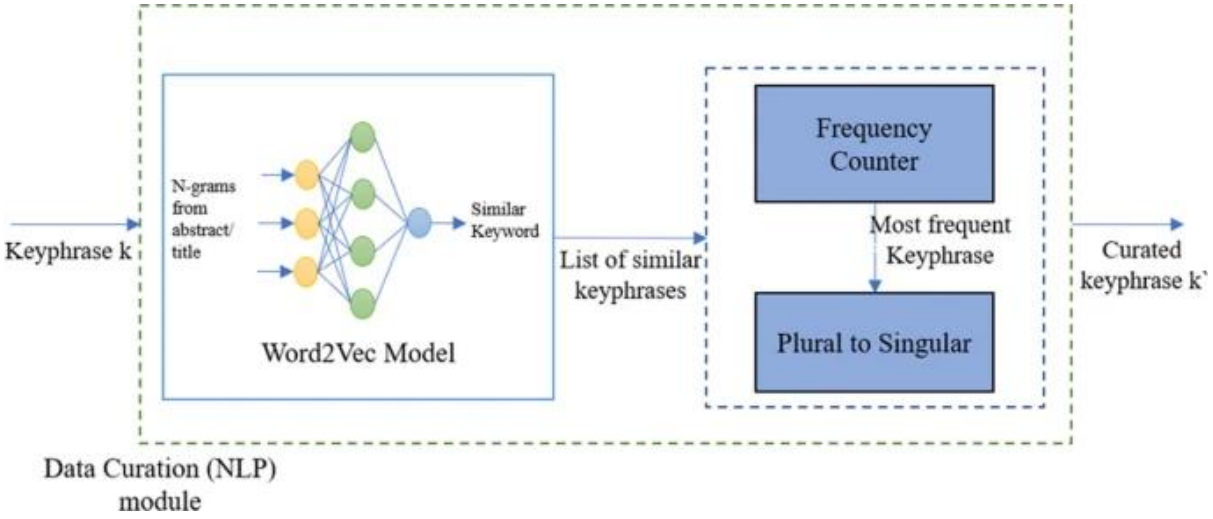


Figure 3.3. Schematic diagram of the NLP module used in the institution recommendation framework described in Stage 1 & 2.

As seen in the figure, a concept key phrase was curated to revert it to its root form and then, if possible, replaced with a more frequently occurring synonym from the database. Further, the citation data for the keyword was collected, and was used as a research performance indicator, in the form of *x*-index (Lathabai, Nandy and Singh, 2021a). A ranking framework for the institutions based on the *x*-index was built, by mapping the curated keywords with articles published by each of the institutions (Lathabai, Nandy and Singh, 2021b). This ranking framework can be used to rank institutions based on their strength in a particular thematic area (mentioned as a concept).

1. **Target population and sample size to be covered:** The project aims to cover publication data for all the disciplines indexed in the Dimensions databases for at least the last 10 years. The data is obtained for 1000 HEIs in India having a reasonable research output.

2. **Methods of data collection:** The data is collected from a well-known academic database of Dimensions through appropriate advanced-level queries. Institution-wise data is collected for all Indian HEIs having reasonable research. Some altmetric data on Indian research output was also collected. In addition, data about Indian institutions in different international rankings is collected and displayed on web portal developed.

3. **Sources of the data:** Academic database of Dimension was accessed for the study. A No Cost agreement was signed with Digital Science for this purpose. In addition, social media and other Web platforms have been crawled for altmetric and other data collection.

4. **Reference period of the data to be covered:** The project has covered data for the time period of 2010 - 2019 for the Indian HEIs.

5. **Method of processing and analysing:** After collecting data, it was pre-processed computationally. The pre-processed data was accessed and processed by writing programs

in Python programming language. The idea was to utilize computational efforts for the purpose and also to develop an automated computational framework, which can produce new results once new data is provided in an automated manner.

6. **Time schedule of activities giving milestones:** The project was executed in a planned manner with following four identifiable phases: (a) Algorithmic Framework Design, (b) Detailed Data Collection, (c) Web-based system design, and (d) Generating technical reports. The detailed timeline of activities are as follows (Figure 3.4):

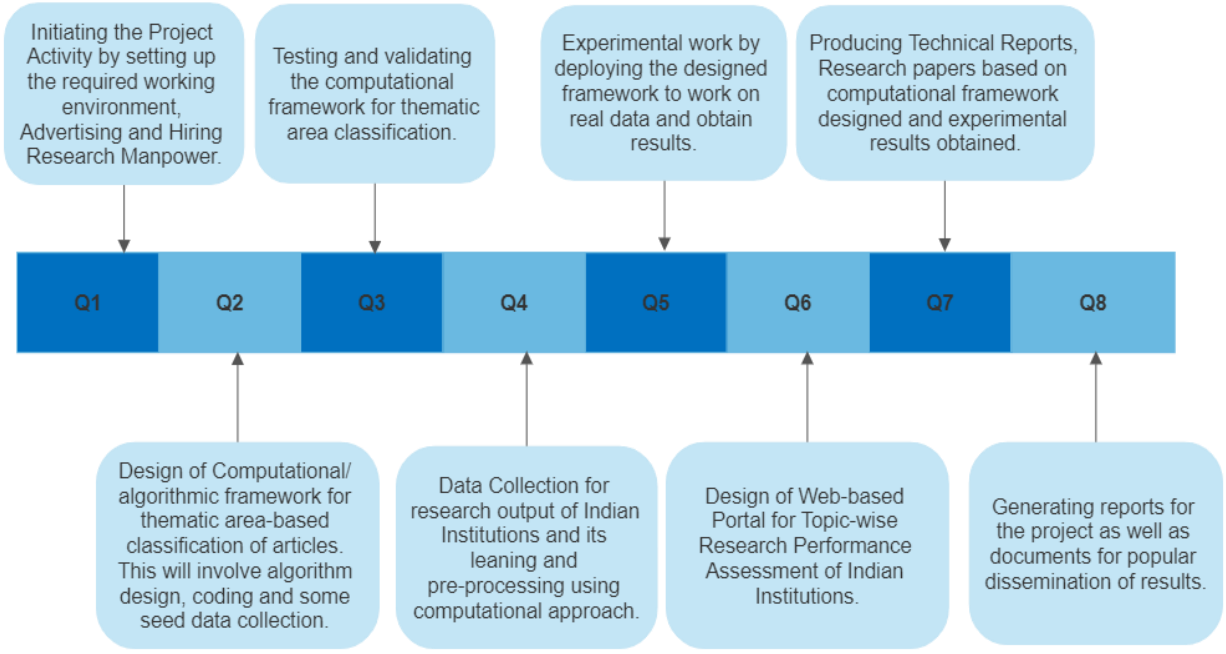


Figure 3.4. Quarter wise time schedule of activities giving milestones

A short summary of the methodology of Stage 2 is provided in **Fig 3.5**. This stage started with downloaded publication data for each institution from Dimensions database, and ended with the formation of individual Institution reports on the web portal of Indian Science Reports.

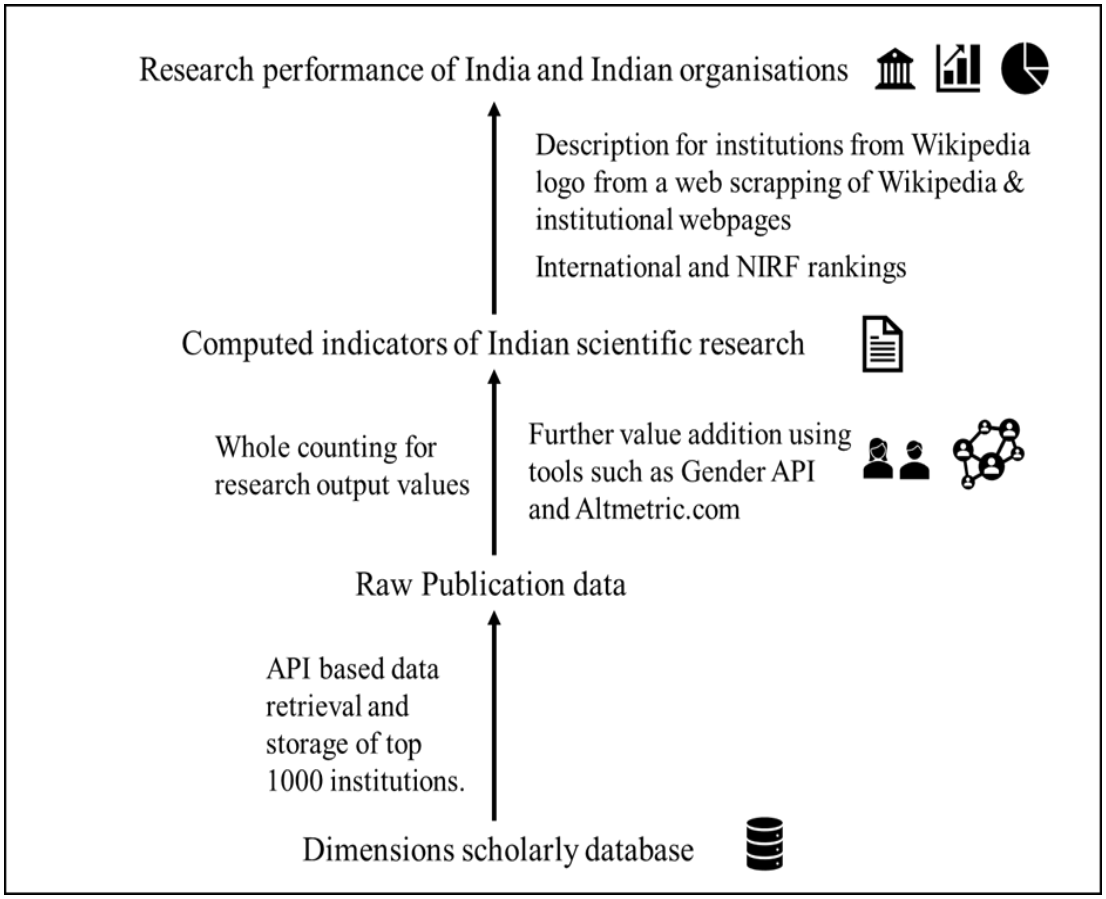


Figure 3.5. The schematic representation of the process of data retrieval, processing and presentation on the Indian Science Reports portal.

Chapter 4

Detailed analysis of the Data

This chapter provides a detailed description of data used for the study from WoS, Scopus and Dimensions data bases. It explains the processing steps undertaken for preparing the publication data for the two stages of the project. In the first section, the extraction of data from WoS, its metadata, selection criteria for institutions, and the development of analytical framework for the evaluation of institution are explained. The second section covers the process of application of the developed framework to larger number of institutions and the creation of web-portal.

The study was divided into two different stages, as mentioned before -

1. Development of the Analytical Framework to rank a set of institutions.
2. Scaling up the framework to include more institutions.

Hence, for the two stages, two separate datasets were used.

For Stage 1, Web of Science[8] (WoS) was chosen as the dataset provider. WoS is a platform which provides access to citation information and other metadata about publications. It is chosen since it is regarded as a standard citation information provider, as it includes top citation indices, including Science Citation Index Expanded, Social Sciences Citation Index and Arts & Humanities Citation Index. Web of Science was originally created as the Science Citation Index, by Eugene Garfield, and is currently owned by Clarivate (previously, Thomson Reuters).

The collected data consisted of metadata fields like Publication ID, Title, Document type, Abstract, Author information, Citation information, Journal information. The fields of Publication Id (UT), Author provided keywords (KE), WoS Indexed keywords (ID), Citation information (Z9) and Author Information (C1) were used to create a weighted network as mentioned in the framework. The data was collected for the time period 2010 to 2019, from the Computer Science subject field. The data was collected for 195 institutions (as listed earlier in Table 3.2). A threshold was set where institutions were considered for the study only if they had 25 or more publications related to 'Computer Science' indexed in WoS for the given time period. For example, Indian Institute of Technology, Kharagpur (IIT Kharagpur) had published 1205 articles in 'Computer Science' within the given time period and was selected for the study.

The publications were analysed with respect to the institutions, and it was observed that certain institutions performed very well when compared to others, in terms of no. of articles produced and citations received. A publication-keyword network, W-K(A) network, was created from the data, which was used to store data about the relationship between each publication and keywords, as mentioned in Chapter 3 (Stage 1). An in-degree analysis of the network provided

[8] Document search - Web of Science Core Collection: https://www.webofscience.com/wos/woscc/basic-search

the number (frequency/count) of publications within which a keyword appears. The most frequently appearing keyword in the scholarly output of an institution can be identified in this way. Also, the citation and publication counts provided the strength of each theme for each institution.

Taking the example of IIT Kharagpur, the top 10 keywords/thematic areas based on citation count and publication count are shown in **Table 4.1.**

Table 4.1. Top 10 thematic areas of research of IIT Kharagpur in terms of number of publications and thematic strength (according to Author keywords)

Publications				**Citations**		
S. No.	**Keyword (Au)**	**Publication count**		**S. No.**	**Keywords (Au)**	**Citation count**
1	genetic algorithm	37		1	wireless sensor network	1007
2	security	36		2	security	895
3	particle swarm optimization	31		3	internet of thing	709
4	wireless sensor network	30		4	cloud computing	641
5	authentication	21		5	avispa	623
6	neural network	20		6	authentication	581
7	learning automaton	17		7	genetic algorithm	546
8	cloud computing	16		8	learning automaton	499
9	simulation	15		9	fog computing	484
10	network-on-chip	15		10	particle swarm optimization	482

Once the weighted indegree (thematic strengths) of all areas are computed, expertise indices *x* and *x(g)* indices can be computed for each institution. Top 10 institutions according to *x* and *x(g)* for author keywords is shown in Table 4.2.

Table 4.2. Top 10 Indian HEIs by *x* and *x(g)*-indices (according to author keywords)

S. No.	**Name of Institution**	***x*-Index (Au)**	**S. No.**	**Name of Institution**	***x(g)*-Index (Au)**
1	Thapar Institute of Engineering Technology	116	1	Thapar Institute of Engineering Technology	191
2	Indian Institute of Technology IIT Kharagpur	115	2	Indian Institute of Technology IIT Delhi	188
3	Indian Institute of Technology IIT Delhi	104	3	Indian Institute of Technology IIT Kharagpur	181
4	Indian Statistical Institute Kolkata	101	4	Indian Statistical Institute Kolkata	180
5	Indian Institute of Technology IIT Roorkee	95	5	Indian Institute of Technology IIT Roorkee	157
6	Vellore Institute of Technology	84	6	Vellore Institute of Technology	141
7	Indian Institute of Technology IIT Kanpur	77	7	International Institute of Information Technology Hyderabad	140
8	Indian Institute of Science IISc Bangalore	74	8	Anna University	129
9	National Institute of Technology Rourkela	70	9	Indian Institute of Science IISc Bangalore	125
10	Anna University	65	10	Indian Institute of Technology IIT Kanpur	124

Similar results can be obtained in the case of keyword-plus too as the spearman's rank correlation between x-indices using author keywords and keyword plus is found to be 0.916 and that between x(g)-indices using author keywords and keyword plus is 0.937.

For the later stage of the project, the Dimensions[9] database was chosen as the dataset. Dimension, similar to WoS, is also a platform which provides citation information and metadata about publications. It covers a broader temporal and publication source than WoS or Scopus databases in most subject areas, and is closer in its coverage to free aggregation databases like Google Scholar (Singh *et al.*, 2021).

Dimensions provides access to its database through APIs. This makes the data collection more hassle-free, and easier to work with large volumes of data. The dimensions database also provides a large and robust set of metadata fields, which helps to analyse different aspects of the data like funding information and author/organisation details. The database also provides a metadata field named concepts, along with a relevance score, which is a set of keywords taken from the publication through certain machine learning processes, and a score for each such keyword considering how relevant the concept is to the publication. This field was taken as the keyword field for the framework mentioned in Stage 1, when it was scaled up to use the new Dimensions data. Also, only the concepts with a relevance score greater than 0.6 were selected, to remove not-so-good recommended keywords from the framework.

For the purpose of this study, the information required was from the Indian Higher Education Institutions (HEIs). The dimensions database at the time of data retrieval consisted of data from 1600 Indian HEIs. Out of these, those with more than 100 publications in 10 years were selected for further analysis. The data of the top 1000 Indian higher education organisations, ranked on the number of publications, were retrieved for the time period of 2010 - 2019.

Within the data, some conflicting publication data were observed when certain Organisation systems were grouped together, like Council of Scientific and Industrial Research (CSIR), or Defence Research and Development Organisation (DRDO). For these conflicts, the aggregated data was removed, while the individual organisations (DRDO laboratories or CSIR institutes) were kept back in the dataset.

The publication meta-data was collected, along with the citation data, for each of the institutions between the time period 2010-2019. The citation data was retrieved till the month of September 2021. This ensured an up-to-date citation count for the publications and hence provided rankings and recommendations accordingly. A list of all the metadata fields used for the analysis is listed in **Table 4.3.** All these raw data were accumulated for each of the institutions, and a detailed report was generated from this publication metadata.

[9] Dimensions website: http://dimensions.ai/

Table 4.3. All metadata fields used for analysis of Indian higher education institutions.

Metadata field	Description
title	Title of a publication.
authors	Ordered list of authors names and their affiliations, as they appear in the original publication. The list can include researcher and organization identifiers, when available
abstract	The publication abstract.
type	Publication type (one of: article, chapter, proceeding, monograph, preprint or book).
year	The year for the version of record of publication (note: when the `date` field is available, this is equal to the year part of the full date).
journal.title	name of journal
journal.id	id of the journal as provided by Dimensions
publisher	Name of the publisher as a string.
reference_ids	Dimensions publication ID for publications in the references list, i.e. outgoing citations
research_orgs	GRID organisations associated with a publication. Identifiers are automatically extracted from author affiliations text, so they can be missing in some cases (note: this field supports :ref:`filter-functions`: ``count``).
open_access_categories_v2	Open Access categories for publications
issn	International Standard Serial Number
altmetric_id	Altmetric Publication ID
field_citation_ratio	Relative citation performance of article when compared to similarly aged articles in its area of research
doi	Digital object identifier.
research_org_countries	Country of the organisations authors are affiliated to, identified using GeoNames codes
authors_count	Count of authors, as they appear in the original publication.
times_cited	Number of citations
concepts_scores	Relevancy scores for `concepts`; where, 'concepts' are the main topics of a publication (note: automatically derived from the publication text using machine learning).
category_for	ANZSRC Fields of Research classification followed by Dimensions
id	Dimensions publication ID.
funders	The GRID organisation who funded this publication.
altmetric	Altmetric Attention Score.
funder_countries	The country of the organisations funding this publication.
category_sdg	SDG - Sustainable Development Goals
relative_citation_ratio	Relative citation performance of an article when compared to others in its area of research
supporting_grant_ids	Grants supporting a publication, returned as a list of dimensions grants IDs

The data was grouped institution-wise and then the data for each institution (research_orgs) was analysed to produce the results accordingly, as discussed in Chapters 5 & 6.

Chapter 5

Result and Discussions

This chapter presents the main results of the study, categorised according to the two sections of study discussed earlier. The conceptual framework for assessment of research performance using publication data has been developed using network analysis of citation data for 195 institutions. This framework was used for the assessment of 1000 Indian Institutions, selected based on their total publications. Various performance indicators were computed and reports of research output of each of the 1000 institutions developed. These reports were presented on the Indian Science Reports portal.

From the first stage of the study, a new computational framework was initially designed using data from the Web of Science Database. Two indices to rank the institutions, named *x*-index and *x*(g)-index (Lathabai, Nandy & Singh, 2021a and 2021b) were also devised, using a network-based approach, as mentioned in Chapter 3. This network-based approach, along with an NLP module, was then recreated in Stage 2 to generate a thematic research portfolio for each of the 1000 institutions, using the publications meta-data from the Dimensions database. The same results are portrayed as a bubble chart of thematic areas of research for each individual institution in the Indian Science Reports portal[10].

The Indian Science Reports Portal

The Indian Science Portal is developed as a platform for consolidated indicators on research performance of Indian universities, research institutions and other organisations, along with national S&T output and analytics reporting system. This platform is developed by leveraging the standard scientometric and data analytics techniques and utilises the research publication listing available on Dimensions (https://app.dimensions.ai/) to develop detailed insights into the research performance. It also provides analytical insights through the application of novel indicators such as *x*-index and *x(g)*-index (Lathabai, *et al.*, 2021a, 2021b). The platform/portal is designed with multiple levels of information richness. It provides broad outlook in terms of comparison between the research performances of India with selected high performing countries across the globe; as well as allows the user to zoom in to see the research performance of individual organisations in India, by looking at indicators such as total publications, total publications in different disciplines, international collaboration, gender distribution, open access etc. It also includes information on indicators which have developed relatively recently and do not feature on other ranking and analysis platforms. These include social media visibility of the research, SDG wise research publications, competence areas of the institutions based on their thematic research strengths. Table 5.1 provides a list of all the Outputs generated by the portal. The left side of the table represents the analysis performed on the database as a whole. These output values help to analyse the national level performance of research-based institutions and organisations in India. The right side of the table represents the performance measures of an individual institution, where the portal shows all the mentioned features for every one of the 1000 institutions.

[10] www.indianscience.net

The main objective of the portal is providing an overview of the scientometric indicators for research output from India as well as individual Indian Institutions. In addition, it also provides useful insights into some aspects such as international collaboration for publication, comparative output for India versus selected countries. The platform can be a useful first step towards the development of a comprehensive listing of India institutions and their research activity as no such listing is yet available. The framework developed for identification of core competencies and expertise indices for organisations is the next step towards improving the coverage of this platform.

The results obtained for indicators after analysis included from the portal:

Publications and Citations: India's overall research output, its growth over time, research output rank and global share, the citations to Indian research output, relative citation ratio and India's share in highly cited research output of the world is provided. It can be seen that India has a high CAGR value of 9.46%, which is less than only three countries - Russia (11.43%), Iran (10.56%) and China (9.50%). In terms of global share, India accounts for 2.95% of the total research output of the world during 2010-2019 period.

Comparison with other major countries: For a better understanding of India's research performance, the values of research output volume, CAGR, and global share of 20 major countries are compared, as shown in different Tables in the portal. It can be seen that since the year 2015, India is the 6th largest producer of S&T research output and ranks 9th in total citations in the year 2019.

Subject Area Distribution of Research Output: Using a spider web chart, the number of publications in each (of the selected 22) subject areas is represented to show the amount of research activity undergoing in these organisations.

International Collaboration: The portal presents analysis of international collaboration patterns in Indian research output. India's international collaboration share has grown from 18.92% of total output in 2010 to 22.98% of total output in 2019. The US, UK, Germany, China and South Korea are the top 5 collaborating countries.

Gender Distribution: The portal includes an analysis of gender distribution of researchers producing research output in India. Overall, 29.30% of Indian research output has a female first author. However, subject area-wise variations exist in the proportion.

Open Access: The availability of scientific research outcomes varies greatly across the world with journals providing free of charge open access to published articles and other journals placing access charge for each article. Across the world, the governments have started to promote open access of research outcomes and are funding research organisations and publication agencies for developing appropriate platforms. The platform provides a number of open access publications by researchers at an overall as well as at the level of the organisations, and even presents the breakdown into the various open access sub-types. Subject area-wise variations in open access and also the open availability of public funded research output is analysed.

Altmetric Attention: The role of social media has rapidly become important with platforms such as Twitter, LinkedIn, Research Gate etc. assuming a significant role in communication and information exchange between the researchers. This has resulted in development of Altmetric (short for Alternative Metrics), a field which specifically focuses on the sharing and visibility of published research on social media platforms. The Indian Science Reports portal provides information about the Altmetrics for the whole of the Indian research output as well as the altmetric attention obtained by an individual organisation.

Research Grants: The total volume of research grants received by Indian institutions from national and international agencies is analysed. Major funding agencies are identified and subject area-wise distribution of grants is presented, finally publications out of grants are identified and listed.

SDG Related Research: Indian research publications on sustainable development goals are presented. The major focus SDGs are identified and the subject area composition of research output on different SDGs is analysed.

Table 5.1. List of Areas and Indicators covered in the Indian Science Reports Portal

National Research Output	Institutional Reports (for Indian Organisations)
• Research Output • Citations • Collaboration • Gender Distribution • Open Access • Social Media Visibility • Research Grants • SDG Related Research • Major Institutions	• Short Introduction • Key Indicators • Research Output and Citations • Authorship and Collaboration • Research Grants • Gender Distribution • Open Access Availability • Social Media Visibility • UN SDG related research • Thematic Structure of Research Output • External Data (Year 2021) Ranking from 5 major ranking platforms

The developed portal is useful for policy makers, scientometric researchers, researchers looking for potential collaborators, data enthusiasts and students among others. It provides analytical information on STI data both at the broad national level as well as on the granular level of institutions, universities, companies and hospitals. Hence it can be used by a very wide audience. As it follows a framework which includes conventional indicators for assessing STI performance within a field, as well as reflect the thematic strengths of an institution it can be used to: (i) select institutions for funding in a specific thematic area, so as to eventually develop these as centres of excellence, and (ii) identify top performers in a given thematic area, which can help in several science policy related decisions. The framework can be used to determine the core competency of an institution in a given subject, determine its thematic research strength in different themes of that subject, its focus on sustainable development goals (SDGs), productivity in the selected time periods and international connections for STI activities.

The data used for analysis is obtained from multiple sources containing metadata about scientific research. Since the primary source of publication metadata is Dimensions, the analysis is limited to institutions with publications listed on the database. As the portal uses only a selected set of indicators, in its present state it is an academic exercise which is limited to selected organisations. It may be used with other well established data sources to make more informed and valid assessments of research performances. A detailed analysis of the national research output is provided below -

The detailed results as shown on the website are as follows:

Indian Research Output during 2010 - 2019

Indian Research Output in the 2010 to 2019 period has grown significantly in volume. While a total of 60,250 publications were there in 2010, by 2019 this increased to 148,724. The Compounded Annual Growth Rate (CAGR) has been 9.46% which is higher than the world average CAGR (5.62%). India's global share of research output has also increased in this period, from 2.17% in 2010 to 3.1% in 2019. The figure 5.1 below present year-wise research output of India and the world, and also India's global share.

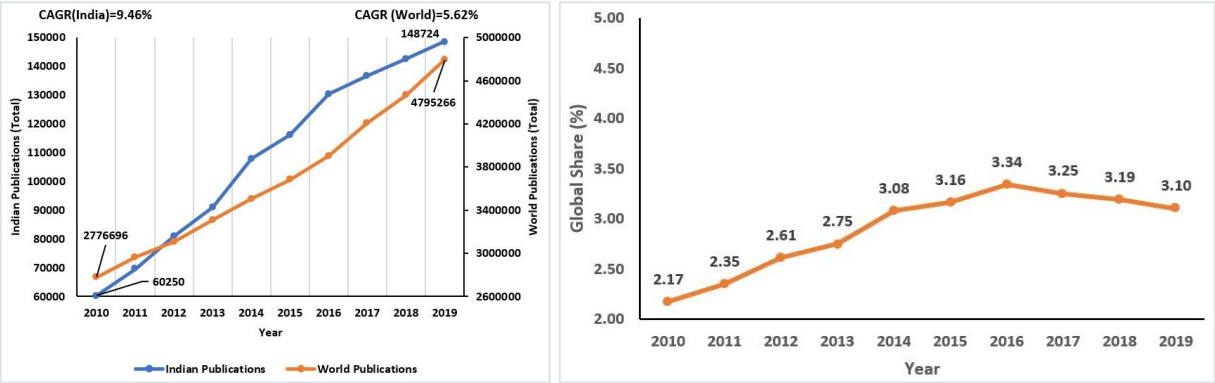


Fig. 5.1. Research Output of India and the world (2010-19)

India's global rank in research output has also been improving constantly during this period. In the year 2010, India ranked 10th globally in research output volume, which improved to 9th in 2011 and 2012, 8th in 2013, 7th in 2014, and 6th in 2015. From 2015 onwards, India continues to be ranked 6th globally in research output volume. The countries ranking above India are - United States, China, United Kingdom, Germany, Japan. The figure below shows year-wise ranked positions of India during this period.

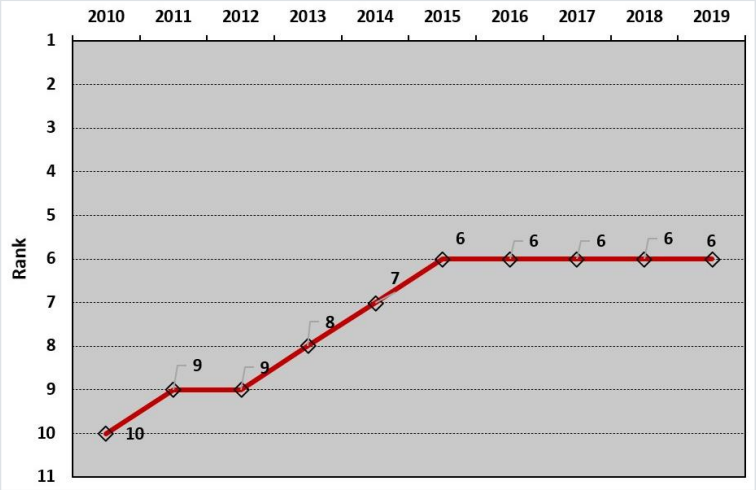


Fig. 5.2. India's global rank in research output (2010-19)

Comparison with other major countries

For a better understanding of India's research performance, the values of research output volume, CAGR, and global share of 20 major countries are compared, as shown in the Table below. It can be seen that India has a high CAGR value of 9.46%, which is less than only three countries - Russia (11.43%), Iran (10.56%) and China (9.50%). In terms of global share, India accounts for 2.95% of the total research output of the world during 2010-2019 period.

Table 5.2. India's research output, CAGR and global share (2010-19)

Rank	Country	No. of Research Publications	CAGR %	Global Share %
1	United States	6,181,247	3.09	16.83
2	China	3,828,795	9.50	10.42
3	United Kingdom	1,824,427	3.80	4.97
4	Japan	1,694,585	1.09	4.61
5	Germany	1,551,543	3.59	4.22
6	France	1,103,707	2.40	3
7	India	1,084,422	9.46	2.95
8	Canada	970,336	3.84	2.64
9	Italy	936,918	4.59	2.55
10	Australia	840,791	6.66	2.29
11	Spain	825,399	4.71	2.25
12	Brazil	791,088	7.59	2.15
13	South Korea	714,331	4.93	1.94
14	Russia	616,395	11.43	1.68
15	Netherlands	548,489	4.33	1.49
16	Switzerland	417,766	5.11	1.14
17	Iran	401,528	10.56	1.09
18	Poland	364,627	8.63	0.99
19	Sweden	354,801	5.05	0.97
20	Taiwan	351,371	1.03	0.96

Subject area distribution of Indian Research Output

Indian research output is visualized in 22 major fields of research, as provided by the Dimensions database. India's research output is dominated by subjects like Medical & Health Sciences, Engineering, Chemical Sciences and Information & Computing Sciences. The subject-area distribution of Indian research output as well as the world-wide research output is shown in the figure below -

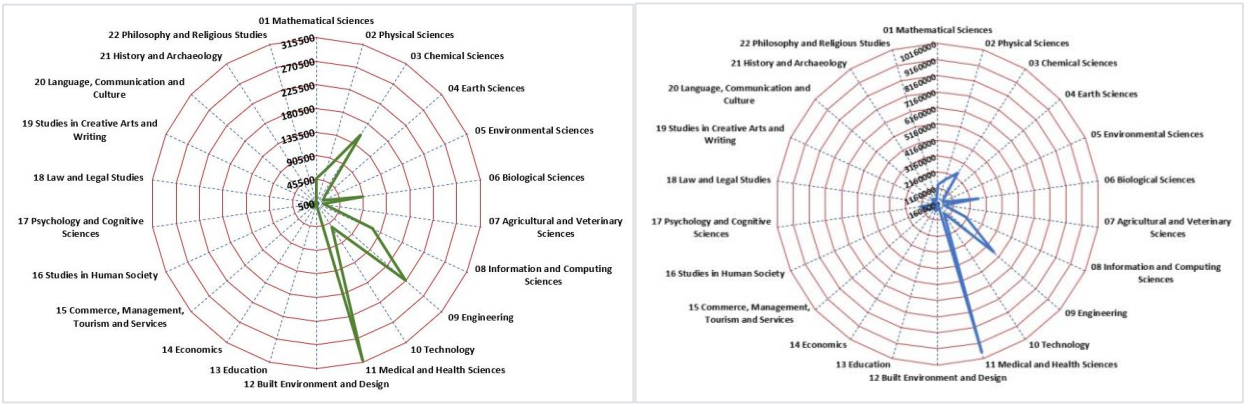


Fig. 5.3. Subject area distribution of India (left) and world (right) (2010-19)

Subject Area-wise CAGR, Global Share and Rank

As seen in the subject area distribution above, India's research performance varies across different subject areas. For the 2010 to 2019 period, India's global rank varies from 3rd in Chemical Sciences (and also Information & Computing Sciences, Technology) to 10th in Medical & Health Sciences, 15th in Studies in Human Society, 20th in History & Archaeology and 28th in Philosophy and Religious studies. These variations are observed in subject-area wise global shares as well. While, Indian Research Output in Technology constitutes 6.63% of global share, it is just 0.34% in Philosophy & Religious studies. The CAGR values in different subject areas also vary with Information and Computing Sciences (13.91%), Environmental Sciences (13.43%) and Engineering (12.83%) being the three fastest growing subject areas. The CAGR values for India in all the subject areas are found to be higher than the world average.

Table 5.3. Subject area-wise research output of India & World (2010-19)

Subject Area	Indian Research Publications	World Research Publications	India's Global Share (%)	India's Rank	India's CAGR (%)	World's CAGR (%)
01 Mathematical Sciences	47,936	1,371,625	3.49	7	10.78	3.22
02 Physical Sciences	67,270	1,716,510	3.92	9	7.49	3.26
03 Chemical Sciences	155,143	2,457,684	6.31	3	8.61	4.56
04 Earth Sciences	20,959	668,745	3.13	12	8.79	4.97
05 Environmental Sciences	14,591	508,979	2.87	11	13.43	8.09
06 Biological Sciences	89,824	2,689,897	3.34	10	7.28	3.25
07 Agricultural and Veterinary Sciences	13,518	574,047	2.35	12	6.59	3.44

08 Information and Computing Sciences	117,753	2,067,798	5.69	3	13.91	5.19
09 Engineering	224,630	4,726,435	4.75	4	12.83	5.98
10 Technology	54,999	829,746	6.63	3	12.78	2.76
11 Medical and Health Sciences	312,250	9,742,475	3.21	10	7.79	3.86
12 Built Environment and Design	2,504	187,021	1.34	15	14.4	8.6
13 Education	5,879	584,798	1.01	12	9.63	8.35
14 Economics	10,666	527,544	2.02	12	13.68	5.62
15 Commerce, Management, Tourism and Services	12,979	642,452	2.02	9	14.72	5.55
16 Studies in Human Society	10,967	1,012,661	1.08	15	12.68	4.94
17 Psychology and Cognitive Sciences	17,865	1,221,175	1.46	13	14.87	3.63
18 Law and Legal Studies	1,631	232,805	0.70	18	13.65	6.13
19 Studies in Creative Arts and Writing	621	162,723	0.38	21	13.55	2.36
20 Language, Communication and Culture	4,623	627,089	0.74	16	9.96	5.07
21 History and Archaeology	2,438	533,187	0.46	20	8.35	3.58
22 Philosophy and Religious Studies	1,466	424,934	0.34	28	11.56	2.65

Citations received by Indian Research output during 2010 - 2019

The Indian Research Output during 2010 to 2019 received a total of 11,805,480 citations. India's global share of citations has increased from 2.43% in 2010 to 4.48% in 2019 (a growth of 2.05% points). In terms of citation rank, India's citation rank has improved from 14th in 2010 to 9th in 2019 (a jump of 5 places).

Table 5.4. Citation volume and global share for India (2010-19)

Year	Volume	Global Share (%)	Citation Rank
2010	1,149,114	2.43	14
2011	1,213,800	2.6	14
2012	1,291,442	2.89	14
2013	1,328,138	3.05	12
2014	1,411,830	3.44	12
2015	1,332,899	3.52	12
2016	1,286,448	3.83	12
2017	1,162,771	4.04	11
2018	958,622	4.26	9
2019	670,416	4.48	9

Comparing these results with respect to other countries

India ranks at 12th place in terms of citation rank during the period 2010 to 2019. However, India's citation rank has improved from 14th in 2010 to 9th in 2019 (a jump of 5 places). Among the countries with highest citation share and rank, the United States is at rank 1, with a global share of 34.84% during 2010 to 2019, followed by China with 14.74% in 2010 to 2019. Other

major countries are the United Kingdom with 10.52% global share in citations, Germany with 8.51% of global citations and Canada with 5.51% of global share during 2010 to 2019 period.

The figure below presents the global share of citations, in 2010 and 2019, of the 20 selected countries.

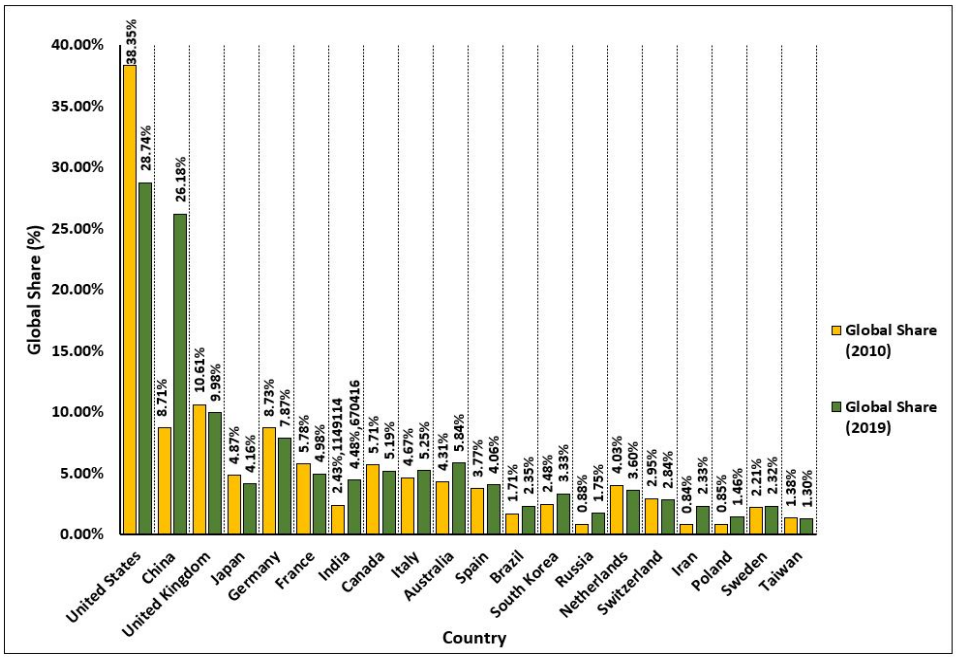


Fig. 5.4. Global share of citations for selected countries (2010-19)

Relative Citation Ratio (RCR) of India in different subject areas

The Relative Citation Ratio (RCR) indicates relative citation performance of a publication when comparing its citation rate to that of other publications in its area of research. A value of more than 1 shows a citation rate above average. India's research output during 2010 to 2019, when divided into 22 major subject areas is as shown below. It can be observed that subject areas - Environmental Science, Agriculture & Veterinary Sciences, Engineering, Earth Sciences and Biological Sciences etc. have citation rate higher than the world average, whereas subject areas - Law & Legal Studies, Philosophy & Religious Studies, Education, Built Environment & Design and Psychology & Cognitive Sciences etc. has a citation rate lower than the world average.

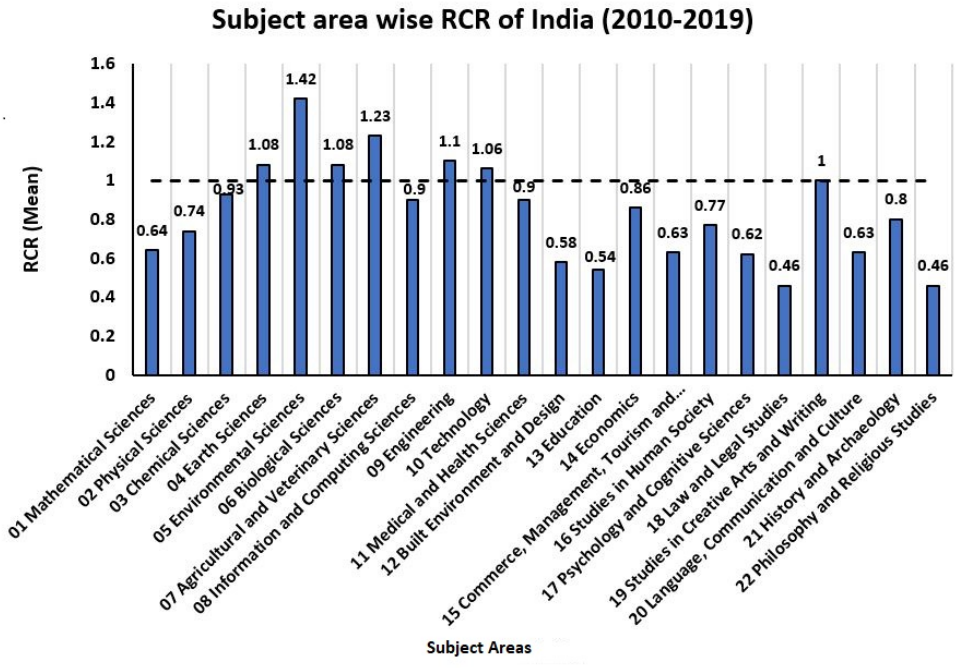


Fig. 5.5. Subject area-wise Relative Citation ratio of India

India's contribution to highly cited papers

Highly cited papers of a country are often measured by the number of publications that it contributes in the top 1% or top 10% most cited papers of the world. In the case of India, it is observed that India's contribution to the top 1% of highly cited papers has grown from 1.85% in 2010 to 4.3% in 2019. Similarly, India's contribution in the top 10% of highly cited papers of the world has grown from 2.28% in 2010 to 4.52% in 2019. The figure below shows the year-wise percentage contribution of India to the top 1% and top 10% highly cited papers of the world.

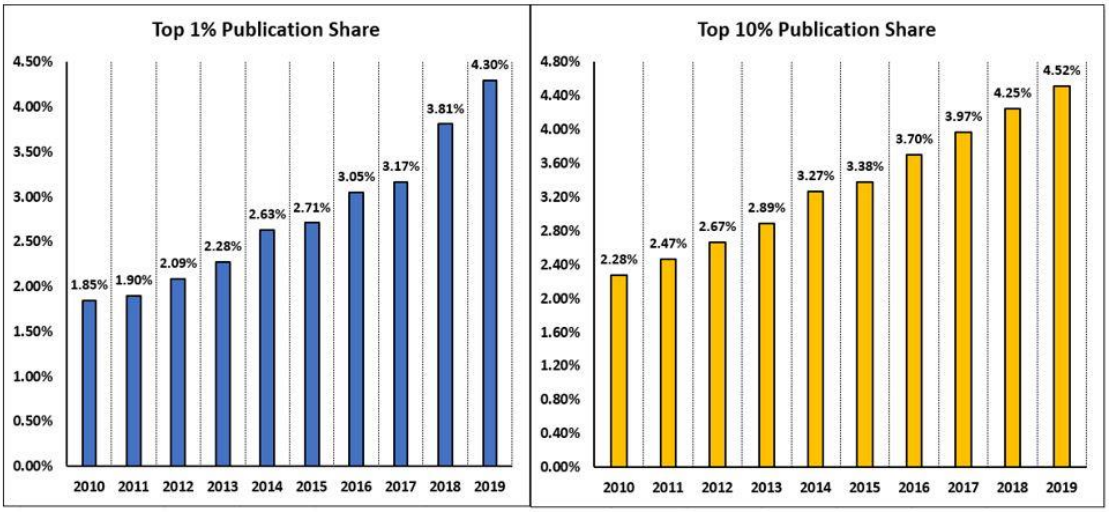


Fig. 5.6. India's share in top 1% and top 10% cited papers

When compared with contribution to top 1% highly cited papers of other major countries, it is observed that China has gained significantly with an increase from 7.78% share in 2010 to 33.2% share in 2019. The United States on the other hand shows a decline from 50.1% share in 2010 to 36.96% share in 2019. Other countries to gain are Japan, India, Italy, Australia, Spain, etc. The countries to lose in their share of top 1% highly cited papers are Germany, France, Canada, etc. The figure below shows the share of top 1% highly cited papers of the major countries during 2010 and 2019.

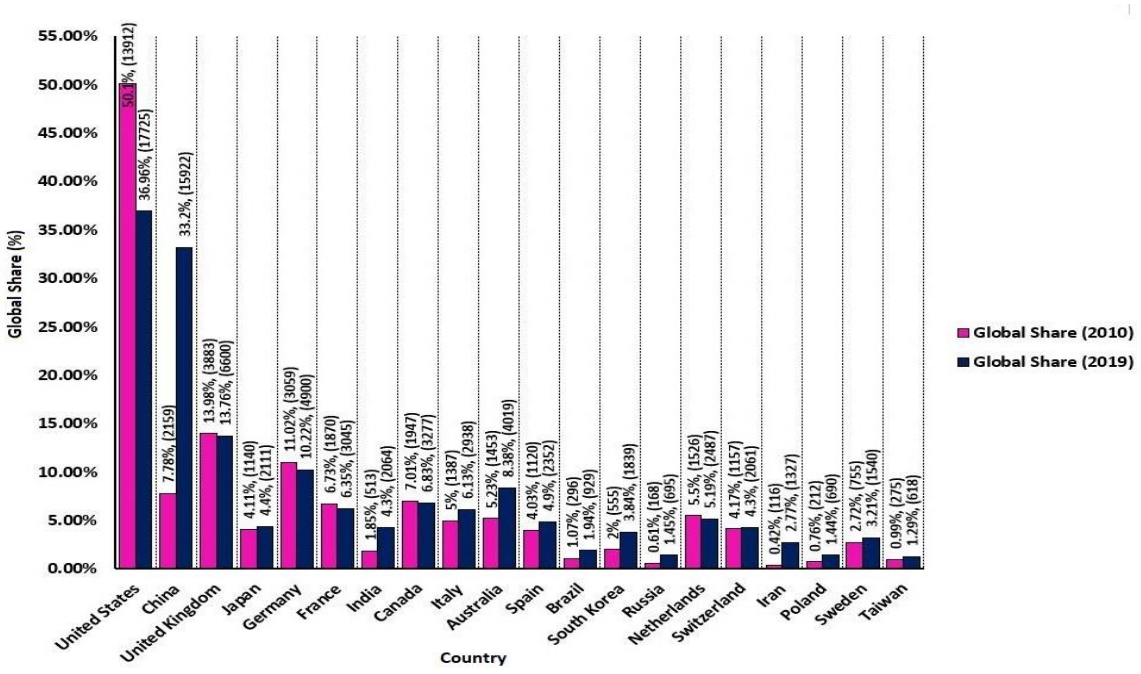


Fig. 5.7. Global share of top 1% cited papers of selected countries

Collaboration patterns in Indian Research output

India's research output during 2010 to 2019 includes research output involving domestic as well as international collaboration. While about 60% of the research output has authors from a single institution, about 15% research output involves domestic collaboration (collaboration between institutions within India). Approximately 20% of the research output involved collaboration at international level. The figure below shows the different types of research output from India for the period 2010 to 2019.

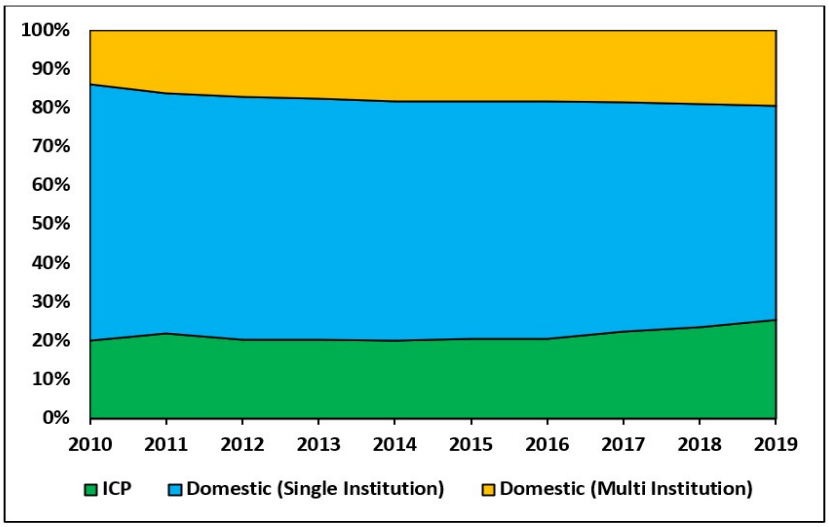


Fig. 5.8. India's collaboration patterns

International Collaboration Patterns

India's international collaboration networks seem to have improved during 2010 to 2019. In 2010, a total of 18.92% of India's research output involved international collaboration which has grown to 22.98% of the total research output in 2019. Since 2016, the growth in international collaboration is more steep. The figure below shows the percentage share of internationally collaborated papers in India's research output.

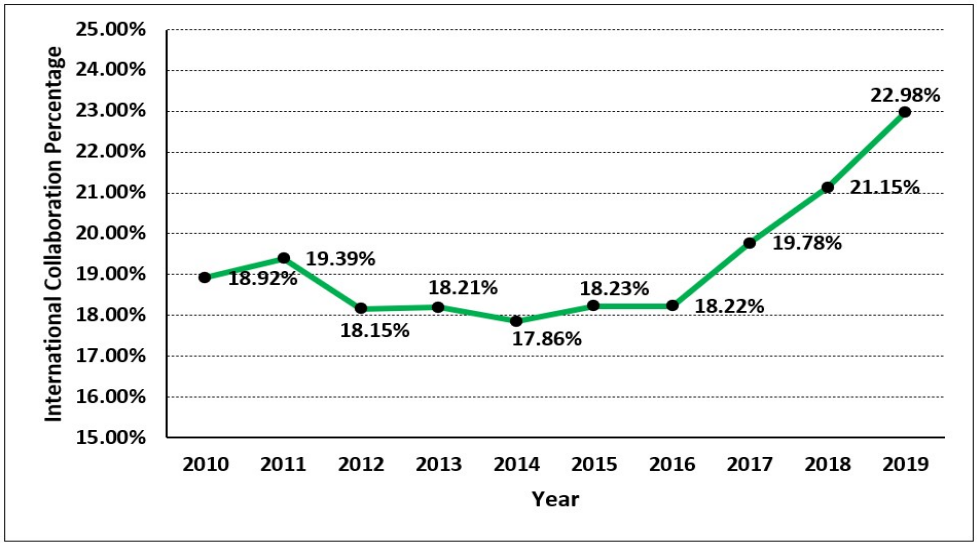


Fig. 5.9. Proportion of internationally collaborated papers in Indian research output

The amount of internationally collaborated papers from India are, however, lesser as compared to the 20 major countries. For example, the United Kingdom has 48.73% of its research output that involves international collaboration. Similarly, France has 50.43%, Australia has 50.98%, and Switzerland has 65.63% of its research output, during 2010 to 2019, involving international collaboration. The table below shows international collaboration patterns of the 20 major countries considered.

Table 5.5. International collaboration patterns of selected countries (2010-19)

Rank	Country	TP (2010 - 2019)	ICP (2010 - 2019)	ICP (%)
1	United States	6,181,247	1,959,644	31.70
2	China	3,828,795	883,947	23.09
3	United Kingdom	1,824,427	889,118	48.73
4	Japan	1,694,585	344,508	20.33
5	Germany	1,551,543	732,467	47.21
6	France	1,103,707	556,554	50.43
7	India	1,084,422	211,740	19.53
8	Canada	970,336	460,453	47.45
9	Italy	936,918	423,813	45.23
10	Australia	840,791	428,650	50.98
11	Spain	825,399	365,192	44.24
12	Brazil	791,088	202,983	25.66
13	South Korea	714,331	192,027	26.88
14	Russia	616,395	160,458	26.03
15	Netherlands	548,489	308,024	56.16
16	Switzerland	417,766	274,177	65.63
17	Iran	401,528	91,611	22.82
18	Poland	364,627	116,614	31.98
19	Sweden	354,801	215,648	60.78
20	Taiwan	351,371	101,556	28.9

India's major collaborating partner countries

India's major collaborating partner countries during 2010 to 2019 includes - United States of America (33.09%), United Kingdom (12.42%), Germany (9.19%), China (8.87%), South Korea (7.72%) and Australia (7.06%). The figure below shows a list of top 25 collaborating partner countries along with the number of collaborated papers during 2010 to 2019.

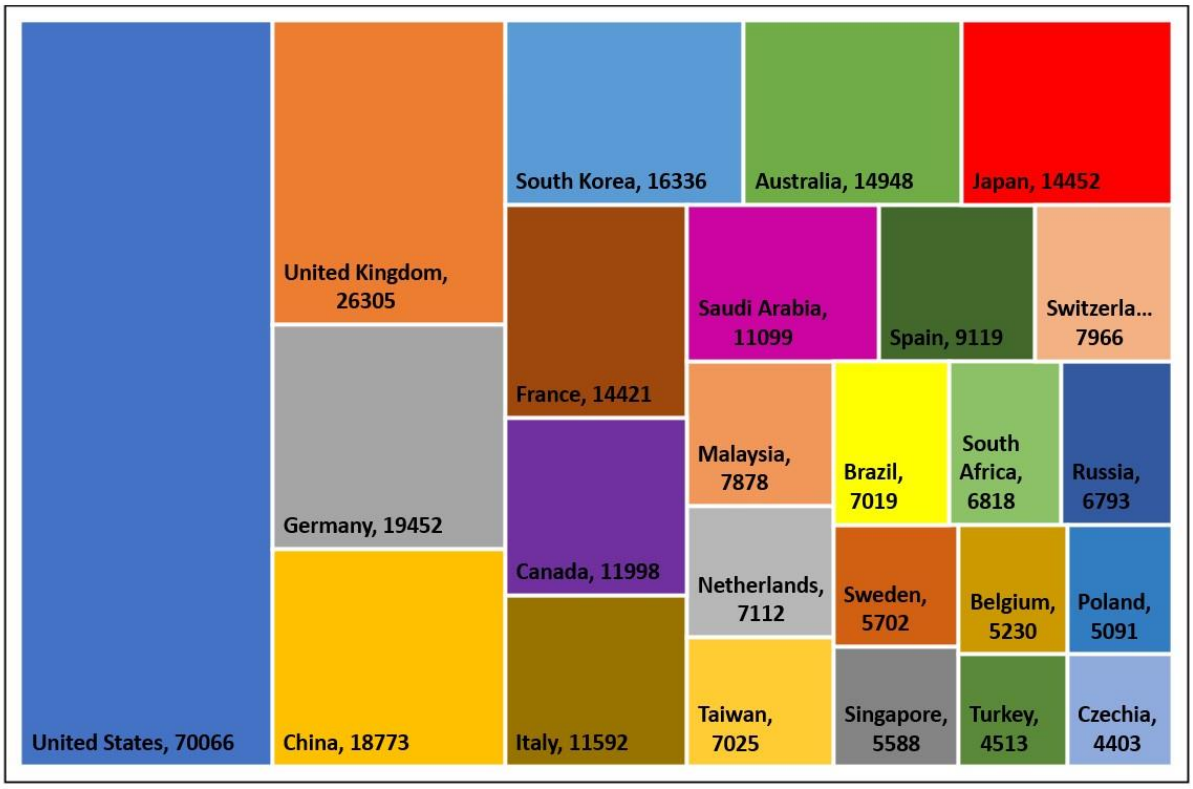
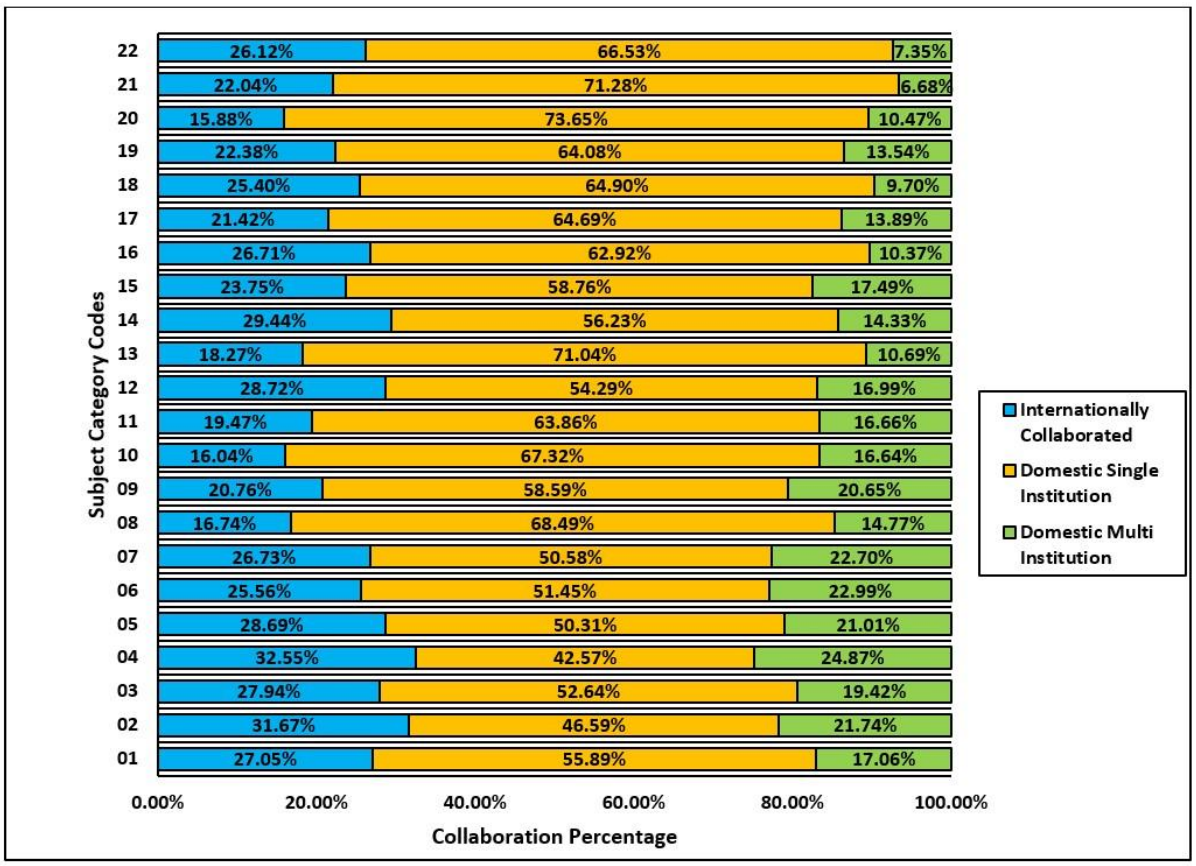


Fig. 5.10. India's major collaborating partners

Subject area-wise distribution of domestic and Internationally Collaborated papers

The international collaboration patterns in Indian research output vary across different subject areas. It ranges from a low of 15.88% in Language, Communication and Culture to 32.55% in Earth Sciences. Subject areas with relatively higher international collaboration percentage are Physical Sciences (31.67%), Economics (29.44%), Built-Environment and Design (28.72%), Environmental Sciences (28.69%). The domestic multi-institution collaborative output varies across different subject areas. For example, Earth Sciences has 24.87% research output as multi-institution collaboration, whereas History and Archaeology has only 6.68% of its research output involving domestic multi-institutional collaboration. The figure below presents the subject area-wise distribution of domestic and internationally collaborated research output of India.



**Subject Codes - 01-Mathematical Science, 02-Physical Sciences, 03-Chemical Sciences, 04-Earth Sciences, 05-Environmental Sciences, 06-Biological Sciences, 07-Agricultural and Veterinary Sciences, 08-Information and Computing Sciences, 09-Engineering, 10-Technology, 11-Medical and Health Sciences, 12-Built Environment and Design, 13-Education, 14-Economics, 15-Commerce, Management, Tourism and Services, 16-Studies in Human Society, 17-Psychology and Cognitive Sciences, 18-Law and Legal Studies, 19-Studies in Creative Arts and Writing, 20-Language, Communication and Culture, 21-History and Archaeology, 22-Philosophy and Religious Studies

Fig. 5.11. Subject area wise collaboration patterns

Citation impact of Internationally Collaborated Papers

The International Collaboration seems to have an advantage in terms of citation impact as compared to domestic papers. For example, the average citations per paper (ACPP) for domestic papers is 7.95, whereas the average citation per paper for Internationally Collaborated papers is 18.65. Similarly, the cited percentage of domestic papers is 76.75% whereas for internationally collaborated papers, it is 89%. Further, International Collaboration with different countries shows different impacts, as shown in the figure below. For example, collaboration with Switzerland leads to a cited percentage of more than 93%, with an ACPP of 35. On the other hand, collaboration with Japan has a cited percentage of 88%, with an ACPP value of 24.5.

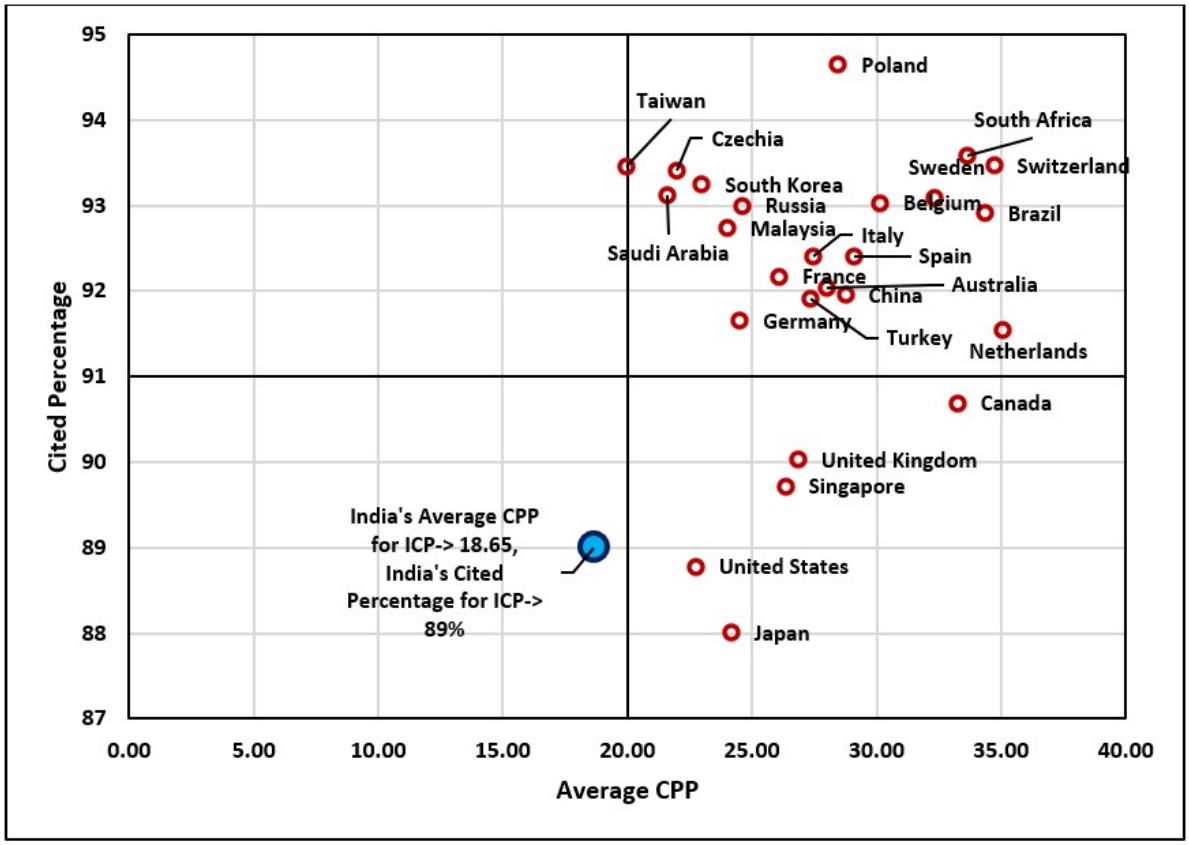


Fig. 5.12. Citation Impact of selected countries

Gender Distribution of Indian Research output

The Indian Research output during 2010 to 2019 was analysed to identify the gender distribution patterns. More precisely, the gender of the first author (leading author) for all the papers, has been determined using the Gender-API service. It is observed that only 29.3% of Indian papers are Female 1st authored, as compared to 70.7% Male 1st authored papers. The distribution of Female and Male 1st have remained almost the same during 2010 to 2019 period. The figure below shows the year-wise gender distribution of Indian Research output.

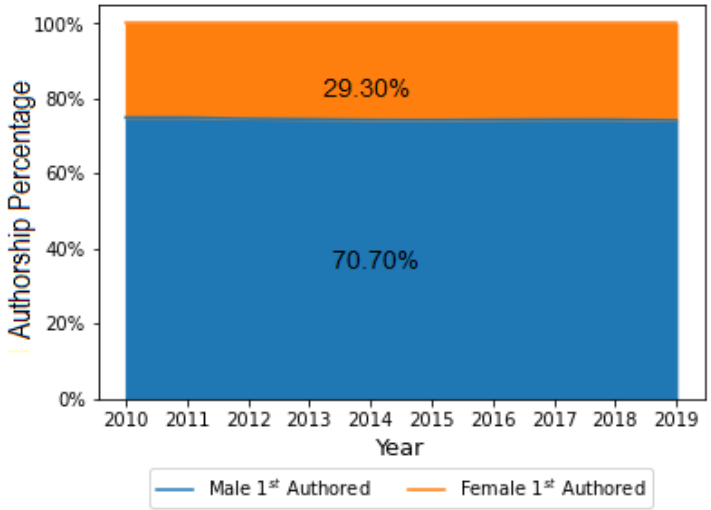


Fig. 5.13. Gender distribution in India's research output

Subject area-wise Gender Distribution

The gender distribution of Indian papers are also analysed with respect to different subject areas. While the majority of the 22 subject areas have almost a similar percentage of Female 1st authored papers, subject areas like History & Archaeology, Built Environment & Design and Law & Legal studies have a slightly higher percentage of Female 1st authored papers. In general, only about one-fourth of the research papers in the majority of the subject areas have Female 1st author. The table below presents the percentage of Female and Male 1st authored papers in different subject areas.

Table 5.6. Subject area wise gender distribution patterns

Subject	papers 1st authored by (%)	
	Male	Female
01 Mathematical Sciences	74.63	25.37
02 Physical Sciences	75.20	24.80
03 Chemical Sciences	74.67	25.33
04 Earth Sciences	74.84	25.16
05 Environmental Sciences	73.84	26.16
06 Biological Sciences	74.01	25.99
07 Agricultural and Veterinary Sciences	74.75	25.25
08 Information and Computing Sciences	74.28	25.72
09 Engineering	74.55	25.45
10 Technology	74.67	25.33
11 Medical and Health Sciences	74.27	25.73
12 Built Environment and Design	72.14	27.86
13 Education	73.66	26.34
14 Economics	74.51	25.49
15 Commerce, Management, Tourism and Services	74.64	25.36
16 Studies In Human Society	74.84	25.16
17 Psychology and Cognitive Sciences	74.98	25.02
18 Law and Legal Studies	72.13	27.87
19 Studies In Creative Arts and Writing	74.07	25.93
20 Language, Communication and Culture	74.17	25.83
21 History and Archaeology	71.88	28.12
22 Philosophy and Religious Studies	73.28	26.72

International Collaboration patterns in Female and Male 1st authored papers

It was analysed whether there exist differences in the propensity for International Collaboration in Female and Male 1st authored papers. For this purpose, the proportion of papers that involve international collaboration in both the sets (Female 1st authored and Male 1st authored papers) were identified through the 'Country' information in the Author-affiliation field. It is observed that both Female and Male 1st authored papers have almost similar proportion of papers involving International Collaboration, with the International Collaboration Proportion in Female 1st authored publications increasing from 9.47% in 2010 to 23.08% in 2019 and International Collaboration Proportion in Male 1st authored publications increasing from

11.67% in 2010 to 23.34% in 2019. The figures below show the international collaboration patterns in Female and Male 1st authored papers.

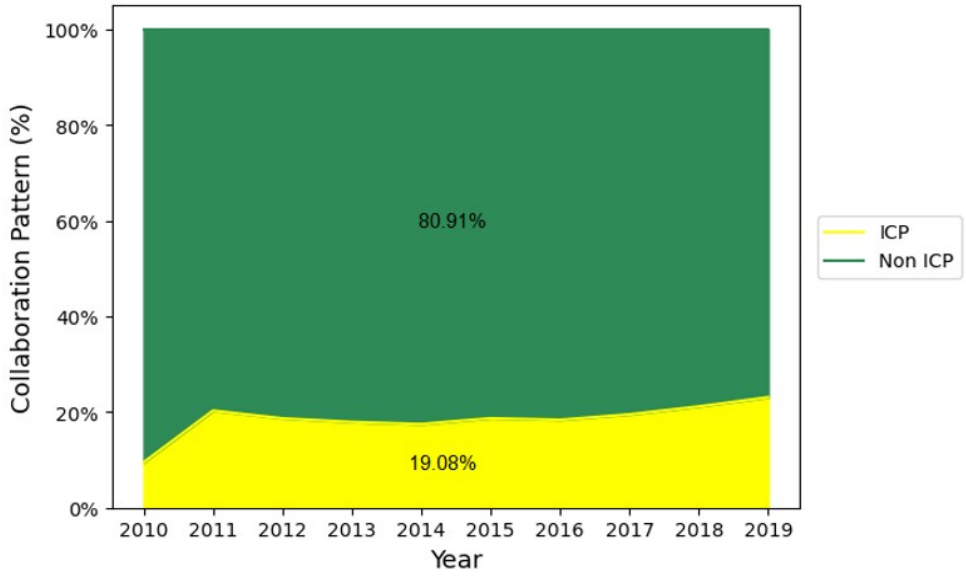


Fig. 5.14. Collaboration patterns in female authored papers

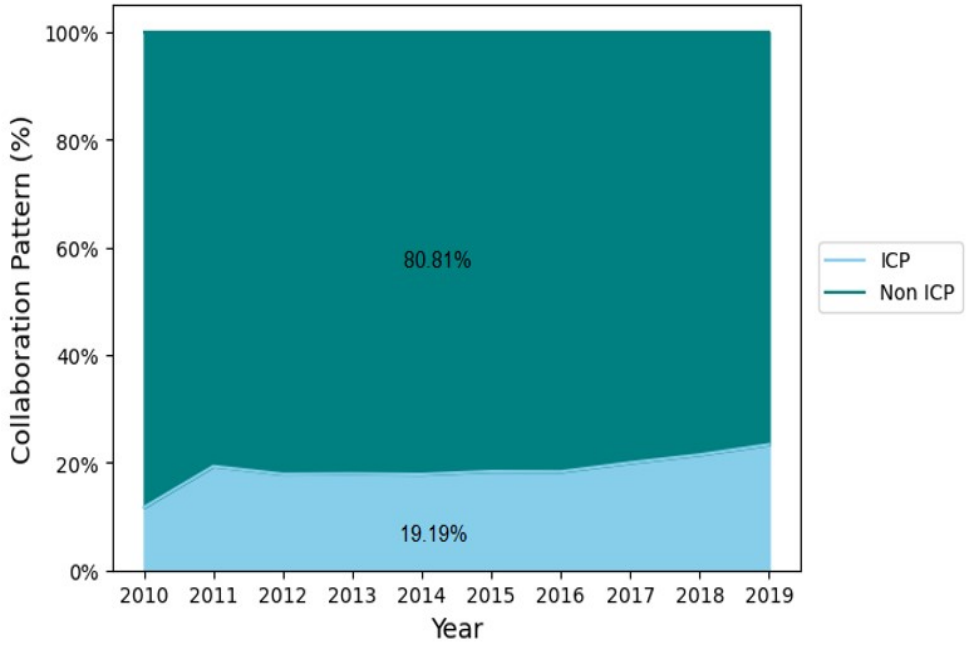


Fig. 5.15. Collaboration patterns in male authored papers

Citation Impact of Female and Male 1st authored papers

The citation impact of Female and male 1st authored papers are analysed by computing the cited percentage (proportion of papers that attracted at least one citation) and Average Citations Per Paper for both the sets. It is observed that, in general, Female and Male 1st authored papers have similar cited percentage values during 2010 to 2019 period. Further, the Average Citations per Paper values of Female and Male 1st authored papers are also similar, with very minor variations. The table below shows the year-wise values of cited percentage and citations per paper for both Female and Male 1st authored papers.

Table 5.7. Cited percentage and citations per paper in female and male authored papers

Year	Cited Percentage		Citations per Paper	
	Female 1st per paper	**Male 1st per paper**	**Female 1st per paper**	**Male 1st per paper**
2010	12.88 %	16.34 %	18.79	18.90
2011	15.25 %	16.12 %	17.48	17.31
2012	17.76 %	16.66 %	15.04	15.20
2013	18.22 %	17.20 %	13.94	14.23
2014	19.01 %	18.09 %	12.47	13.11
2015	19.90 %	19.02 %	11.16	11.53
2016	19.14 %	19.11 %	9.82	10.02
2017	20.09 %	20.52 %	8.49	8.65
2018	23.66 %	24.04 %	6.81	6.93
2019	30.63 %	30.73 %	4.60	4.71
Overall	**79.25 %**	**79.28 %**	**10.66**	**10.90**

Open Access availability of Indian Research Output

The Indian research output during 2010 to 2019 has been analysed to identify what proportion of research output is available in Open Access. It is observed that Open Access availability of Indian Research Output has improved from 25.86 % in 2010 to 35.13 % in 2019. In overall terms, 33.61% of the Indian Research output during the 2010-2019 period is found to be available in Open Access. The figure below (on the left) shows year-wise percentage of Open Access availability of the overall Indian Research Output during 2010 to 2019 period. Among the Open Access papers, Gold Open Access is the most prevalent type (increasing from 43.01% in 2010 to 63.44% in 2019). This is followed by Green Open Access (19.67%), Bronze (16.1%) and Hybrid (7.12%). The figure below (on the right) shows year-wise Open Access sub-types of during the period 2010 to 2019.

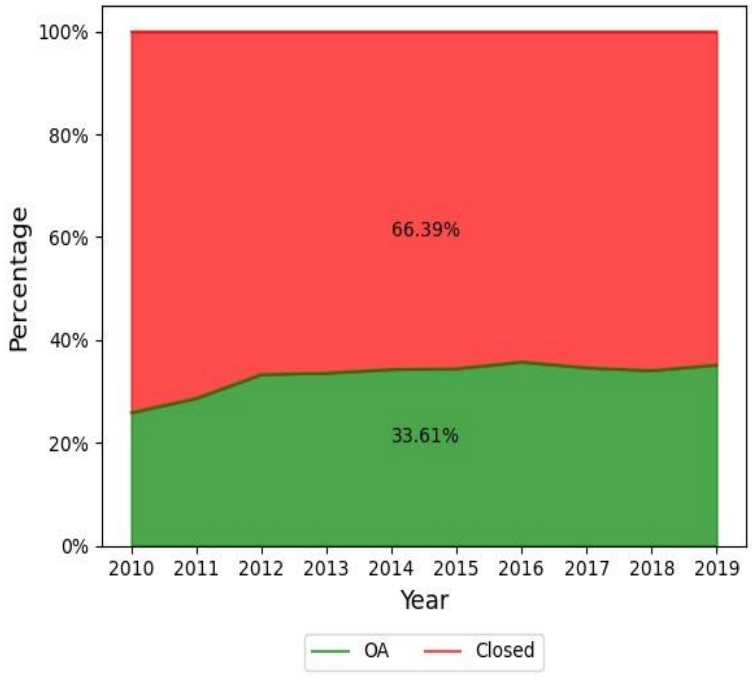


Fig. 5.16. Open access patterns in Indian research output

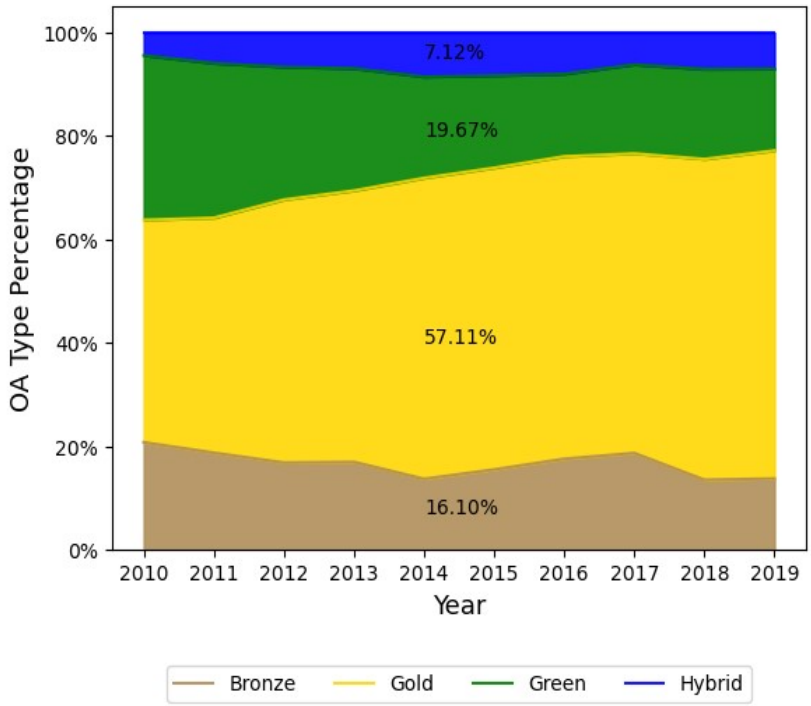


Fig. 5.17. Open access subtype distribution

Comparison with other major countries

The Open Access levels of India are compared with 20 other major countries. It is observed that India is on the Lower side of Open Access availability level, with only 33.61% papers available in Open Access. In comparison, Brazil has 62.91% of the research papers in Open Access, Switzerland has 55.79% papers in Open Access, the United Kingdom 55.59% papers in Open Access, Netherlands (54.08%), Sweden (53.32%), Poland (51.68&). Only China (26.44%), Iran (28.3%) and Taiwan (31.03%) have OA proportion less than India. The table below shows OA percentage for 20 major countries.

Table 5.8. Comparison of OA patterns with other selected countries

Country	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Australia	30.11	33.79	37.54	39.94	41.55	44.03	46.99	48.56	48.92	48.97
Brazil	60.55	61.01	62.43	61.46	60.08	61.44	64.54	64.88	65.22	63.93
Canada	31.66	33.84	36.22	38.32	39.64	42.15	44.06	46.07	47.67	47.77
China	12.23	14.41	19.07	19.79	22.26	27.64	30.28	32.5	32.9	34.45
France	31.16	36.84	38.12	39.09	40.83	44.15	46.96	49.96	53.27	58.69
Germany	28.52	34.54	37.03	37.59	40.13	42.62	45.29	46.27	48.71	50.79
India	25.86	28.63	33.27	33.55	34.25	34.4	35.71	34.56	34.03	35.13
Iran	17.37	21.52	25.67	25.02	27.61	28.93	30.69	30.47	31.2	32.49
Italy	29.06	33.16	35.89	37.95	40.48	43.28	45.72	49.06	50.78	52.9
Japan	23.1	27.1	29.25	31.57	34.38	38.79	40.83	36.56	39.12	40.85
Netherlands	40.69	43.56	44.52	43.65	45.31	51.99	57.96	63.96	68.22	69.36
Poland	29.24	37.63	42.49	43.78	51.16	52.34	54.39	57.45	59.99	62.97
Russia	13.27	18.18	22.09	24.21	25.67	30.86	34.36	37.17	42.16	50.57
South Korea	23.78	26.5	29.97	31.65	34.13	36.91	39.34	42.14	44.5	46.83
Spain	32.48	36.27	39.92	40.8	45.07	48.27	51.15	54.52	57.06	58.98

Sweden	36.81	41.92	45.04	47.19	50.32	52.64	55.41	59.51	64.71	66.33
Switzerland	42.61	46.99	50.46	51.87	53.74	55.85	59.44	60.11	62.96	64.32
Taiwan	18.14	20.33	25.85	26.91	29.78	34.13	35.32	38.45	40.18	41.95
UK	33.76	37.58	41.24	45.57	51.34	57.2	65.79	69.11	71.06	69.15
USA	35.57	38.75	41.05	42.26	43.81	47.25	49.62	49.84	51.66	51.64

Subject area-wise Open Access availability of Indian Research Output

While India has overall 33.61% papers available in Open Access for the 2010- 2019 period, Open Access availability varies across different subject areas. These variations are as large as 48%. Subjects like Studies in Creative Arts and Writing (10.93%), Information and Computing Science (14.17%) and Technology (15.21%) have a very low proportion of papers available in OA; subjects like Medical & Health Sciences (58.66%), Biological Sciences (41.54%) and Physical Sciences (38.74%) have relatively higher proportion of papers available in Open Access.

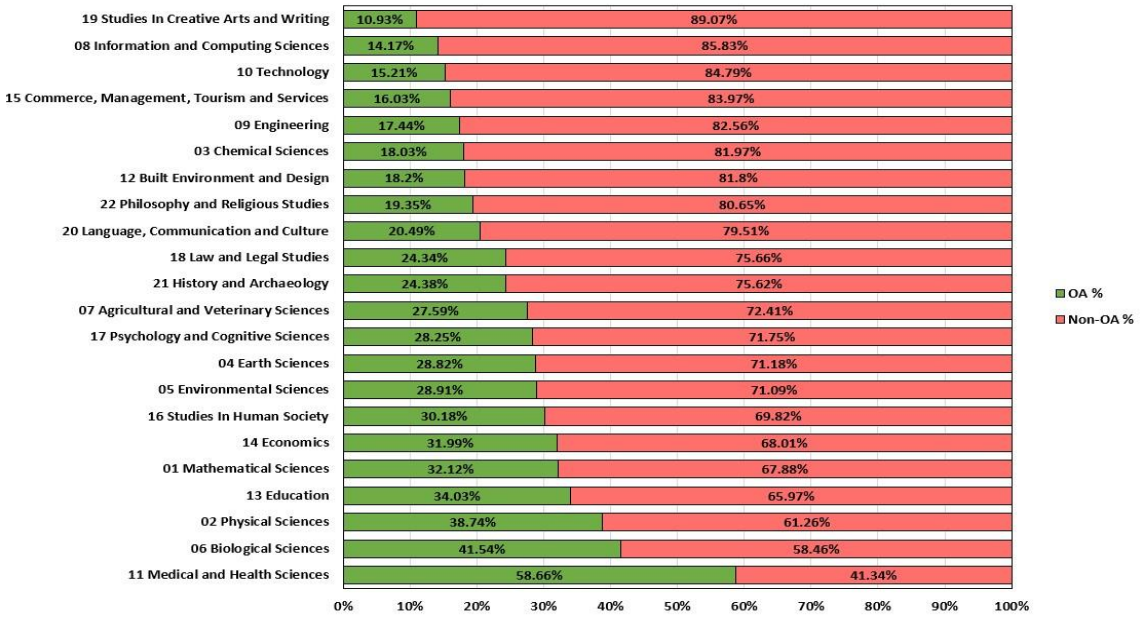


Fig. 5.18. Subject area wise variation in open access availability

Open Access availability of Funded Research Output

As it is often a condition and/or expectation of the funding agencies that research outputs out of publicly funded research projects should be openly accessible, therefore the research outputs out of the funded projects is analysed to find out what proportion of the research output is available in Open Access. It is observed that only about 29.06% of the funded research output in India is available in OA, though the availability has increased slightly from 25.22% in 2010 to 30.04% in 2019. The figure below (on the left) shows the year-wise Open Access availability of the funded research output. Out of the total funded research output during 2010-2019, 71% is Closed Access, 12% Gold Open Access, 9% Green Open Access, 5% Bronze Open Access and 3% Hybrid Open Access. The pie-chart below (on the right) shows the distribution.

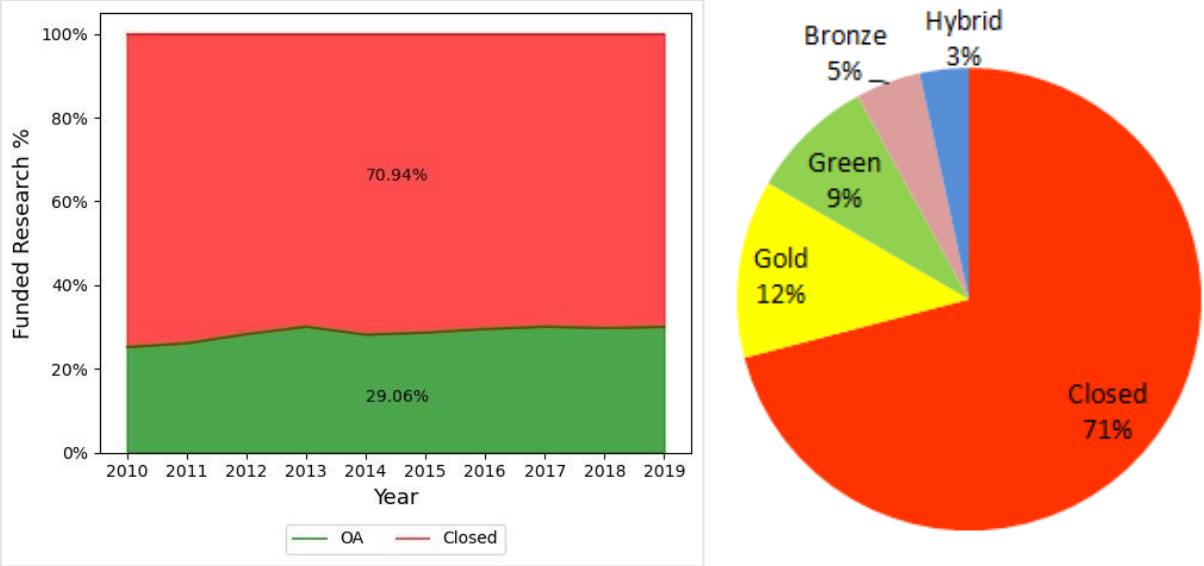


Fig. 5.19. Open access availability of funded research output

Social Media Visibility of Indian Research Output

The altmetrics (used for Alternative Metrics) have recently emerged as a popular measure of impact of research, in addition to the traditionally used measure of citations. Altmetrics aims to capture the social media activity around scientific research. Some studies have suggested that on an average, about 48% of Research output of the world gets some Social Media attention. In this context, the social media attention level for Indian Research Output during 2010-2019, has also been computed. It is observed that out of the total research output in 2010, 13.7% of the research output gets some social media attention. This level has continuously increased during the period, reaching to 25.2% in 2017 and settling down to 23.3% in 2019. The figure below shows the year-wise altmetric coverage percentage for the Indian Research output during 2010 - 2019 period.

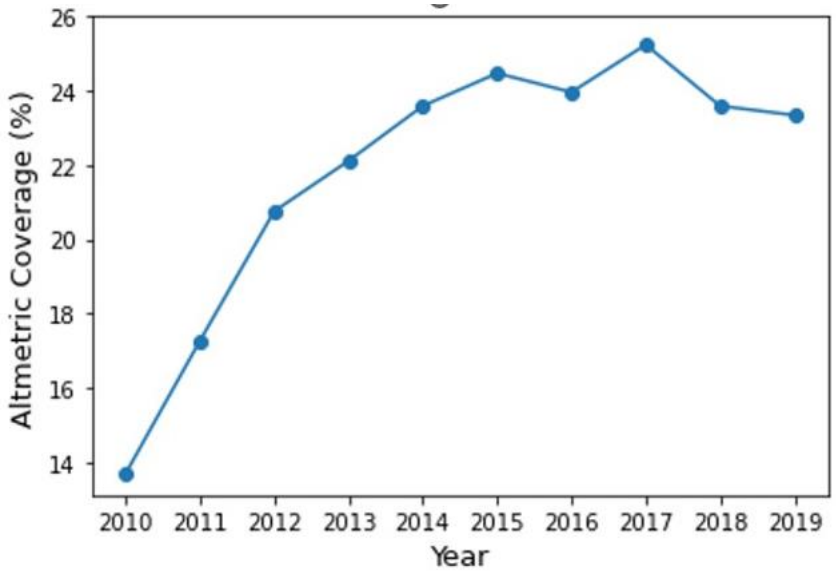


Fig. 5.20. Social media visibility of Indian research output

Coverage and Mentions in different platforms

The social media coverage and mentions per paper have also been analysed for certain selected platforms. In the case of Twitter, the coverage percentage has increased from 2.84% in 2010 to 19.4% in 2019, with 6.20 average tweets per paper.

In case of Mendeley, the coverage percentage has increased from 13.5% in 2010 to 24.84% in 2017 and finally reaching 22.8% in 2019, with 41.33 average mentions per paper. The figure below shows the year-wise coverage percentage of the research in Mendeley.

In the case of Facebook, the coverage percentage has increased from 1.19% in 2010 to 4.14% in 2015, before settling down at 2.75% in 2019, with 1.94 average mentions per paper. The figure below shows the year-wise coverage percentage of the research in Facebook.

Subject area-wise variations in social media coverage

The social media coverage of a research output in different subject areas vary significantly, ranging from coverage percentage of 40.18% for Biological Sciences, to 9.47% in Information & Computing Sciences. The coverage variations are also seen for different platforms, with varied values of coverage percentage and average mentions per paper. The table below shows the overall as well as platform-wise coverage percentage and average mentions per paper.

Table 5.9. Subject area wise variations in social media coverage

Subject	Altmetric Coverage	Twitter Coverage	Average Tweets per paper	Facebook Coverage	Average Facebook mentions per paper	Mendeley Coverage	Average Mendeley mentions per paper
01 Mathematical Sciences	16.28	10.56	4.75	1.75	1.39	15.48	22.59
02 Physical Sciences	30.73	21.6	3.64	3.76	1.61	29.85	24.18
03 Chemical Sciences	25.71	17.25	2.34	2.03	1.46	25.39	31.79
04 Earth Sciences	27.47	16.43	9	3.54	1.78	27.26	45.8
05 Environmental Sciences	34.01	23.37	9.02	5.81	1.92	33.65	75.15
06 Biological Sciences	40.18	29.67	6.2	5.68	1.89	39.95	48.61
07 Agricultural and Veterinary Sciences	30.34	19.03	5.38	4.17	2.09	30.21	58.33
08 Information and Computing Sciences	9.47	4.02	12.05	0.81	1.32	9.34	42
09 Engineering	14.27	7.3	2.76	1.25	1.43	14.13	46.46
10 Technology	11.1	5.25	3.59	1.09	2.51	10.95	42.18
11 Medical and Health Sciences	31.32	21.61	7.97	6.29	2.19	30.93	44.01
12 Built Environment and Design	25.25	14.62	4.83	3.07	1.13	24.85	71.48
13 Education	17.81	12.54	5.59	3.62	1.45	17.54	38.91
14 Economics	21.64	13.15	6.65	3.07	1.49	21.07	48.74
15 Commerce, Management, Tourism and Services	19.91	12.09	4.88	2.77	1.61	19.57	88.85
16 Studies In Human Society	31.19	22.42	7.9	5.54	1.91	30.28	50.79

17 Psychology and Cognitive Sciences	25.54	17.3	7.74	6.19	1.73	25.17	46.88
18 Law and Legal Studies	26.48	19.57	16.97	3.24	2.4	23.55	24.48
19 Studies In Creative Arts and Writing	24.6	16.56	4.83	4.34	1.26	23.63	19.29
20 Language, Communication and Culture	16.65	10.88	7.74	3.28	1.35	15.57	26.98
21 History and Archaeology	27.18	18.64	12.07	7.22	3.24	25.04	19.75
22 Philosophy and Religious Studies	28.34	20.44	6.77	5.25	1.23	26.36	28.98

Research Grants Volume

The volume of research funding to Indian Institutions, during the period 2010 - 2019, has increased significantly. While the total grant volume was 308.02 Million USD in 2010, it increased to more than double by 2019 (672.97 Million USD in 2019). The figure below (on the left) shows a year-wise amount of research funding in Million USD. Out of the total grants for research during 2010-2019, 38.71% are from domestic funding agencies and 61.29% are from international funding agencies. The domestic grants have increased marginally during this period. The figure below (on the right) shows distribution of domestic and international grants during 2010 - 2019.

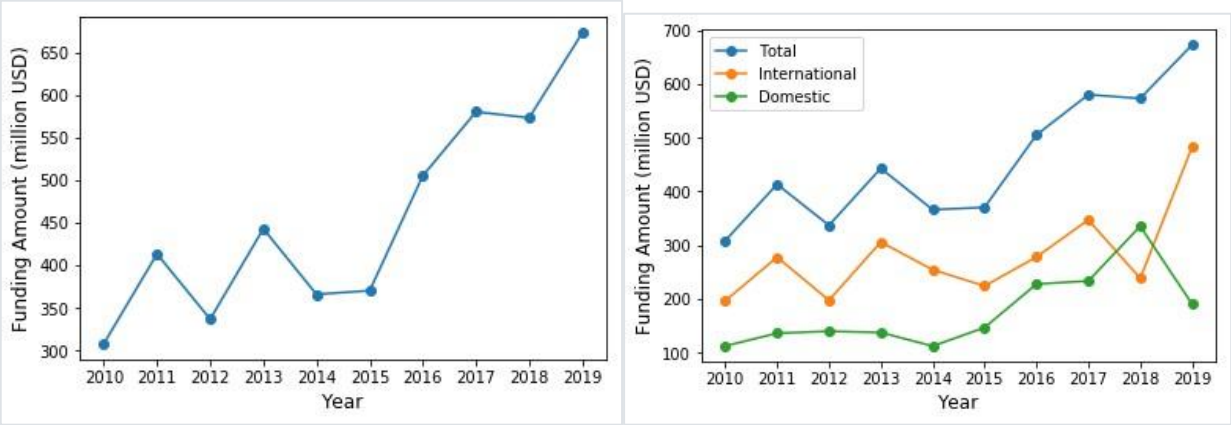


Fig. 5.21. Volume of research grants

Comparison with other major countries

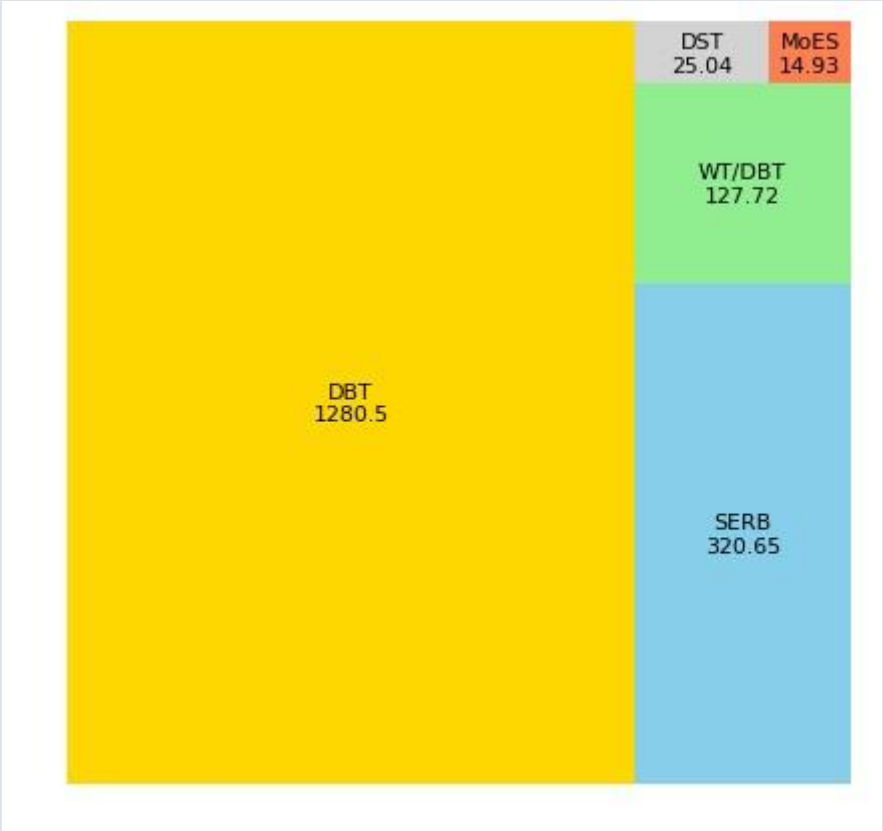
In terms of total volume of research grants during 2010 - 2019, the United States leads with a total grant volume of 406.5 billion USD, followed by the United Kingdom (128.5 billion USD), Germany (126.2 billion USD). This is followed by France (58.5 billion USD), Spain (48.6 billion USD) and Italy (48 billion USD). India ranks 15th in Total Research Grant Volume with a value of 4.6 billion USD. Thus, the Research Grant volume for India is about 100 orders of magnitude lesser as compared to the United States, and 27 times less as compared to the United Kingdom and Germany. The table below shows the number and volume of research grants along with distribution of domestic and international grants. It is observed that the United States, Japan, China and Canada have predominantly domestic grants, whereas Brazil, France, Italy, Netherlands, Russia, South Korea and Spain have a major share of international grants.

Table 5.10. Volume of grants for selected countries

Country	No. of Grants	Total grants (million $)	Domestic (million $)	International (million $)
United States	532081	406544.58	393528.71 (96.80%)	13015.87 (3.20%)
United Kingdom	137156	128453.77	69130.75 (53.82%)	59323.03 (46.18%)
Germany	162791	126204.67	57775.39 (45.78%)	68429.29 (54.22%)
France	28688	58457.27	251.06 (0.43%)	58206.21 (99.57%)
Spain	18932	48615.29	747.91 (1.54%)	47867.38 (98.46%)
Italy	15149	48008.22	604.24 (1.26%)	47403.98 (98.74%)
Netherlands	24271	43518.59	300.12 (0.69%)	43218.47 (99.31%)
Switzerland	31725	43467.47	8827.18 (20.31%)	34640.29 (79.69%)
Sweden	44416	42765.12	14718.07 (34.42%)	28047.04 (65.58%)
China	392754	38436.46	33106.52 (86.13%)	5329.95 (13.87%)
Japan	323697	32123.81	28367.11 (88.31%)	3756.71 (11.69%)
Canada	265151	29129.55	23694.93 (81.34%)	5434.62 (18.66%)
Poland	66090	27834.03	13171.54 (47.32%)	14662.48 (52.68%)
Australia	37203	20821.03	15807.16 (75.92%)	5013.87 (24.08%)
India	18382	4568.94	1768.83 (38.71%)	2800.10 (61.29%)
Brazil	88682	2568.46	0.00 (0%)	2568.46 (100%)
Russia	89590	2165.51	40.43 (1.87%)	2125.07 (98.13%)
South Korea	1558	2046.19	0.00 (0%)	2046.19 (100%)
Taiwan	1272	925.03	0.00 (0%)	925.03 (100%)
Iran	103	142.17	0.00 (0%)	142.17 (100%)

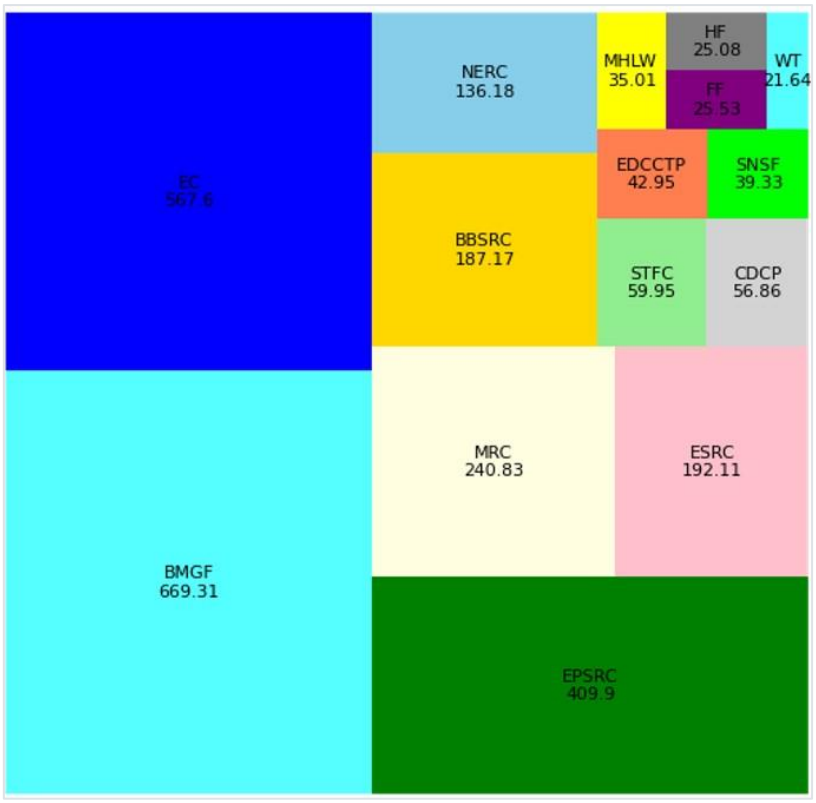
Major Funding Agencies

The Indian Research, during 2010 - 2019 period, has been funded by both domestic and international agencies. The major domestic funders are Department of Biotechnology (1,280.5 million USD), Science and Engineering Research Board (320.6 million USD), Wellcome Trust-DBT India Alliance (127.7 million), Department of Science and Technology (25 million USD) and Ministry of Earth Sciences (14.9 million USD). The major international funders include Bill and Melinda Gates Foundation (669 million USD), European Commission (568 million USD), Engineering and Physical Sciences Research Council (410 million USD), Medical Research Council (241 million USD) etc. The figure below (on the left) shows tree maps of major Domestic Funding Agencies and the figure below (on the right) shows tree maps of major International Funding Agencies.



**DBT: Department of Biotechnology, SERB: Science and Engineering Research Board, WT/DBT: Wellcome Trust/DBT India Alliance, DST: Department of Science and Technology, MoES: Ministry of Earth Sciences.

Fig. 5.22. Major national funding agencies



**BMGF: Bill & Melinda Gates Foundation, EC: European Commission, EPSRC: Engineering and Physical Sciences Research Council, MRC: Medical Research Council, ESRC: Economic and Social Research Council, BBSRC: Biotechnology and Biological Sciences Research Council, NERC: Natural Environment Research Council, STFC: Science and Technology Facilities Council, CDCP: Centers for Disease Control and Prevention, EDCCTP: European & Developing Countries Clinical Trials Partnership, SNSF: Swiss National Science Foundation, MHLW: Ministry of Health Labour and Welfare, FF: Ford Foundation, HF: Hewlett Foundation, WT: Wellcome Trust

Fig. 5.23. Major international funding agencies

Subject area-wise distribution of grants

The volume of grants, during 2010 - 2019 period, in different subjects, vary significantly. Medical & Health Sciences, with a grant volume of 670 million USD, tops the chart. This is followed by subject areas like Studies in Human Society (364 million USD), Engineering (343 million USD), Biological Sciences (290 million USD), Information & Computing Sciences (246 million USD) and Environmental Sciences (225 million USD). The table below shows subject area-wise distribution of grants along with percentage distribution of Domestic and International grants in each subject area.

Table 5.11. Subject area-wise distribution of grants

Subject	No. of Grants	Amount Of Grants (Million$)	Domestic Grant (Million $)	International Grant (Million $)
01 Mathematical Sciences	29	31.34	1.31 (4.17%)	30.03 (95.83%)
02 Physical Sciences	80	84.39	1.66 (1.96%)	82.74 (98.04%)
03 Chemical Sciences	127	146.74	4.37 (2.98%)	142.37 (97.02%)

04 Earth Sciences	95	69.68	0.51 (0.74%)	69.16 (99.26%)
05 Environmental Sciences	82	225.38	0.95 (0.42%)	224.43 (99.58%)
06 Biological Sciences	418	289.65	72.2 (24.93%)	217.45 (75.07%)
07 Agricultural and Veterinary Sciences	74	85.28	0.58 (0.68%)	84.7 (99.32%)
08 Information and Computing Sciences	129	245.68	1.41 (0.57%)	244.27 (99.43%)
09 Engineering	251	343.04	1.02 (0.3%)	342.03 (99.7%)
10 Technology	27	46.49	1.7 (3.65%)	44.8 (96.35%)
11 Medical and Health Sciences	882	669.88	68.99 (10.3%)	600.89 (89.7%)
12 Built Environment and Design	8	3.41	0 (0%)	3.41 (100%)
13 Education	25	13.72	0 (0%)	13.72 (100%)
14 Economics	65	109.81	0 (0%)	109.81 (100%)
15 Commerce, Management, Tourism and Services	36	62.45	0 (0%)	62.45 (100%)
16 Studies in Human Society	208	363.82	0.49 (0.13%)	363.33 (99.87%)
17 Psychology and Cognitive Sciences	65	29.20	5.85 (20.04%)	23.35 (79.96%)
18 Law and Legal Studies	13	13.67	0 (0%)	13.67 (100%)
19 Studies in Creative Arts and Writing	4	0.78	0 (0%)	0.78 (100%)
20 Language, Communication and Culture	48	25.93	0 (0%)	25.93 (100%)
21 History and Archaeology	44	13.00	0 (0%)	13 (100%)
22 Philosophy and Religious Studies	5	2.45	0 (0%)	2.45 (100%)

Publications supported by grants

The publication output supported by research grants for India, are computed from the data. The table below shows year-wise funding volume, supported publications and publications per Million USD. It can be observed that the publications per Million USD value is close to 1 in the initial period, which decreases further to 0.6 publications per Million USD in 2018. The subject area-wise distribution of publications supported by grants are also shown below.

Table 5.12. Year-wise Publication volume supported by grants

Year	Funding Amount in million $	Resulting publications	Publication per million $
2010	308.02	321	1.042
2011	413.338	376	0.91
2012	336.836	462	1.372
2013	442.888	531	1.199
2014	365.928	393	1.074
2015	370.297	378	1.021
2016	505.225	398	0.788
2017	580.211	449	0.774

2018	573.222	368	0.642
2019	672.976	230	0.342

Table 5.13. Subject Area-wise Distribution of publications supported by grants

Subject	No. Of Grants	Amount Of Grants (Million $)	Resulting Publications	Publication Per Million
01 Mathematical Sciences	29	22.50	20	0.89
02 Physical Sciences	80	82.05	53	0.65
03 Chemical Sciences	127	142.86	66	0.46
04 Earth Sciences	95	66.02	46	0.70
05 Environmental Sciences	82	220.68	51	0.23
06 Biological Sciences	418	259.60	244	0.94
07 Agricultural and Veterinary Sciences	74	81.35	60	0.74
08 Information and Computing Sciences	129	221.30	82	0.37
09 Engineering	251	315.55	142	0.45
10 Technology	27	45.57	20	0.44
11 Medical and Health Sciences	882	517.38	339	0.66
12 Built Environment and Design	8	3.32	5	1.50
13 Education	25	11.08	10	0.90
14 Economics	65	98.85	40	0.40
15 Commerce, Management, Tourism and Services	36	34.77	17	0.49
16 Studies in Human Society	208	332.25	125	0.38
17 Psychology and Cognitive Sciences	65	24.89	31	1.25
18 Law and Legal Studies	13	12.95	8	0.62
19 Studies in Creative Arts and Writing	4	0.66	1	1.51
20 Language, Communication and Culture	48	16.27	21	1.29
21 History and Archaeology	44	10.40	24	2.31
22 Philosophy and Religious Studies	5	1.09	2	1.84

Indian Research Publications on Sustainable Development Goals

The Sustainable Development Goals (SDGs) or Global Goals are a collection of 17 interlinked global goals designed to be a "blueprint to achieve a better and more sustainable future for all". The SDGs were set up in 2015 by the United Nations General Assembly and are intended to be achieved by the year 2030. They are included in a UN Resolution called the 2030 Agenda or what is colloquially known as Agenda 2030.

**Source - https://sdgs.un.org

Fig. 5.24. The 17 SDGs

In this context, India's research output during 2010 - 2019 has been analysed to find out what amount of research output is related to the Sustainable Development Goals. A publication is said to be about a Sustainable Development Goal (SDG), if it is related to the concerned SDG in one way or another. The Dimensions database provides an SDG related tagging of research publications through its own algorithmic approaches (apparently based on Machine Learning). It is observed that the three SDGs (7-Affordable & Clean Energy, 3-Good Health & Well Being and 13-Climate Action) have got significant attention of the Indian Research community, as measured by Indian Research publications. For the SDG 7-Affordable & Clean Energy, the number of research publications have increased from 1313 in 2010 to 9612 in 2019 (with a CAGR value of 22%). For SDG 3-Good Health & Well-Being, research publications have increased from 1408 in 2010 to 5582 in 2019 with a CAGR of 14.8%. Similarly, the SDG 13-Climate Action has also seen a growth of 336 publications in 2010 to 2513 publications in 2019 (with a CAGR value of 22.3%). There is also some research on other SDGs like 2-Zero Hunger, 4-Quality Education and 11-Sustainable cities and communities, though the volume in these cases are much lesser. The figure below shows the year-wise research output from India, on the 17 different SDGs. A tree map of the total research output on different SDGs during the period 2010-2019 is also shown thereafter.

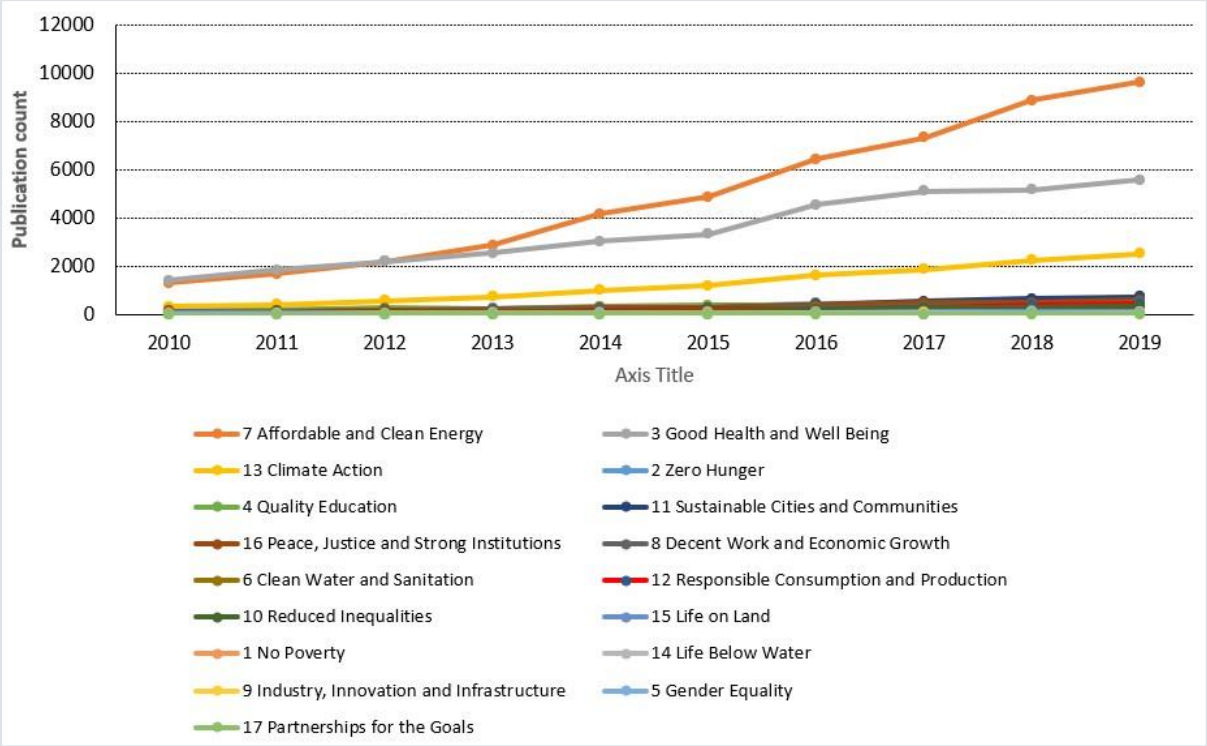


Fig. 5.25. India's research output on SDGs

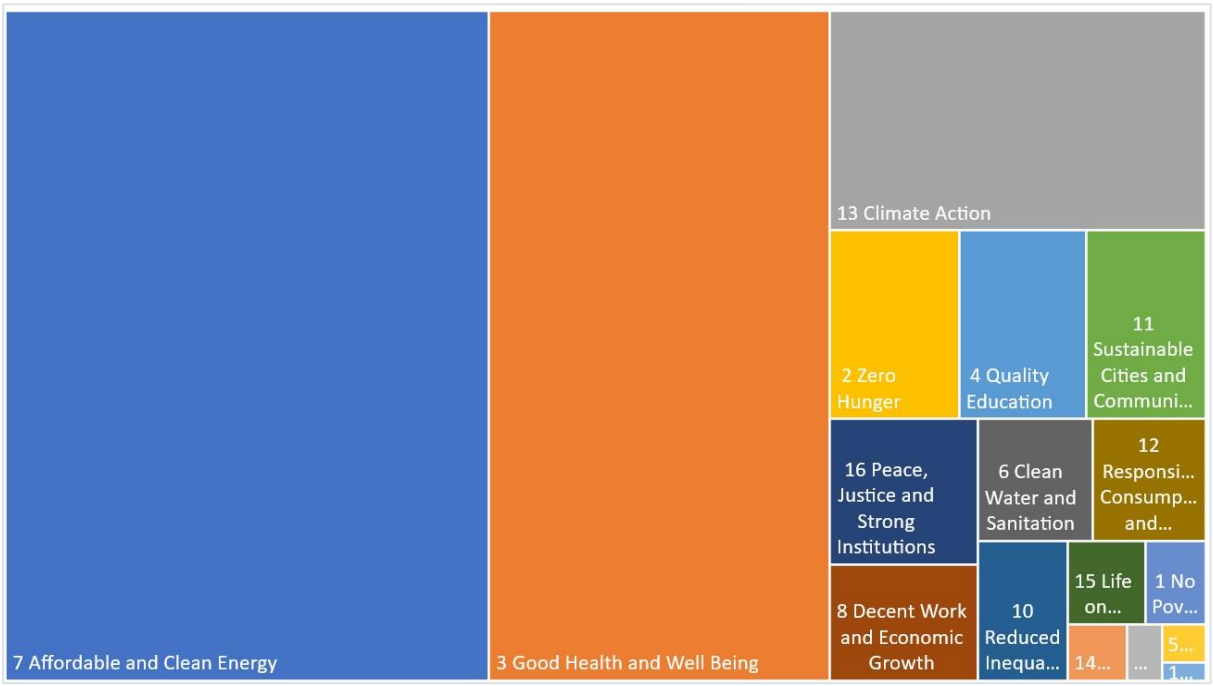


Fig. 5.26. Tree map of India's research output on SDGs

Subject area-wise composition of Research Output on SDGs

Researchers from different areas have contributed to different SDGs. For the SDG 7-Affordable & Clean Energy, about 45% of the publications in the subject area are 'Engineering', followed by 16% from Chemical Sciences, 12% from Technology, and 11% from Information and Computing Science. For SDG 3-Good Health & Well Being, about 78% publications are in the area of Medical and Health Sciences, followed by 6% in Biological

Sciences and 5% in Information & Computing Science. Similarly for SDG 13-Climate Actions, about 47% of the publications are from Engineering, 12% from Earth Sciences and 10% from Chemical Sciences. The table below shows contributions from different subject areas to the research output on SDGs.

Table 5.14. Subject area wise research output on 17 SDGs

Subjects	**SDG 1**	**SDG 2**	**SDG 3**	**SDG 4**	**SDG 5**	**SDG 6**	**SDG 7**	**SDG 8**	**SDG 9**	**SDG 10**	**SDG 11**	**SDG 12**	**SDG 13**	**SDG 14**	**SDG 15**	**SDG 16**	**SDG 17**
01 Mathematical Sciences	3	6	137	21	2	16	2318	25	6	367	48	41	408	1	3	24	0
02 Physical Sciences	0	5	49	6	0	4	1716	1	1	33	12	3	37	1	1	6	0
03 Chemical Sciences	0	46	410	10	0	145	9425	7	4	3	96	159	1395	45	3	24	0
04 Earth Sciences	2	26	18	1	0	402	232	3	1	1	99	5	1687	89	17	2	0
05 Environmental Sciences	12	429	100	1	0	282	300	41	3	8	248	139	789	179	819	26	3
06 Biological Sciences	12	995	2259	27	0	245	1321	67	0	10	85	260	1008	238	550	25	1
07 Agricultural and Veterinary Sciences	16	791	242	3	0	88	188	62	0	3	9	134	302	53	187	10	0
08 Information and Computing Sciences	17	103	1872	536	3	39	6596	376	105	91	540	162	619	21	20	389	1
09 Engineering	15	123	872	80	2	712	26284	119	81	59	1025	639	6723	82	59	28	3
10 Technology	2	34	438	16	0	16	7109	43	22	7	131	12	101	8	1	23	0
11 Medical and Health Sciences	220	1826	28135	809	67	461	383	295	9	402	517	47	164	10	2	772	21
12 Built Environment and Design	0	0	2	2	0	1	202	2	0	0	196	2	38	0	0	0	0

13 Education	5	13	74	1874	12	5	6	16	3	23	12	1	5	0	0	24	3
14 Economics	330	143	577	57	12	102	1205	1031	59	556	188	123	538	8	27	195	31
15 Commerce, Management, Tourism and Services	25	10	41	50	17	6	87	623	31	60	86	662	57	0	1	189	12
16 Studies in Human Society	202	98	369	363	182	121	269	437	26	454	620	35	340	11	36	1080	57
17 Psychology and Cognitive Sciences	4	44	436	355	14	8	90	121	0	21	45	9	20	1	1	202	0
18 Law and Legal Studies	5	2	69	23	13	6	17	29	0	23	7	4	13	6	6	561	3
19 Studies in Creative Arts and Writing	0	0	2	4	0	1	2	0	0	1	0	0	2	0	0	8	0
20 Language, Communication and Culture	9	6	31	143	45	2	12	17	0	65	13	13	5	0	1	177	0
21 History and Archaeology	5	5	36	28	5	3	14	16	0	41	14	1	15	0	1	196	5
22 Philosophy and Religious Studies	4	1	5	28	4	2	5	1	0	25	5	0	2	0	4	67	0

Chapter 6

Findings/ Summary and recommendations

This chapter contains a bird's eye view of the project, summarising the main findings of the study. It provides a concise gist of physical deliverables of the project, analyses the strengths and weaknesses of the ranking framework and the web portal (Indian Science Report). It also suggests possible future directions for the web portal and it's scaling up into a more comprehensive repository of data and insights on scientometric indicators.

Main Objectives of the study

This project has looked at the institutional scientific output using the different properties of publication data as indicators. Using the different methods of scientometric analysis, it has looked at these properties for,

- Development of the Computational Framework to rank a set of institutions.
    - Data collection, pre-processing and analysis
    - Development of Analytical framework
- Scaling up the framework to include more institutions.
    - Design of web portal with publication data from 500 institutions
    - Pilot testing and validation of web portal among the scientific community
    - Scaling up to 1000 institutions after pilot testing.

Project Deliverables

This network-based approach, along with an NLP module, was then recreated in Stage 2 to generate a thematic research portfolio for each of the 1000 institutions, using the publications meta-data from the Dimensions database. The same results are portrayed as a bubble chart of thematic areas of research for each individual institution in the Indian Science Reports portal[11]. Within the bubble chart, the size of the bubble represents the number of citations received by the individual area of research, whereas the position of the bubble is determined by the citation count as well as the publication count for the research area. An example of the same is shown in Chapter 6, named as Thematic Area of Research. The full set of analytical outcomes are available in www.indianscience.net portal.

SWOT analysis

Strengths

Author, Subject, Institution specific, output based analysis of the research performance.

Weaknesses

Careful use of analysis results as it is based on research publication data only.

[11] www.indianscience.net

Other factors are not included.

Opportunities

Can be replicated and scaled up to include various institutions, easily adapted to include other indicators by assigning different weights.

Threats

Dependent on availability of publication metadata from the curated databases such as Dimensions and Web of Science.

Limitations

The developed portal (Indian Science Reports) is developed as an academic exercise to provide useful quantitative indicators & values of Indian scientific research, both at the level of the country as well as at the level of individual institutions. It does not present a input side data and analytics for comprehensive research performance assessment exercise, as it would require a lot of more data (such as number of researchers, research budget, research facilities etc.) and several normalizations (such as publications per capita, output per unit of funding etc.). The portal in its present state can serve as a proof of concept for a fine-grained thematic area classification system and a scientometric resource for India and Indian institutions. Data about patents and grants can be added in future.

Discussion and Conclusion

The main objective of the developed portal is providing an overview of the scientometric indicators for research output from India as well as individual Indian Institutions. In addition, it also provides useful insights into some aspects such as international collaboration for publication, comparative output for India versus selected countries. The platform can be a useful first step towards the development of a comprehensive listing of India institutions and their research activity as no such listing is yet available. The framework developed for identification of core competencies and expertise indices for organisations is the next step towards improving the coverage of this platform.

The developed portal is useful for policy makers, scientometric researchers, researchers looking for potential collaborators, data enthusiasts and students among others. It provides analytical information on STI data both at the broad national level as well as on the granular level of institutions, universities, companies and hospitals. Hence it can be used by a very wide audience. As it follows a framework which includes conventional indicators for assessing STI performance within a field, as well as reflect the thematic strengths of an institution it can be used to: (i) select institutions for funding in a specific thematic area, so as to eventually develop these as centres of excellence, and (ii) identify top performers in a given thematic area, which can help in several science policy related decisions. The framework can be used to determine the core competency of an institution in a given subject, determine its thematic research strength in different themes of that subject, its focus on sustainable development goals (SDGs), productivity in selected time periods and international connections for STI activities.

Research Summary

Annotation of project (for website uploading only) - in 300 words

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Title

Design of a Computational Framework for Discipline-wise and Thematic Mapping of Research Performance of Indian Higher Educational Institutions

Author

Dr Vivek Kumar Singh

Institution

Department of Computer Science
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Year

2020-22

Model Research Summary

Design of a Computational Framework for Discipline-wise and Thematic Mapping of Research Performance of Indian Higher Educational Institutions. 2020-2022, by Vivek Kumar Singh. Department of Computer Science, Banaras Hindu University, Varanasi, Uttar Pradesh, India. 2020

This work provides a quantitative and qualitative analysis of the progress of Indian S&T as reflected in the publications output reported in global secondary services. The study also brings out strong and weak areas of research, quantity and quality of output, and dynamics of research across institutions, subjects, sub-fields and core journals for Indian S&T publications. The analysis uses data from WOS and Dimensions for the years 2010-19. India's research output was mapped and compared with some of the leading countries in S&T research. Indian Research Output in the 2010 to 2019 period grew from 60,250 to 148,724 publications and it moved from 10th to 6th position in terms of global productivity. Engineering and technology, chemical sciences, biological sciences and medicine have been the leading areas of research in India. These disciplines have registered 15% growth during the 2010-19 period. Agricultural sciences and environmental sciences have been medium productive. Mathematics, physical sciences, atmospheric and earth sciences were the least productive areas. During the period, we see Anna University at the top of the list of institutions ranked on the basis of the number of publications produced in the given time period. A total of 1000 Higher Education organizations, which include Institutions, Government Hospitals, and Research Facilities, were studied and their publication records analysed, to bring out the results of this study. Detailed analytics is available at www.indianscience.net portal. The research work also resulted in creation of new analytical framework which were duly published in reputed scientific journals in the field.

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List of Appendix

Appendix 1: Publications Out of the project

The research conducted for the completion of project "Design of a Computational Framework for Discipline-wise and Thematic Mapping of Research Performance of Indian Higher Educational Institutions" was also published in different reputed journals. Some refined results have also been communicated for publication at the time of completion of this report. These are as follows:

1. Hiran H Lathabai, Abhirup Nandy, **Vivek Kumar Singh**, "**Institutional Collaboration Recommendation: An expertise-based framework using NLP and Network Analysis**", ***Expert Systems with Applications***. Volume 209, 15 December 2022, 118317, DOI: 10.1016/j.eswa.2022.118317. (ISSN: 0957-4174, **IF: 8.665**)
   https://www.sciencedirect.com/science/article/abs/pii/S0957417422014464

2. Anurag Kanaujia, Prashasti Singh, Abhirup Nandy, **Vivek Kumar Singh**, "**Research Contribution of major Centrally Funded Institution Systems of India**", ***Current Science***, Vol. 123, No. 09, pp. 1082-1088. Nov. 2022. DOI: 10.18520/cs/v123/i9/1082-1088 (ISSN: 0011-3891, **IF: 1.169**)
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3. Jyoti Paswan, **Vivek Kumar Singh**, Mousumi Karmakar, Prashasti Singh, "**Does University-Industry-Government Collaboration in Research gets higher citation and altmetric impact? A Case study from India**", ***Scientometrics,*** Vol. 127, No. 11, pp. 6063-6082. Sep. 2022. DOI: 10.1007/s11192-022-04508-1 (ISSN:1588-2861, **IF: 3.801**)
   https://link.springer.com/article/10.1007/s11192-022-04508-1

4. **Vivek Kumar Singh**, Abhirup Nandy, Prashasti Singh, Mousumi Karmakar, Aakash Singh, Hiran H. Lathabai, Satya Swarup Srichandan, and Anurag Kanaujia, "**Indian Science Reports: A web-based Scientometric portal for mapping Indian research competencies at overall and Institutional levels**", ***Scientometrics***, Vol. 127, No. 07, pp. 4227–4236. June 2022. DOI: 10.1007/s11192-022-04395-6 (ISSN:1588-2861, **IF: 3.238**)
   https://link.springer.com/article/10.1007/s11192-022-04395-6

5. **Vivek Kumar Singh**, Prashasti Singh, Ashraf Uddin, Parveen Arora & Sujit Bhattacharya, "**Exploring the relationship between journals indexed from a country and its research output: An empirical investigation**", ***Scientometrics,*** Vol. 127, No. 06, pp. 2933-2966. April 2022. DOI: 10.1007/s11192-022-04366-x (ISSN:1588-2861, **IF: 3.238**)
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6. Hiran H Lathbai, Abhirup Nandy & **Vivek Kumar Singh**, "***x*-index: Identifying core competency and thematic research strengths of institutions using an NLP and Network based ranking framework**" ***Scientometrics***, Vol. 126, No. 12, pp. 9557–9583. Nov. 2021. DOI: 10.1007/s11192-021-04188-3 (ISSN:1588-2861, **IF: 3.238**)
   https://link.springer.com/article/10.1007/s11192-021-04188-3

7. Hiran H. Lathabai, Abhirup Nandy & **Vivek Kumar Singh**, "**Expertise-based institutional collaboration recommendation in different thematic areas**", Proceedings

of 11thInternational Workshop on Bibliometric-enhanced Information Retrieval, **ECIR**, 28th March- 1st April, 2021. Lucca, Tuscany, pp. 45-52.
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8. Satya Swarup Srichandan, Rajesh Piryani, **Vivek Kumar Singh**, and Sujit Bhattacharya, "**The Status and Patterns of open Access in Research Output of Most Productive Indian Institutions**", ***Journal of Scientometric Research***, Vol. 9, No. 2, pp. 96-110, Aug. 2020. DOI:10.5530/jscires.9.2.13 (ISSN: 2320-0057, Cite Score: 0.85)
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https://link.springer.com/article/10.1007/s11192-020-03472-y

10. Jyoti Paswan &**Vivek Kumar Singh**, "**Gender and Research Publishing Analyzed through the Lenses of Discipline, Institution Types, Impact and International Collaboration: A Case Study from India**" ***Scientometrics***, Vol. 123, No. 1, pp. 497-515, Apr. 2020. DOI: 10.1007/s11192-020-03398-5 (ISSN:1588-2861, **IF:2.867**).
https://link.springer.com/article/10.1007/s11192-020-03398-5

Appendix 2: A list of all the institutions mentioned within the research

A P J Abdul Kalam Technological University, Thiruvananthapuram	Abasaheb Garware College, Pune
Acharya Nagarjuna University, Guntur	Adamas University, Kolkata
Aditya Jyot Eye Hospital, Mumbai	Advanced Centre for Treatment, Research and Education in Cancer, Mumbai
Advanced Materials and Processes Research Institute, Bhopal	Agharkar Research Institute
Ahmedabad Civil Hospital, Ahmedabad	Ahmedabad University, Ahmedabad
Alagappa University	Al-Ameen College of Pharmacy, Bengaluru
Aliah University, Kolkata	Aligarh Muslim University
All India Institute of Hygiene and Public Health, Kolkata	All India Institute of Medical Sciences Bhopal
All India Institute of Medical Sciences Raipur, Raipur	All India Institute of Medical Sciences, Delhi
Amala Institute of Medical Sciences, Thrissur	Ambedkar University Delhi, Delhi
AMET University, Chennai	Amity University, Noida
AMRI Hospitals, Kolkata	Amrita Institute of Medical Sciences and Research Centre, Kochi
Amrita Vishwa Vidyapeetham University	Anand Agricultural University
Andhra University, Visakhapatnam	Anna University, Chennai
Annamalai University	Apollo Gleneagles Hospitals, Kolkata
Apollo Hospitals, Bilaspur	Apollo Hospitals, Chennai
Apollo Hospitals, Hyderabad	Aravind Eye Hospital, Madurai
Armed Forces Medical College, Pune	Army Hospital Research and Referral, New Delhi
Aryabhatta Research Institute of Observational Sciences, Nainital	Ashoka Trust for Research in Ecology and the Environment, Bengaluru
Ashoka University, Delhi	Asian Institute of Gastroenterology, Hyderabad
Assam Agricultural University, Jorhat	Assam Don Bosco University, Guwahati
Assam Medical College, Dibrugarh	Assam University
Aster Medcity, Kochi	AstraZeneca, Bengaluru
Atomic Energy Regulatory Board, Mumbai	Atomic Minerals Directorate for Exploration and Research, Hyderabad
Avinashilingam University, Coimbatore	Awadhesh Pratap Singh University, Rewa

Ayush & Health Sciences University Chhattisgarh, Raipur	Azim Premji University, Bengaluru
B. J. Medical College & Sassoon Hospital, Pune	B. V. Patel Pharmaceutical Education and Research Development Centre, Ahmedabad
B.J. Medical College, Ahmedabad	B.S. Abdur Rahman Crescent Institute of Science & Technology
Baba Farid University of Health Sciences, Faridkot	Baba Raghav Das Medical College, Gorakhpur
Babasaheb Bhimrao Ambedkar University	Babu Banarasi Das University, Lucknow
Baby Memorial Hospital, Kozhikode	Bai Jerbai Wadia Hospital for Children, Mumbai
Balaji Dental & Craniofacial Hospital, Chennai	Banaras Hindu University
Banasthali University	Bangalore Medical College and Research Institute
Bangalore University	Bankura Sammilani Medical College, Bankura
Bapuji Dental College and Hospital, Davangere	Barkatullah University
Basavatarakam Indo American Cancer Hospital and Research Institute, Hyderabad	Bennett University, Greater Noida
Berhampur University	Bhabha Atomic Research Centre, Mumbai
Bharat Electronics , Bengaluru	Bharath University
Bharathiar University, Coimbatore	Bharathidasan University
Bharati Vidyapeeth Deemed University, Pune	Bharti Hospital, Karnal
Bhavnagar University, Bhavnagar	Bhopal Memorial Hospital & Research Centre, Bhopal
Bhubaneswar Borooah Cancer Institute, Guwahati	Bidhan Chandra Krishi Viswavidyalaya, Krishnanagar
Bihar Agricultural University, Banka	Biju Patnaik University of Technology
Birla Institute of Technology and Science - Hyderabad Campus	Birla Institute of Technology and Science, Pilani
Birla Institute of Technology and Science, Pilani - Goa Campus, Sancoale	Birla Institute of Technology, Mesra
BLDE University, Bijapur	BLK Super Speciality Hospital, New Delhi
BML Munjal University, Gurgaon	Bombay College of Pharmacy, Mumbai
Bombay Hospital	Bose Institute, Kolkata
Botanical Survey of India, Kolkata	Bundelkhand University, Jhansi
Burdwan Medical College & Hospital	Cadila Healthcare , Ahmedabad
Calcutta National Medical College and Hospital	Cancer Institute, Chennai
CARE Hospitals, Hyderabad	Center for Excellence in Basic Sciences, Mumbai

Central Agricultural University, Imphal	Central Arid Zone Research Institute, Jodhpur
Central Building Research Institute, Roorkee	Central Council for Research in Ayurvedic Science, New Delhi
Central Council for Research in Homoeopathy, New Delhi	Central Drug Research Institute, Lucknow
Central Electrochemical Research Institute, Karaikudi	Central Electronics Engineering Research Institute, Pilani
Central Food Technological Research Institute, Mysore	Central Glass and Ceramic Research Institute, Kolkata
Central Ground Water Board, Faridabad	Central Inland Fisheries Research Institute, Barrackpur
Central Institute for Research on Goats, Farah	Central Institute of Agricultural Engineering, Bhopal
Central Institute of Brackishwater Aquaculture, Chennai	Central Institute of Fisheries Education, Mumbai
Central Institute of Fisheries Technology, Kochi	Central Institute of Freshwater Aquaculture, Bhubaneswar
Central Institute of Medicinal and Aromatic Plants, Lucknow	Central Institute of Mining and Fuel Research, Dhanbad
Central Institute of Plastics Engineering and Technology, Chennai	Central Institute of Post-Harvest Engineering and Technology, Ludhiana
Central Institute of Psychiatry, Ranchi	Central Leather Research Institute, Chennai
Central Marine Fisheries Research Institute, Kochi	Central Mechanical Engineering Research Institute, Durgapur
Central Potato Research Institute, Shimla	Central Power Research Institute, Bengaluru
Central Research Institute for Dryland Agriculture, Hyderabad	Central Rice Research Institute, Cuttack
Central Road Research Institute, New Delhi	Central Salt and Marine Chemicals Research Institute, Bhavnagar
Central Scientific Instruments Organisation, Chandigarh	Central Sheep and Wool Research Institute, Tonk
Central Soil Salinity Research Institute, Karnal	Central Tuber Crops Research Institute, Thiruvananthapuram
Central University of Gujarat	Central University of Haryana, Mahendragarh
Central University of Himachal Pradesh, Dharamsala	Central University of Jammu, Jammu
Central University of Jharkhand, Ranchi	Central University of Karnataka, Gulbarga
Central University of Kerala	Central University of Punjab
Central University of Rajasthan	Central University of South Bihar, Gaya

Central University of Tamil Nadu, Thiruvarur	Centre for Cellular and Molecular Biology, Hyderabad
Centre for Chronic Disease Control, Gurgaon	Centre for Development of Advanced Computing, Pune
Centre For Development Studies, Thiruvananthapuram	Centre for DNA Fingerprinting and Diagnostics, Hyderabad
Centre for Materials for Electronics Technology, Pune	Centre for Nano and Soft Matter Sciences, Bengaluru
Centre for Studies in Social Sciences Calcutta, Kolkata	Centre of Biomedical Research, Lucknow
Centurion University of Technology and Management, Bhubaneswar	Chacha Nehru Bal Chikitsalaya, Delhi
Chaitanya Bharathi Institute of Technology, Hyderabad	Chandigarh University
Charotar University of Science and Technology	Chaudhary Charan Singh Haryana Agricultural University, Hisar
Chaudhary Charan Singh University, Meerut	Chaudhary Devi Lal University, Sirsa
Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Palampur	Chennai Mathematical Institute, Chennai
Chettinad Academy of Research and Education, Chennai	Chettinad Health City, Chennai
Chhatrapati Shahu Ji Maharaj University, Kanpur	Chhattisgarh Swami Vivekanand Technical University
Chitkara University	Chittaranjan National Cancer Institute, Kolkata
Christ University, Bengaluru	Christian Medical College & Hospital, Vellore
Christian Medical College, Ludhiana	Cochin University of Science and Technology
College of Medicine & JNM Hospital, Kalyani	College of Medicine & Sagore Dutta Hospital, Kolkata
Columbia Asia, Bengaluru	Command Hospital Air Force, Bengaluru
Command Hospital, Lucknow	Cooper Hospital, Mumbai
Cotton University, Guwahati	Council of Scientific and Industrial Research, New Delhi
CPCL Polytechnic College, Chennai	D.Y. Patil University, Navi Mumbai
Darshan Dental College and Hospital, Udaipur	Datta Meghe Institute of Medical Sciences, Wardha
DAV University, Jalandhar	Dayalbagh Educational Institute
Dayanand Medical College & Hospital, Ludhiana	Deccan College of Medical Sciences, Hyderabad
Deen Dayal Upadhyay Gorakhpur University	Deenanath Mangeshkar Hospital and Research Center, Pune

Deenbandhu Chhotu Ram University of Science and Technology	Defence Food Research Laboratory, Mysore
Defence Institute of Advanced Technology, Pune	Defence Institute of Physiology and Allied Sciences, Delhi
Defence Materials and Stores Research and Development Establishment, Kanpur	Defence Metallurgical Research Laboratory, Hyderabad
Defence Research and Development Establishment, Gwalior	Defence Research and Development Laboratory, Hyderabad
Defence Research and Development Organisation, New Delhi	Defence Research Laboratory, Tezpur
Dehradun Institute of Technology University, DehraDun	Delhi Pharmaceutical Science and Research University, New Delhi
Delhi Technological University	Department of Atomic Energy, Mumbai
Department of Electronics and Information Technology, New Delhi	Department of Public, Chennai
Department of Science and Technology, New Delhi	Devi Ahilya Vishwavidyalaya, Indore
Dharmsinh Desai University, Nadiad	Dhirubhai Ambani Institute of Information and Communication Technology, Gandhinagar
Dibrugarh University	Doon University, DehraDun
Dr D Y Patil Dental College & Hospital, Pimpri	Dr Shroff Charity Eye Hospital, Delhi
Dr. A.P.J. Abdul Kalam Technical University, Lucknow	Dr. B. R. Ambedkar National Institute of Technology Jalandhar
DR. B.R.A. Institute Rotary Cancer Hospital, New Delhi	Dr. Babasaheb Ambedkar Marathwada University, Aurangabad
Dr. Babasaheb Ambedkar Technological University, Goregaon	Dr. Bhim Rao Ambedkar University, Agra
Dr. D. Y. Patil Medical College, Hospital and Research Centre, Pune	Dr. D.Y. Patil Vidyapeeth, Pune, Pune
Dr. Hari Singh Gour University	Dr. M.G.R. Educational and Research Institute, Chennai
Dr. NTR University of Health Sciences, Vijayawada	Dr. R. Ahmed Dental College and Hospital, Kolkata
Dr. Rajendra Prasad Government Medical College, Kangra	Dr. Ram Manohar Lohia Avadh University, Faizabad
Dr. Ram Manohar Lohia Hospital, New Delhi	Dr. Ram Manohar Lohia Institute of Medical Sciences, Lucknow
Dr. Reddy's Laboratories, Hyderabad	Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Solan
Dwarkadas J. Sanghvi College of Engineering, Mumbai	Eastern Command Hospital, Kolkata

Employees' State Insurance Model Hospital, New Delhi	Energy and Resources Institute, New Delhi
Era's Lucknow Medical College and Hospital	Eternal University, Rajgarh
Fakir Mohan University, Balasore	Father Muller Medical College Hospital, Mangalore
Fatima Mata National College, Kollam	Fernandez Hospital, Hyderabad
Forest Research Institute, Dehradun	Fortis Escorts Heart Institute, New Delhi
Fortis Escorts Hospital, Jaipur	Fortis Hospital, Bengaluru
Fortis Hospital, Mohali	Fortis Hospital, Noida
Fortis Memorial Research Institute, Gurgaon	French Institute of Pondicherry, Puducherry
Frontier Lifeline Hospital, Chennai	G.B. Pant Institute of Himalayan Environment and Development, Almora
Gajara Raja Medical College, Gwalior	Galgotias University, Greater Noida
Gandhi Medical College, Bhopal	Gandhigram Rural Institute, Dindigul
Ganesh Shankar Vidyarthi Memorial Medical College	Ganga Hospital, Coimbatore
Ganpat University, Ahmedabad	Gas Turbine Research Establishment, Bengaluru
Gauhati Medical College and Hospital, Guwahati	Gauhati University
Gautam Buddha University, Greater Noida	General Electric, Bengaluru
Geological Survey of India, Kolkata	George Institute for Global Health, New Delhi
Gian Sagar Medical College and Hospital, Patiala	GITAM University, Visakhapatnam
GLA University, Mathura	Global Hospitals, Hyderabad
Goa Dental College and Hospital, Bambolim	Goa Medical College, Bambolim
Goa University	Government Dental College & Research Institute, Bengaluru
Government Dental College and Hospital, Ahmedabad	Government General Hospital, Chennai
Government Kilpauk Medical College, Chennai	Government Medical College and Hospital, Chandigarh
Government Medical College Bhavnagar, Bhavnagar	Government Medical College, Amritsar, Amritsar
Government Medical College, Aurangabad	Government Medical College, Haldwani
Government Medical College, Jammu	Government Medical College, Kottayam
Government Medical College, Kozhikode	Government Medical College, Nagpur
Government Medical College, Patiala	Government Medical College, Sangli
Government Medical College, Srinagar	Government Medical College, Surat
Government Medical College, Thiruvananthapuram	Government Medical College, Thrissur

Government of West Bengal, Kolkata	Govind Ballabh Pant Hospital, New Delhi
Govind Ballabh Pant University of Agriculture and Technology	Govt. Dental College & Hospital, Nagpur
Grant Medical College and Sir Jamshedjee Jeejeebhoy Group of Hospitals, Mumbai	Graphic Era University
Gujarat Ayurved University	Gujarat Cancer & Research Institute, Ahmedabad
Gujarat Forensic Sciences University, Gandhinagar	Gujarat Technological University
Gujarat University, Ahmedabad	Gulbarga University
Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana	Guru Ghasidas Vishwavidyalaya, Bilaspur
Guru Gobind Singh Indraprastha University	Guru Gobind Singh Medical College and Hospital, Faridkot
Guru Jambheshwar University of Science and Technology, Hisar	Guru Nanak Dev University
Guru Teg Bahadur Hospital, Delhi	Gurukul Kangri Vishwavidyalaya, Haridwar
Gyan Vihar University, Jaipur	Haldia Institute of Technology
Harcourt Butler Technical University, Kanpur	Harish-Chandra Research Institute, Allahabad
HCG Cancer Hospital, Bengaluru	Healthcare Global Enterprises, Bengaluru
Hemwati Nandan Bahuguna Garhwal University	High Energy Materials Research Laboratory, Pune
Himachal Pradesh University	Hindu Rao Hospital, Delhi
Hindustan Aeronautics Limited, Bengaluru	Hindustan Institute of Technology and Science, Chennai
Homi Bhabha National Institute, Mumbai	IBM, Bengaluru
IBM Research, New Delhi	ICAR Research Complex for NEH Region, Shillong
ICFAI Business School, Hyderabad	ICFAI Foundation for Higher Education, Hyderabad
IFTM University, Moradabad	IITB-Monash Research Academy, Mumbai
INCLEN Trust International, New Delhi	India Meteorological Department, New Delhi
Indian Agricultural Research Institute, New Delhi	Indian Agricultural Statistics Research Institute, New Delhi
Indian Association for the Cultivation of Science, Kolkata	Indian Centre for Space Physics, Kolkata
Indian Council of Agricultural Research, New Delhi	Indian Council of Medical Research, New Delhi
Indian Institute of Astrophysics, Bengaluru	Indian Institute of Chemical Biology, Kolkata

Indian Institute of Chemical Technology, Hyderabad	Indian Institute of Engineering Science and Technology, Shibpur
Indian Institute of Foreign Trade, New Delhi	Indian Institute of Horticultural Research, Bengaluru
Indian Institute of Information Technology and Management, Gwalior	Indian Institute of Information Technology and Management, Kerala, Thiruvananthapuram
Indian Institute of Information Technology Design and Manufacturing Jabalpur	Indian Institute of Information Technology, Allahabad
Indian Institute of Information Technology, Design and Manufacturing, Kancheepuram, Chennai	Indian Institute of Integrative Medicine, Jammu
Indian Institute of Management Ahmedabad	Indian Institute of Management Bangalore
Indian Institute of Management Calcutta	Indian Institute of Management Indore
Indian Institute of Management Kozhikode, Kozhikode	Indian Institute of Management Lucknow, Lucknow
Indian Institute of Management Raipur, Raipur	Indian Institute of Management Rohtak, Rohtak
Indian Institute of Petroleum, Dehradun	Indian Institute of Public Health Gandhinagar, Gandhinagar
Indian Institute of Pulses Research, Kanpur	Indian Institute of Remote Sensing, Dehradun
Indian Institute of Rice Research, Hyderabad	Indian Institute of Science Bangalore
Indian Institute of Science Education and Research Kolkata	Indian Institute of Science Education and Research Mohali
Indian Institute of Science Education and Research Pune	Indian Institute of Science Education and Research, Bhopal
Indian Institute of Science Education and Research, Thiruvananthapuram	Indian Institute of Science Education and Research, Tirupati, Tirumala - Tirupati
Indian Institute of Soil and Water Conservation, Dehradun	Indian Institute of Soil Science, Bhopal
Indian Institute of Space Science and Technology, Thiruvananthapuram	Indian Institute of Sugarcane Research, Lucknow
Indian Institute of Technology (ISM) Dhanbad	Indian Institute of Technology BHU
Indian Institute of Technology Bhubaneswar	Indian Institute of Technology Bombay
Indian Institute of Technology Delhi	Indian Institute of Technology Gandhinagar
Indian Institute of Technology Guwahati	Indian Institute of Technology Hyderabad
Indian Institute of Technology Indore	Indian Institute of Technology Jodhpur
Indian Institute of Technology Kanpur	Indian Institute of Technology Kharagpur
Indian Institute of Technology Madras	Indian Institute of Technology Mandi
Indian Institute of Technology Palakkad, Palakkad	Indian Institute of Technology Patna

Indian Institute of Technology Roorkee	Indian Institute of Technology Ropar
Indian Institute of Technology Tirupati, Tirumala - Tirupati	Indian Institute of Toxicology Research, Lucknow
Indian Institute of Tropical Meteorology, Pune	Indian Institute of Vegetable Research, Varanasi
Indian Institute of Wheat and Barley Research, Karnal	Indian National Centre for Ocean Information Services, Hyderabad
Indian Oil Corporation, New Delhi	Indian School of Business, Hyderabad
Indian Space Research Organisation, Bengaluru	Indian Spinal Injuries Centre, New Delhi
Indian Statistical Institute, Kolkata	Indian Veterinary Research Institute, Bareilly
Indira Gandhi Centre for Atomic Research, Kalpakkam	Indira Gandhi Delhi Technical University for Women, New Delhi
Indira Gandhi Government Medical College & Hospital, Nagpur	Indira Gandhi Institute of Child Health, Bengaluru
Indira Gandhi Institute of Development Research, Mumbai	Indira Gandhi Institute of Medical Sciences, Patna
Indira Gandhi Institute of Technology, Talcher	Indira Gandhi Medical College and Research Institute, Puducherry
Indira Gandhi Medical College, Shimla	Indira Gandhi National Open University
Indira Gandhi National Tribal University, Amarkantak	Indraprastha Apollo Hospitals, New Delhi
Indraprastha Institute of Information Technology Delhi	Infosys, Bengaluru
INHS Asvini, Mumbai	Institute for Development and Research in Banking Technology, Hyderabad
Institute for Plasma Research, Gandhinagar	Institute for Social and Economic Change, Bengaluru
Institute for Stem Cell Biology and Regenerative Medicine, Bengaluru	Institute of Advanced Study in Science and Technology, Guwahati
Institute of Bioinformatics, Bengaluru	Institute of Bio-Resources and Sustainable Development, Imphal
Institute of Chemical Technology, Mumbai	Institute of Child Health, Kolkata
Institute of Cytology and Preventive Oncology, Noida	Institute of Economic Growth, New Delhi
Institute of Genetics and Hospital for Genetic Diseases, Hyderabad	Institute of Genomics and Integrative Biology, Delhi
Institute of Himalayan Bioresource Technology, Palampur	Institute of Human Behaviour and Allied Sciences, Delhi
Institute of Infrastructure Technology Research and Management, Ahmedabad	Institute of Life Sciences, Bhubaneshwar
Institute of Liver and Biliary Sciences, New Delhi	Institute of Management Technology, Ghaziabad

Institute of Mathematical Sciences, Chennai	Institute of Medical Sciences and Sum Hospital, Bhubaneswar
Institute of Medical Sciences, Varanasi	Institute of Microbial Technology, Chandigarh
Institute of Minerals and Materials Technology, Bhubaneshwar	Institute of Nuclear Medicine & Allied Sciences, New Delhi
Institute of Physics, Bhubaneshwar	Institute of Post Graduate Medical Education and Research, Kolkata
Institute of Seismological Research, Gandhinagar	Institute of Technology Management, Mussoorie
Institute of Transplantation Sciences, Ahmedabad	Institute of Wood Science and Technology, Bengaluru
Integral University	International Advanced Research Centre for Powder Metallurgy and New Materials, Hyderabad
International Centre for Genetic Engineering and Biotechnology, New Delhi	International Centre for Theoretical Sciences, Bengaluru
International Crops Research Institute for the Semi-Arid Tropics, Patancheru	International Institute for Population Sciences, Mumbai
International Institute of Information Technology Bangalore, Bengaluru	International Institute of Information Technology, Bhubaneswar
International Institute of Information Technology, Hyderabad	International Management Institute, New Delhi
Inter-University Accelerator Centre, New Delhi	Inter-University Centre for Astronomy and Astrophysics, Pune
Islamic University of Science and Technology, Awantipur	ITM University, Gwalior
J.C. Bose University of Science & Technology, YMCA, Faridabad	Jadavpur University
Jai Narain Vyas University, Jodhpur	Jain University, Bengaluru
Jaipur National University, Jaipur	Jamia Hamdard
Jamia Millia Islamia	Jaslok Hospital, Mumbai
Jaswant Rai Speciality Hospital, Meerut	Jawaharlal Institute of Post Graduate Medical Education and Research, Puducherry
Jawaharlal Nehru Centre for Advanced Scientific Research, Bengaluru	Jawaharlal Nehru Medical College Hospital, Aligarh
Jawaharlal Nehru Medical College, Ajmer	Jawaharlal Nehru Medical College, Belgaum
Jawaharlal Nehru Technological University Anantapur	Jawaharlal Nehru Technological University, Hyderabad
Jawaharlal Nehru Technological University, Kakinada	Jawaharlal Nehru Tropical Botanic Garden and Research Institute, Thiruvananthapuram
Jawaharlal Nehru University	Jaypee Institute of Information Technology, Noida

Jaypee University of Engineering and Technology, Guna	Jaypee University of Information Technology, Solan
JECRC University, Jaipur	Jehangir Hospital, Pune
Jiwaji University, Gwalior	Jodhpur National University, Jodhpur
JSS Dental College and Hospital, Mysore	JSS Medical College and Hospital, Mysore
JSS University	Jubilee Mission Medical College and Research Institute, Thrissur
Junagadh Agricultural University, Junagadh	K J Somaiya Medical College, Mumbai
K S Hegde Medical Academy	Kadi Sarva Vishwavidyalaya, Gandhinagar
Kakatiya University, Warangal	Kalasalingam Academy of Research and Education
Kalawati Saran Children's Hospital, New Delhi	Kamineni Institute of Dental Sciences, Nalgonda
Kanchi Kamakoti CHILDS Trust Hospital, Chennai	Kannur University
Karnatak University, Dharwad	Karnataka Health Promotion Trust, Bengaluru
Karnataka Institute of Medical Sciences, Hubli	Karnataka Veterinary Animal and Fisheries Sciences University, Bidar
Karpagam Academy of Higher Education	Karunya University
Kasturba Hospital, Manipal	Kasturba Medical College, Manipal
Kazi Nazrul University, Asansol	Kempegowda Institute of Medical Sciences, Bengaluru
Kerala Agricultural University, Thrissur	Kerala Institute of Medical Sciences, Thiruvananthapuram
Kerala University of Fisheries and Ocean Studies, Kochi	Kerala University of Health Sciences
Kerala Veterinary and Animal Sciences University, Kalpetta	Kidwai Memorial Institute of Oncology, Bengaluru
KIIT University	King Edward Memorial Hospital and Seth G.S. Medical College, Mumbai
King Edward Memorial Hospital Research Centre, Pune	King George's Medical University, Lucknow
KLE Technological University, Hubli	KLE University
KM Shah Dental College and Hospital, Vadodara	Kokilaben Dhirubhai Ambani Hospital, Mumbai
Koneru Lakshmaiah Education Foundation, Guntur	Kothiwal Dental College and Research Centre, Moradabad
Kovai Medical Center and Hospital, Coimbatore	KPC Medical College and Hospital, Kolkata
Krishna Institute of Medical Sciences Deemed University	Krishna Institute of Medical Sciences, Secunderabad

Krishna University, Machilipatnam	Kumaun University
Kurukshetra University	Kuvempu University, Shimoga
L V Prasad Eye Institute, Hyderabad	Lady Hardinge Medical College, New Delhi
Lakeshore Hospital, Kochi	Lala Lajpat Rai Memorial Medical College, Meerut
Lala Lajpat Rai University of Veterinary and Animal Sciences, Hisar	Lilavati Hospital & Research Centre, Mumbai
LNM Institute of Information Technology, Jaipur	Lok Nayak Jai Prakash Narayan Hospital, New Delhi
Lokmanya Tilak Municipal General Hospital and Lokmanya Tilak Municipal Medical College, Mumbai	Lovely Professional University
M S Ramaiah University of Applied Sciences	M S Swaminathan Research Foundation, Chennai
M.J.P. Rohilkhand University, Bareilly	M.S. Ramaiah Medical College, Bengaluru
Madan Mohan Malaviya University of Technology, Gorakhpur	Madras Diabetes Research Foundation, Chennai
Madras Institute of Orthopaedics and Traumatology, Chennai	Madras Medical College, Chennai
Madras Medical Mission	Madurai Kamaraj University
Madurai Medical College, Madurai	Maharaj Vijayaram Gajapathi Raj College of Engineering, Vizianagaram
Maharaja Krishna Chandra Gajapati Medical College and Hospital, Brahmapur	Maharaja Ranjit Singh Punjab Technical University, Bathinda
Maharaja Sayajirao University of Baroda	Maharana Pratap University of Agriculture and Technology, Udaipur
Maharashtra University of Health Sciences	Maharishi Markandeshwar University, Mullana, Ambala
Maharshi Dayanand University, Rohtak	Mahatma Gandhi Dental College & Hospital, Jaipur
Mahatma Gandhi Institute of Medical Sciences, Wardha	Mahatma Gandhi Medical College and Research Institute, Puducherry
Mahatma Gandhi Memorial Medical College, Indore	Mahatma Gandhi Mission Medical College and Hospital, Aurangabad
Mahatma Gandhi Mission's Dental College and Hospital, Navi Mumbai	Mahatma Gandhi University, Kottayam
Mahindra Ecole Centrale, Hyderabad	Malabar Cancer Centre, Tellicherry
Malaviya National Institute of Technology Jaipur	Mamata Medical College, Khammam
Management Development Institute, Gurgaon	Manav Rachna International Institute of Research and Studies, Faridabad
Mangalore University	Manipal Academy of Higher Education, Manipal

Manipal Hospital, Bengaluru	Manipur University
Manonmaniam Sundaranar University, Tirunelveli	Marwadi Education Foundation, Rajkot
Maulana Abul Kalam Azad University of Technology (MAKAUT) (formerly known as West Bengal University of Technology (WBUT))	Maulana Azad Institute of Dental Sciences, New Delhi
Maulana Azad Medical College, New Delhi	Maulana Azad National Institute of Technology, Bhopal
Max Healthcare, New Delhi	Max Super Speciality Hospital, Delhi
Mazumdar Shaw Medical Centre, Bengaluru	Medanta The Medicity, Gurgaon
Medical College and Hospital, Kolkata	Medwin Hospital, Hyderabad
Meenakshi Ammal Dental College and Hospital, Chennai	Melaka Manipal Medical College
Mewar University, Chittorgarh	Microsoft Research, Bengaluru
Ministry of Earth Sciences, New Delhi	Ministry of Health and Family Welfare, New Delhi
Mizoram University	MNR Dental College and Hospital, Medak
Mody University of Science and Technology, Lachhmangarh Sikar	Mohanlal Sukhadia University, Udaipur
Mother Teresa Women's University, Kodaikanal	Motilal Nehru Medical College, Allahabad
Motilal Nehru National Institute of Technology, Allahabad	Muljibhai Patel Urological Hospital, Nadiad
Mysore Medical College, Mysore	Narayan Medical College and Hospital, Nellore
Narayana Dental College and Hospital, Nellore	Narayana Health, Bengaluru
Narayana Nethralaya, Bengaluru	Narsee Monjee Institute of Management Studies
National Aerospace Laboratories, Bengaluru	National Agri-Food Biotechnology Institute, Mohali
National AIDS Control Organisation, New Delhi	National AIDS Research Institute, Pune
National Atmospheric Research Laboratory, Tirupati	National Botanical Research Institute, Lucknow
National Brain Research Centre, Gurgaon	National Bureau of Agricultural Insect Resources, Bengaluru
National Bureau of Agriculturally Important Microorganisms, Mau	National Bureau of Animal Genetic Resources, Chandigarh
National Bureau of Fish Genetic Resources, Lucknow	National Bureau of Plant Genetic Resources, New Delhi
National Center for Disease Control, New Delhi	National Centre for Antarctic and Ocean Research, Vasco da Gama
National Centre for Biological Sciences, Bengaluru	National Centre for Cell Science, Pune

National Centre for Earth Science Studies, Thiruvananthapuram	National Centre for Medium Range Weather Forecasting, Noida
National Centre for Radio Astrophysics, Pune	National Chemical Laboratory, Pune
National Dairy Research Institute, Karnal	National Defence Academy, Pune
National Environmental Engineering Research Institute, Nagpur	National Geophysical Research Institute, Hyderabad
National Institute for Interdisciplinary Science and Technology, Thiruvananthapuram	National Institute for Research in Reproductive Health, Mumbai
National Institute for Research in Tribal Health, Jabalpur	National Institute of Advanced Studies, Bengaluru
National Institute of Animal Nutrition and Physiology, Bengaluru	National Institute of Biomedical Genomics, Kolkata
National Institute of Cancer Prevention and Research, Noida	National Institute of Cholera and Enteric Diseases, Kolkata
National Institute of Epidemiology, Chennai	National Institute of Food Technology Entrepreneurship and Management, Sonepat
National Institute of Health and Family Welfare, New Delhi	National Institute of Hydrology, Roorkee
National Institute of Immunohaematology, Mumbai	National Institute of Immunology, New Delhi
National Institute of Industrial Engineering, Mumbai	National Institute of Malaria Research, New Delhi
National Institute of Mental Health and Neurosciences, Bengaluru	National Institute of Nutrition, Hyderabad
National Institute of Occupational Health, Ahmedabad	National Institute of Ocean Technology, Chennai
National Institute of Oceanography, Panjim	National Institute of Pathology, New Delhi
National Institute of Pharmaceutical Education and Research, Ahmedabad	National Institute of Pharmaceutical Education and Research, Guwahati
National Institute of Pharmaceutical Education and Research, Hyderabad	National Institute of Pharmaceutical Education and Research, Mohali
National Institute of Pharmaceutical Education and Research, Raebareli	National Institute of Plant Genome Research, New Delhi
National Institute of Research in Tuberculosis, Chennai	National Institute of Science Education and Research, Bhubaneswar
National Institute of Technical Teachers Training and Research, Chandigarh	National Institute of Technical Teachers' Training and Research, Bhopal
National Institute of Technology Agartala	National Institute of Technology Calicut
National Institute of Technology Delhi, New Delhi	National Institute of Technology Durgapur
National Institute of Technology Hamirpur	National Institute of Technology Jamshedpur, Jamshedpur

National Institute of Technology Karnataka	National Institute of Technology Kurukshetra
National Institute of Technology Manipur, Imphal	National Institute of Technology Meghalaya
National Institute of Technology Patna	National Institute of Technology Raipur
National Institute of Technology Rourkela	National Institute of Technology Silchar
National Institute of Technology Srinagar, Srinagar	National Institute of Technology Tiruchirappalli
National Institute of Technology Warangal	National Institute of Virology, Pune
National JALMA Institute for Leprosy & Other Mycobacterial Diseases, Agra	National Metallurgical Laboratory, Jamshedpur
National Physical Laboratory of India, New Delhi	National Remote Sensing Centre, Hyderabad
National Research Centre for Grapes, Pune	National Research Centre on Equines, Hisar
National Research Centre on Plant Biotechnology, New Delhi	Nature Conservation Foundation, Mysore
Naval Materials Research Laboratory, Ambarnath	Naval Physical & Oceanographic Laboratory, Kochi
Navsari Agricultural University, Surat	Netaji Subhas University of Technology, New Delhi
Netaji Subhash Chandra Bose Medical College, Jabalpur	NIIT University, Jaipur
Nil Ratan Sircar Medical College and Hospital, Kolkata	NIMS University, Jaipur
Nirma University, Ahmedabad	Nitte University, Bengaluru
Nizam's Institute of Medical Sciences, Hyderabad	Noorul Islam University
North Bengal Medical College and Hospital	North Bengal University, Siliguri
North East Institute of Science and Technology, Jorhat	North Eastern Hill University, Shillong
North Eastern Indira Gandhi Regional Institute of Health and Medical Sciences, Shillong	North Eastern Regional Institute of Science and Technology, Itanagar
North Maharashtra University, Jalgaon	North Orissa University, Baripada
Novartis, Hyderabad	O. P. Jindal Global University, Sonepat
Odisha University of Agriculture and Technology, Bhubaneswar	Osmania General Hospital, Hyderabad
Osmania Medical College, Hyderabad	Osmania University
Oxford Dental College and Hospital, Bengaluru	P. D. Hinduja Hospital and Medical Research Centre
P.M.N.M. Dental College and Hospital, Bagalkot	Pacific Dental College and Hospital, Udaipur
Pandit Bhagwat Dayal Sharma Post Graduate Institute of Medical Sciences, Rohtak	Pandit Bhagwat Dayal Sharma University of Health Sciences, Rohtak

Pandit Deendayal Petroleum University, Gandhinagar	Pandit Ravishankar Shukla University, Raipur
Panjab University	Parul University, Vadodara
Patna Medical College and Hospital, Patna	Patna University, Patna
Peoples University, Bhopal	Periyar Maniammai Institute of Science & Technology, Vallam
Periyar University, Salem	PES University, Bengaluru
Physical Research Laboratory, Ahmedabad	Piramal, Mumbai
Pondicherry Institute of Medical Sciences	Pondicherry University
Poornaprajna Institute of Scientific Research, Bengaluru	Population Council, New Delhi
Post Graduate Institute of Medical Education and Research,Chandigarh	Pramukhswami Medical College, Anand
Pravara Institute of Medical Sciences, Ahmednagar	Presidency University, Kolkata
PRIST University, Vallam	Professor Jayashankar Telangana State Agricultural University, Hyderabad
PSG Institute of Advanced Studies, Coimbatore	PSG Institute of Medical Sciences & Research, Coimbatore
Pt. Jawahar Lal Nehru Memorial Medical College, Raipur	Public Health Foundation of India, New Delhi
Punjab Agricultural University	Punjab Engineering College
Punjab Technical University	Punjabi University, Patiala
R. G. Kar Medical College and Hospital, Kolkata	Rabindranath Tagore Medical College, Udaipur
Ragas Dental College & Hospital, Chennai	Raiganj University, Raiganj
Raja Ramanna Centre for Advanced Technology, Indore	Rajarajeswari Dental College and Hospital, Bengaluru
Rajarajeswari Medical College and Hospital, Bengaluru	Rajasthan Technical University
Rajasthan University of Health Sciences, Jaipur	Rajendra Institute of Medical Sciences, Ranchi
Rajendra Memorial Research Institute of Medical Sciences, Patna	Rajiv Gandhi Cancer Institute and Research Centre, New Delhi
Rajiv Gandhi Centre for Biotechnology, Thiruvananthapuram	Rajiv Gandhi Institute of Petroleum Technology, Raebareli
Rajiv Gandhi Technical University, Bhopal	Rajiv Gandhi University of Health Sciences, Bengaluru
Rajiv Gandhi University of Knowledge Technologies, Adilabad	Rajiv Gandhi University, Itanagar

Ramakrishna Mission Vivekananda Educational and Research Institute, Kolkata	Ramakrishna Mission, Howrah
Raman Research Institute, Bengaluru	Rani Durgavati University, Jabalpur
Rashtrasant Tukadoji Maharaj Nagpur University	Ravenshaw University, Cuttack
Rayalaseema University, Kurnool	Regional Cancer Center, Thiruvananthapuram
Regional Centre for Biotechnology, Faridabad	Regional Institute of Medical Sciences, Imphal
Regional Medical Research Center, Bhubaneswar	Regional Medical Research Centre, Dibrugarh
Reliance Industries, Mumbai	Research & Development Establishment, Pune
Research Centre Imarat, Hyderabad	Reserve Bank of India, Mumbai
REVA University, Bengaluru	RK University, Rajkot
Roland Institute of Pharmaceutical Sciences, Brahmapur	Ruby Hall Clinic, Pune
Ruxmaniben Deepchand Gardi Medical College, Ujjain	S Nijalingappa Medical College and HSK Hospital & Research Centre, Bagalkot
S.N. Bose National Centre for Basic Sciences, Kolkata	Sacred Heart College, Kochi
Safdarjung Hospital, New Delhi	Saha Institute of Nuclear Physics, Kolkata
Saifee Hospital, Mumbai	Sam Higginbottom Institute of Agriculture, Allahabad
Sambalpur University	Samsung, Bengaluru
Sangath, Raia	Sanjay Gandhi Post Graduate Institute of Medical Sciences, Lucknow
Sankara Nethralaya, Chennai	Sant Gadge Baba Amravati University
Sant Longowal Institute of Engineering and Technology, Sangrur	Saraswati Dental College and Hospital, Lucknow
Sardar Patel Medical College, Bikaner	Sardar Patel Post Graduate Institute of Dental and Medical Sciences, Lucknow
Sardar Patel University	Sardar Vallabhbhai National Institute of Technology Surat
Sarojini Naidu Medical College, Agra	SASTRA University
Sathyabama Institute of Science and Technology	Saurashtra University, Rajkot
Saveetha University	Sawai ManSingh Medical College and Hospital, Jaipur
SDM College of Medical Science and Hospital, Hubli	Serum Institute of India, Pune
Sharda University	Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Jammu

Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir	Sher-i-Kashmir Institute of Medical Sciences, Srinagar
Shiv Nadar University	Shivaji University, Kolhapur
Shobhit University, Meerut	Shoolini University
Shree Guru Gobind Singh Tricentenary University, Gurgaon	Shreemati Nathibai Damodar Thackersey Women's University, Mumbai
Shri BM Patil Medical College, Bijapur	Shri Mata Vaishno Devi University
Shri Ramswaroop Memorial University, Lucknow	Shri Sathya Sai Medical College and Research Institute, Ammapettai
Shri Vile Parle Kelavani Mandal, Mumbai	Sidho Kanho Birsha University, Puruliya
Sikkim Manipal University	Sikkim University, Gangtok
Siksha O Anusandhan University	Silchar Medical College and Hospital, Silchar
Sinhgad Dental College and Hospital, Pune	Sir Ganga Ram Hospital, New Delhi
Sir Sayajirao General Hospital Medical College, Vadodara	Sitaram Bhartia Institute of Science and Research, New Delhi
Smt. Kashibai Navale Medical College and General hospital, Pune	Smt. N.H.L. Municipal Medical College, Ahmedabad
Society for Applied Microwave Electronics Engineering & Research, Mumbai	Solapur University
Solid State Physics Laboratory, Delhi	South Asian University, New Delhi
Southern Command Hospital, Pune	Sree Balaji Dental College and Hospital, Chennai
Sree Chitra Tirunal Institute for Medical Sciences and Technology, Thiruvananthapuram	Sri Aurobindo Institute of Medical Sciences, Indore
Sri Balaji Vidyapeeth University, Puducherry	Sri Chandrasekharendra Saraswathi Viswa Mahavidyalaya, Kanchipuram
Sri Devaraj Urs Medical College, Kolar	Sri Dharmasthala Manjunatheshwara College of Dental Sciences & Hospital, Hubli
Sri Guru Granth Sahib World University, Fatehgarh Churian	Sri Jayadeva Institute of Cardiovascular Sciences and Research, Bengaluru
Sri Krishnadevaraya University, Anantapur	Sri Manakula Vinayagar Medical College and Hospital, Puducherry
Sri Ramachandra University, Porur	Sri Sathya Sai Institute of Higher Learning, Puttaparthi
Sri Siddhartha Medical College, Tumakuru	Sri Venkateswara Institute of Medical Sciences
Sri Venkateswara University	Sri Venkateswara Veterinary University, Tirumala - Tirupati
Sriram Chandra Bhanja Medical College Hospital, Cuttack	SRM Dental College, Chennai

SRM Institute of Science and Technology, Chennai	SRM University, Sonipat
St Xavier’s College, Ahmedabad	St. Joseph Dental College, Eluru
St. Peter's Institute of Higher Education and Research, Chennai	St. Stephen’s Hospital, Delhi
St.John's Medical College Hospital, Bengaluru	Stanley Medical College, Chennai
STMicroelectronics, Greater Noida	Structural Engineering Research Centre, Chennai
Sumandeep Vidyapeeth University, Vadodara	Subharti Medical College, Meerut
Sugarcane Breeding Institute, Coimbatore	Sun Pharma, Mumbai
Suven Life Sciences, Hyderabad	Swami Devi Dyal Hospital and Dental College, Barwala
Swami Rama Himalayan University, Dehradun	Swami Ramanand Teerth Marathwada University
Swami Vivekanand Subharti University	Swami Vivekananda Yoga Anusandhana Samsthana, Bengaluru
Symbiosis International University	Syngene International, Bengaluru
T A Pai Management Institute, Manipal	T. D. Medical College, Alappuzha
Tamil Nadu Agricultural University, Coimbatore	Tamil Nadu Dr. M.G.R. Medical University
Tamil Nadu Government Dental College and Hospital, Chennai	Tamil Nadu Veterinary and Animal Sciences University, Chennai
Tata Consultancy Services, Pune	Tata Institute of Fundamental Research, Mumbai
Tata Institute of Social Sciences, Mumbai	Tata Main Hospital, Jamshedpur
Tata Medical Center, Kolkata	Tata Memorial Hospital, Mumbai
Tata Sons, Mumbai	Tata Steel, Mumbai
Tea Research Association, Jorhat	Techno India University, Kolkata
Teerthanker Mahaveer University, Moradabad	TERI University, New Delhi
Texas Instruments, Bengaluru	Tezpur University
Thai Moogambigai Dental College and Hospital, Chennai	Thapar University, Patiala
The NorthCap University, Gurgaon	Thiruvalluvar University
TIFR Centre for Interdisciplinary Sciences, Hyderabad	Tilka Manjhi Bhagalpur University, Banka
Topiwala National Medical College & BYL Nair Charitable Hospital	Translational Health Science and Technology Institute, Gurgaon
Tripura University	Tumkur University
UGC DAE Consortium for Scientific Research, Indore	Uka Tarsadia University, Surat
University College of Medical Sciences, Delhi	University of Agricultural Sciences, Bangalore

University of Allahabad	University of Burdwan
University of Calcutta	University of Calicut
University of Delhi	University of Engineering & Management, Kolkata
University of Gour Banga, Mokdumpur	University of Hyderabad
University of Jammu	University of Kalyani
University of Kashmir	University of Kerala
University of Kota, Kota	University of Lucknow
University of Madras	University of Mumbai
University of Mysore	University of Petroleum and Energy Studies, Dehradun
University of Pune	University of Rajasthan
Utkal University	Uttar Pradesh Pandit Deen Dayal Upadhyaya Pashu Chikitsa Vigyan Vishwavidyalaya Evam Go-Anusandhan Sansthan, Mathura
Uttarakhand Technical University	Vardhman Mahavir Medical College & Safdarjung Hospital, New Delhi
Variable Energy Cyclotron Centre, Kolkata	Vector Control Research Centre, Puducherry
Veer Bahadur Singh Purvanchal University, Jaunpur	Veer Narmad South Gujarat University
Veer Surendra Sai University of Technology, Sambalpur	Vel Tech Dr. RR & Dr. SR Technical University
Vellore Institute of Technology University	Vels University, Chennai
Vidyasagar University, Medinipur	Vignan's Foundation for Science, Technology & Research, Guntur
Vijayanagara Institute of Medical Sciences, Bellary	Vikram Sarabhai Space Centre, Thiruvananthapuram
Vikram University, Ujjain	Virus Unit, Kolkata
Visva-Bharati University	Visvesvaraya National Institute of Technology, Nagpur
Visvesvaraya Technological University, Belgaum	Vivekananda Institute of Medical Sciences, Kolkata
Vokkaligara Sangha Dental College & Hospital, Bengaluru	Voluntary Health Services Hospital, Chennai
Wadia Institute of Himalayan Geology	West Bengal State University
West Bengal University of Animal and Fishery Sciences, Kolkata	West Bengal University of Health Sciences
Wildlife Institute of India, Dehradun	World Health Organization - India, New Delhi

World Health Organization Regional Office for South-East Asia, New Delhi	Xavier Institute of Management, Bhubaneswar, Bhubaneswar
Xavier School of Management, Jamshedpur	Yashoda Hospital, Secunderabad
Yenepoya University, Mangalore	Yogi Vemana University, Kadapa
YR Gaitonde Centre for AIDS Research and Education, Chennai	Zoological Survey of India, Kolkata