Project Completion Report

PROJECT TITLE

Contribution of India on Climate Change Research in Comparison with Major Countries: A Bibliometric Study of 30 years (1987-2016)

Implemented by

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DST PROJECT NO.

[DST/NSTMIS/05/20/2017-18 dated 05.11.2018 and revised on 04.11.2019]

Study Sponsored by

National Science and Technology Management Information System (NSTMIS)

Department of Science & Technology

Government of India

(April, 2021)

Preface

Climate change has long been regarded as a scientific problem, and it is no longer just one of many environmental and regulatory issues. Mitigation of climate change needs a comprehensive scientific understanding as well as concerted national and international action. This means taking steps that are in line with existing development goals for a developing country like India. Though progress has been made in monitoring and recognising climate change, many scientific, technical, and institutional challenges still stand in the way of precisely anticipating, reacting to, and mitigating climate change's effects. The NAPCC is comprised of "Eight National Missions," each of which represents a multi-faceted, long-term strategy. Bibliometric and scientometric approaches were used to compare India's contribution to climate change research with that of other major countries over the last 35 years. This study examines the quantitative and qualitative contributions of Indian climate change research in relation to the top 20 countries as measured by publication production in Web of Science, Scopus, and the Indian Citation Index. This research looked at the quantitative contributions of various bibliometric parameters (organisations, authors, and journals) as well as their ranking among the top 20 countries. This study also evaluated the comparative impact of the carried-out research by top 20 countries through citation analysis. The contribution and impact of the Indian collaborative research were also quantified. Most proficient collaborative countries, organizations and authors of Indian climate change research were identified. The impacts of the implications of the National Action Plan on Climate Change were quantified covering “Eight national Mission” from WoS, Scopus and Indian Citation Index. Specific missions' leading research areas were also recognised. There were reported changing patterns in research areas and research themes related to Indian climate change. The top 20 countries were studied for their comparative interrelationships for different environmental parameters, publications, and patents. This research uncovered several strengths and weaknesses in Indian climate change research. Finally, some suggestions and recommendations have been made to improve the performance of Indian climate change research to reduce the impact.

ACKNOWLEDGEMENTS

Firstly, I would like to express my sincere thankfulness and deepest gratitude to the LPAC members for their valuable suggestions and guidance. The LPAC comprised the following:

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I thank the DST-NSTMIS (CHORD), Govt. of India, for providing the fund to carry out this study. I am very grateful to the Bose Institute for providing me the accession to the databases and various journals.

I am very much gratified to the Principal, Dinabandhu Mahavidyalaya for providing me an opportunity and infrastructure to carry out this project.

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Executive Summary

Importance of this study

Climate change has long been regarded as a scientific concern, and it is no longer merely one of many environmental and regulatory issues. Since 1980, annual global temperatures have risen by 0.4°C, with even greater increases in some areas (IPCC, 2001). Climate change mitigation necessitates a thorough scientific understanding as well as coordinated national and global action. Adopting a sustainable development direction by transitioning to environmentally sustainable technology and encouraging energy management, renewable energy, forest conservation, reforestation, and water conservation, among other things, is the most successful way to combat climate change. The most urgent concern for developing countries is reducing their natural and socioeconomic systems' vulnerability to predicted climate change. For a developing country like India, this means taking steps that are in line with current development objectives. While progress has been made in tracking and understanding climate change, many scientific, technological, and institutional barriers remain in the way of precisely preparing for, responding to, and mitigating climate change's impact.

India has actively engaged in multilateral negotiations under the United Nations Framework Convention on Climate Change in a positive, constructive, and forward-thinking way, acknowledging that climate change is a significant environmental issue that affects the entire world. In this regard, India has decided that it's per capita greenhouse gas emissions would never exceed those of developed countries. India has prioritised maintaining a high growth rate to improve the living conditions of the vast majority of Indians and reduce their vulnerability to the effects of climate change. The National Action Plan for Climate Change (NAPCC) addressed the country's immediate and critical concerns by shifting the country's development path, including expanding current and planned programmes, to follow a sustainable development path that promotes both economic and environmental goals. The National Action Plan on Climate Change (NAPCC) of India aimed to encourage climate change understanding, adaptation, and mitigation, as well as energy efficiency and natural resource conservation. The NAPCC is made up of "Eight National Missions," which represent multi-pronged, long-term, and organised strategies for meeting key climate change objectives.

Objectives of the study

Climate change study is one of the most rapidly changing fields of science. Various bibliometric and scientometric approaches may be used to measure and map the theoretical impetus behind the current focus on climate change research. As a result, the aim of this study is to quantify India's contribution to climate change research in relation to other major countries over the last 35 years using bibliometric and scientometric methods, with the following objectives:

1) To evaluate the period-wise evolving trends of research productivity and contributions by different bibliometric parameters of India and other countries
2) To evaluate the impact of the research conducted by India in comparison with other countries using citation analysis
3) To analyse the research collaboration of India with different countries
4) To evaluate the interrelationship among the national goal on climate change and the research publications of India covering Indian and international journals
5) To evaluate the comparative evolving trends of the research area and research topic of the select countries including India using scientometric techniques
6) To understand the inter-relationship among the carried-out research topics and country-specific socio-economic & environmental problems

Methodology details

The initial search string was developed by combining the most relevant keywords in the climate change research. Various combinations of important keywords, related to climate change were used to generate different search strings to retrieve the publication data in this topic from the Web of Science (WoS). Many alternatives of the keywords and boolean operators were used for coverage of maximum publication data. Keywords were extracted from the publication data retrieved from the web of Science with the help of Sci2 software. New keywords related to climate change in terms of their causal factors, impacts, mitigative measures, issues, etc. were incorporated from the extracted keywords list to prepare the final search string. The Boolean operators and searching method are different in the case of the Indian Citation Index as compared to the other two databases namely the Web of Science and Scopus.

Total publications data were primarily analysed for the individual countries, Institutes, authors, journals and research areas in Web of Science and Scopus. The total period was divided into seven periods of 5-years each through the refine key. Further, the timespans from 1990 to 2019 were also divided into three periods of 10-years each to understand the decadal growth of the bibliometric parameters. Publication data from each period were analysed for the individual countries, institutes, authors, journals, and research areas and downloaded separately in Excel format and plotted graphically. All the bibliometric parameter data of the top 20 countries were also downloaded and analysed from both of the databases. The total data from the Indian Citation Index were downloaded and analysed in Excel.

Citation data of the total publications and were obtained by selecting the "Create Citation Reports" key of Web of Science. The citation report of the individual countries has also been created and downloaded for further analysis. The citation data from Scopus and the Indian Citation Index were exported and analysed in Excel. Graphs were plotted to show the period-wise trends of the h-index, citation of publications for quality analysis. Five-year impact factors for countries were also calculated from WoS for the qualitative analyses of the ongoing research performance. The complete citation data from Scopus and Indian Citation Index were not downloaded as it was not possible for all data therefore the average citation and five-year impact factor were not studied.

Impact factors of country-specific top 100 journals as per the number of publications were collected from the InCites Journal Citation Reports (JCR) Selected JCR Year: 2017. The impact factors of individual publications of top 100 journals were also calculated for the top 20 countries. Alongside, the frequency distributions of the top 100 journals among different impact factor categories were also studied for the top 20 countries and plotted graphically.

Collaborations in research provide an opportunity to increase the impact and scope of research. The number of collaborating countries was identified during different periods and presented graphically from the Web of Science database. The network analysis techniques were used to understand the patterns of the interactions among the top 20 countries in climate change research from the Web of Science database. The most productive countries were chosen to form co-occurrence matrices to which a multidimensional scaling algorithm (Pajek and VOSviewer) was applied to produce the network maps. The network map of collaboration with the top 50 collaborating countries of Indian research was also drawn from both the Web of Science and Scopus database. The research collaborations were visualized through generating a network map with the help of VOSviewer among the top 500 authors, the top 100 organisations of total Indian publications. The number of collaboration links, total link strength, number of documents, total citations and average citations of the top 500 authors, the top 100 organisations of total Indian publications were also represented in tables.

A comparative study was performed to understand the impact of Indian collaborative research by analysing the number of publications, total citations, average citations, h-index and % of publications without any citation among the collaborative publications with top 20 countries, the collaborative publications with rest of the countries and total Indian publications from both of the WoS and Scopus databases. The results were represented graphically.

Bibliographic coupling identifies relationships between authors whose contributions share references (Garfield E, 2001). Coupling analysis provides insights on groups of scientists having similar interests and using the same sources to conduct research. The bibliometric analysis tool Vos Viewer was used to generate the coupling network map of the top 100 organizations and the top 500 authors. The number of shared links, total link strength, number of documents, total citations and average citations of the top 500 authors, the top 100 organisations of total Indian publications were also represented in tables.

India's National Action Plan on Climate Change (NAPCC) focused on promoting understanding of climate change, adaptation and mitigation, energy efficiency, and natural resources conservation. The core of the NAPCC is comprised of “Eight National Missions” representing multi-pronged, long-term, and integrated strategies to achieve key goals in the context of climate change.

The interrelationship among the national goals on climate change and the research publications of India were studied for eight national missions. Various search strings were generated by combining keywords related to the topics on the different national missions. The research publications in eight different national missions were retrieved using the search strings from both the Web of Science, Scopus, and Indian Citation Index databases, and the growth of publications and contributions in different research areas were analysed.

The total publication data was retrieved from the Web of Science, Scopus, and Indian Citation Index using the different search-string for different National Missions. The year-wise growth of the number of total global and Indian publications related to different National Missions was graphically presented along with the total Global and Indian comparative contribution in the top 30 research areas. Besides, Indian publication contribution in the top 30 research areas before and after the adoption of the missions was also analysed.

The year-wise growth of the number of total global and Indian publications related to different National Missions was graphically presented along with the total Global and Indian comparative contribution in the top 30 research areas. Besides, Indian publication contribution in the top 30 research areas before and after the adoption of the missions was also analysed. The number of publications contributed by top 20 individual countries in top 30 individual research areas of total global climate change research during the successive periods (1985-2019) was analysed and the rank of India in the individual research area among the top 20 countries was identified and represented through tables.

The thematic evolution of the different missions from before the mission to the after the mission research was studied using Science Mapping Analysis Software Tool (SciMAT) (Cobo et al., 2011, 2012) from the Web of Science database. Cluster's information of strategic maps was represented in tabular form by giving their centrality, density, document counts, document h-index and document citations for different periods to understand the thematic evolution.

Period-wise growth of the number of the research area of total global publications on "Climate Change" was graphically presented along with the period-wise growth of the number of the research area during different periods of top 20 countries. The total, as well as periodical Global and Indian comparative contribution in the top 30 research areas was also analysed and represented graphically with their Compound period-wise growth (CPGR).

As mentioned before, the total 35 years' time span was further divided into seven periods of five years each to understand the thematic evolution of the climate change research front of India at successive periods. The thematic evolution of Indian total climate change research was studied from the Web of Science data using Science Mapping Analysis Software Tool (SciMAT) (Cobo et al., 2011,2012). Thematic evolution of Indian total climate change was represented through strategic diagrams at successive periods. Themes were plotted as circles denoting different theme clusters according to centrality and density in strategic diagrams.

Share of global cumulative CO_2 emissions (%), CO_2 emissions (metric tons per capita, of top 20 countries) and Publication share % data of top 20 countries based on publications data (Scopus) were taken from University of OXFORD, 2017, the World Bank, 2014, and Scopus and Web of Science database respectively. Accordingly, these results were interpreted. Besides total Greenhouse gas emission % change from 1990 (The World Bank, 2012) and the inter-relationship of CO_2 emission (Our World in Data based on Global Carbon Project, 2020) and GDP current prices (2018) in billions of US dollars (International Monetary Fund,2018) was studied and explained. The GERD data of the top 20 countries were retrieved from the World Bank,2015, and its interrelation with the publication share of those countries was interpreted. Comparative analysis of electricity production from coal sources and fossil fuel energy Consumption of top 20 countries also analysed from the World Bank, 2015 along with the % renewable energy Consumption of top 20 countries. The comparative data of the land area and forest cover of the top 20 countries were collected from the World Bank, 2016 and represented graphically.

The total global patent publications were recorded from World Intelectual Property Organization (WIPO) on 31.03.2021 using the search string which was used to retrieve the publication data from the Web of Science and Scopus. Then a comparative analysis of the number of patent publications and number of global and Indian research publications on climate change from WoS and Scopus were performed. The top 20 countries were identified based on the number of patent publications and their correlation with the number of publications from the Web of Science and Scopus during 1985-2019 were identified.

Alongside, the patent data was also collected from WIPO GREEN. WIPO GREEN is an online technology sharing site. It aids global efforts to combat climate change by linking environmentally friendly technology providers and seekers. It brings together key players to catalyse green technology progress and diffusion through its database, network, and acceleration projects. The top 30 countries were identified based on the number of patents index in this database and their contributions in different sectors were represented in tabular form.

Results & Discussions

Publication Contribution

Using the final search string a total of 4,66,426 publications were retrieved globally from the Web of Science (WoS) database. The compound annual growth rate was 18.77 %. The total number of publications were increased from 808 during the initial period (1985-1989) to 205135 during the last period (2015-2019) with a compound period-wise growth rate (CPGR) of 151.63 %. Among the 232 countries or regions of the total global publications, the top 30 countries contributed about 87.22% (normalized) and the top 20 countries contributed about 79% (normalised) of the total global publications.

India held 13th rank by contributing 14532 publications i.e., 2 % (normalised) of the total global publications in the Web of Science database. During the last 5-year period India secured 10th position by contributing 8140 publications. Nine countries having more CPGR than the group's average CPGR and India's rank was 13th with a CPGR of 200.74%. During the last ten-years period seven countries have contributed more than the group average publications during the last periods and India secured 11th position by contributing 12290 publications during the last period. Seven countries having more CPGR than the group's average CPGR and India's rank was 5th with a CPGR of 175.03%.

A total of 649544 publications were retrieved globally from the Scopus database from 1985 to 2019. India held 9th rank by contributing 24865 publications i.e., 2.66 % (normalised) of the total global publications. India has contributed to the total global publications at a higher proportion of publications in the Scopus database than that of the publications in the Web of Science database. India achieved 8th position during the last five-year period (2015-2019) by contributing 13717 publications with a CPGR of 112.73%. India also achieved 8th position during the last ten-year period (2010-2019) by contributing 20511 publications with a CPGR of 412.80 %. India's rank was 5th based on CPGR (ten-year period).

A total of 9845 publications were retrieved globally from the Indian Citation Index database from 2005 to 2019. India published a total of 7748 publications. The publications were increased from 158 in 2005 to 658 in 2019 with a CAGR of 10.72 %. Total Indian publications were increased from 1145 during the initial period (2005-2009) to 3861 during the last period (2015-2019) with a compound period-wise growth rate (CPGR) of 83.63 %. India ranked the 1st throughout the periods.

Contribution by bibliometric parameters

During the last five-year and ten-year period India ranked 15th position by involving 6588 and 7915 organizations respectively in the Web of Science and Scopus database. There were no Indian organisations in the global top 30 and top 100 organisations. There were only 9 Indian organisations in the top 500 organization's list namely Indian Institute Of Technology System IIT System (Rank-109), Indian Council of Agricultural Research ICAR (Rank-169), Ministry of Earth Sciences MOES India (Rank-218), Department of Space DOS Government of India (Rank-258), Council of Scientific Industrial Research CSIR India (Rank-285), Department of Science Technology India (Rank-395), Indian Institute of Tropical Meteorology IITM (Rank-407), Indian Space Research Organisation ISRO (Rank-432), Indian Institute of Science IISC Bangalore (Rank-467).

India ranked 16th position by involving 24689 authors with a CPGR of 243.61 % during the last five-year period. During the last ten-year period India ranked 18th position by involving 31671 authors with a CPGR of 432.71 %. Based on the number of abstracts published in different meetings, India ranked better (6th) position by contributing 1134 and 1679 during last five-year period and ten-year period respectively.

During the last five-year and ten-year periods, India ranked 9th position by publishing in 1978 and 2649 source titles. The average number of publications per journal by India is much lower than the average number of publications per journal by the top 20 countries throughout the periods. Top 30 source titles or journals have published 22.21 % of the total global research on climate change. Top 30 source titles or journals have published 15.93 % of the total Indian research on climate change. India has contributed at a higher proportion than the global in some low-impact journals (IF range 2-5). India has contributed at a lower proportion than the global in some high-impact journals namely Nature, Science. Similar trends were observed from Scopus database. Top 30 source titles or journals have published 12.41 % of the total Indian research on climate change. The top 30 source titles or journals of the Indian Citation Index have published 33.20 % of the total Indian publications on climate change.

Citation impact

The average citation of publications from WoS of the top 20 countries was 61.65 during the initial period (1985-1989) and it was decreased to 54.16 during the next period. Then the average citation was increased for consecutive two periods (57.09 & 67.20) and during subsequent periods it was decreased. India ranked in the last position throughout the periods. The average citation of publications of the top 30 countries was 48.96 during the initial period (1985-1989) and it was increased at successive periods until 2000-2004 and during subsequent periods it was decreased. India also ranked the last position during last two consecutive periods.

The calculated 5-year impact factor of the publications from WoS of the top 20 countries was increased from 1.42 during the initial period (1985-1989) to 7.073 during the last period 2015-2019. India ranked 19th during the last period. The calculated 5-year impact factor of the publications of the top 30 countries was increased from 1.20 during the initial period (1985-1989) to 6.97 during the last period 2015-201 and India ranked 29th during the last period.

The Group average h-index of the total publication from WoS of the top 20 countries is 324.25. Eight countries have a higher h-index than the group average h-index and India ranked 19th. The average h-index of the top 20 countries were increased from 10.8 during the initial period (1985-1989) to 178.1 during 2005-2009 and the h-index of the last two consecutive periods was decreased. India ranked the 18th position during the last three periods. The average h-index of the top 30 countries were increased from 7.93 during the initial period (1985-1989) to 150.50 during 2005-2009. India ranked 21st position during the last three periods.

The average % of total publications from WoS of top 20 countries in country-specific top 100 journals is 53.39% and India ranked 14th by publishing 51.77% of total Indian publications. The average impact factor of country-specific top 100 journals of top 20 countries is 4.43 and India ranked last with having an average impact factor of 2.97. The average impact factor of individual publications in country-specific top 100 journals of top 20 countries is 4.63 and India ranked last with having an average impact factor of 2.386.

The most frequent publications from WoS of the top 20 countries were published in the 3 to 4.99 IF category followed by 1 to 2.99 and 5to 9.99 IF categories. Above 20 IF was the lowest frequent IF category followed by 10 to 19.99 IF category. India ranked better in below one and no IF categories.

The Group average h-index of the total publication of the top 20 countries from Scopus is 331.55. The average h-index of the top 20 countries were increased from 37.25 during the initial period (1985-1989) to 193.45 during 2005-2009 and the h-index of the last two consecutive periods was decreased. India ranked the 17th position for the last two periods.

The average % of total publications from Scopus of top 20 countries in country-specific top 100 journals is 43.92 % and India ranked the last by publishing 36.66 % of total Indian publications. The average impact factor of country-specific top 100 journals of top 20 countries is 4.15. India ranked 19th with having an average impact factor of 2.88. The average impact factor of individual publications in country-specific top 100 journals of top 20 countries is 4.617 and India ranked 19th with having an average impact factor of 2.54 per publication.

The most frequent publications from Scopus of the top 20 countries were published in the 3 to 4.99 IF category followed by 1 to 2.99 and 5 to 9.99 IF categories. Above 20 IF was the lowest frequent IF category followed by 10 to 19.99 IF category. India ranked better in the below one and no IF categories.

The total citations of total global publications were increased slightly during the 2nd period then decreased abruptly during the last period.

The total citations of total global and Indian publications from Indian Citation index were increased slightly during the 2nd period then decreased abruptly during the last period. Whereas, the number of not cited publications of both global and Indian publications were increased at successive periods. It is quite interesting to see the average citation of Indian publications was quite higher than the average citation of total global publications. During the last period, the h-index of global publication (7) was higher as compared to the h-index of Indian publications (6).

Research collaboration

The average number of collaborating countries of the top 20 countries were increased from 5.1 during the initial period (1985-1989) to 180.1 during 2015-2019. In the case of India, it was increased from 2 to 172 and ranked the 15th position during the last period.

India has published the maximum collaborative research publications (WoS) with the USA followed by England, Germany, and France. It has been observed that 31.97 % of total Indian publications were collaborative. Among the total of 14663 Indian publications, 4022 (27.43 %) publications were published from the collaboration with the top 20 India's collaborating countries. Only 639 (4.36 %) publications were published in collaboration with the rest of the collaborating countries of India. The average citations of the collaborative publications with the top 20 India's collaborating countries were about two times greater than that of the average citations of total Indian publications. There is very less difference between the h-index of total Indian publications and collaborated publications with top 20 countries as compared to the number of publications. About 13.45 % of the total Indian publications have no citation as compared to publications with the top 20 India's collaborating countries (5.20%). About 9.86 % of the collaborative publications with rest of the India's collaborating countries were without any citations.

Indian Institute of Technology system is the most collaborative organization from India followed by the Ministry of Earth Sciences, Council of Scientific & Industrial research. Centre National De La Recherche Scientifique CNRS is the most collaborative international organization in Indian collaborative research (WoS). Indian Institution Tropical Meteorology registered with 10th rank and this the only organization based on total Link strength within the top 20 organization. Chinese Academy of Sciences registered the highest collaboration link strength in Indian climate change research collaboration followed by Columbia University, University of Washington, University of California San Diego, The University of Maryland, The University of Tokyo.

KUMAR, A registered with the highest number of collaborations with 247 authors in 287 publications, and with 973 collaboration strength followed by SINGH, AK and SINGH, R number of collaboration of authors of 163 and 149 with link strength of 644.

Indian Institution of Tropical Meteorology registered with the highest amount of co-citation among the top 100 organisations of bibliographic coupling of organizations followed by another Indian organisation India Meteorological Department. The top three authors namely KUMAR, A, RAJEEVAN, M, and SRIVASTAVA, AK were the most co-cited authors of Indian publications in this field. KUMAR, A registered with the highest number of authors of 499 with whom he was co-cited in 287 documents followed by RAJEEVAN, M co-cited with 438 authors in 50documents.

India has published the maximum collaborative research publications from Scopus database with the USA followed by England, Germany and Australia. The 23.13 % of total Indian publications with the top 20 Indian collaborating countries received 47.31 % (207746 citations) of the total Indian citations. Indian Institute of Technology Delhi is the most collaborative organization from India followed by the Indian Institute of Tropical Meteorology IITM, Indian Institute of Science IISC Bangalore, Indian Space Research Organisation. Centre National De La Recherche Scientifique CNRS is the most collaborative international organization in Indian collaborative research.

National Solar Mission

India ranked 4th with 20686 publications related to the "National Solar Mission" from WoS. It is very interesting to see that the CAGR of Indian publications from 2009 to 2019 is fairly higher as compared to the previous period (1985-2008) than the global total publications. Therefore, it may infer that the National Solar Mission of India instigates R&D activities on various objectives of solar mission thereby the growth of publications accelerated. India has contributed at a higher proportion than the global in some research areas namely: Energy fuel, Engineering Electrical Electronic, Physics Condensed Matter, Green Sustainable Science Technology, Thermodynamics, Mechanics and Automation Control Systems which are mainly deal with the technological development to mitigate climate change. After the introduction of the mission the above-mentioned research area also contributed at higher rate. During 2009-2019 SOLAR-CELLS" was the central theme along with "POWER-SYSTEMS", "ABSORBERS", "DISTRIBUTED-GENERATIONS" and "SURFACES".

Scopus database resulted in a total of 3,48,464 publications related to the "National Solar Mission" India has contributed 25933 publications and secured 3rd rank globally. The CAGR (25.77 %) of Indian publications was also higher than the global total publications. India has contributed at a higher proportion than the global in some research areas namely: Engineering, Energy, Chemical engineering, Computer Science, Mathematics, Social Sciences, Multidisciplinary, Decision Sciences, etc. After the introduction of the mission, the following research areas Engineering, Energy, Materials Science, Physics and Astronomy, Computer Science, etc. were the most important and contributed more than 1500 publications.

Indian Citation Index recorded a total of 1657 Indian publications. The CAGR of Indian publications from 2009 to 2019 is lower than the global total publications and also lower than the previous period. India has contributed at a higher proportion than the global in some research areas namely: Engineering Science and Technology, Agriculture, Electrical Engineering, Energy and Fuel Science and Chemical Engineering

National Mission for Enhanced Energy Efficiency

A total of 157811 global and 10239 Indian publications related to the "National Mission for Enhanced Energy Efficiency" were retrieved from the Web of Science database. India secured 3rd rank globally based on the number of publications. The CAGR of Indian publications was lower than the total global publications before 2008. The CAGR of Indian publications from 2009 to 2019 is fairly higher than the global total publications. India has contributed at a higher proportion than the global in some research areas namely: Engineering Electrical Electronic, Telecommunications, Computer Science Information Systems, Computer Science Hardware Architecture, Computer Science Theory Methods, Computer Science Artificial Intelligence, Automation Control Systems. After the introduction of the mission, the following research areas Energy Fuels, Engineering Electrical Electronic, Telecommunications, Computer Science Theory Methods, Computer Science Information Systems were the most important and contributed more than 1000 publications. During this time, the most active theme was "WIRELESS-SENSOR-NETWORK" followed by "ENERGIES,". The themes "WSNS", "GREEN-COMMUNICATIONS" and " CO2-EMISSIONS " were discovered to be getting more popular.

A total of 2,72,519 publications were included in the Scopus database. India has contributed 19094 publications related to the "National Mission for Enhanced Energy Efficiency" and is ranked third in the world. It's fascinating to note that the CAGR of Indian publications (26.83 %) is also higher than the global total publications. In some research fields, such as Computer Science, Mathematics, Medicine, Decision Sciences, Veterinary, India has contributed more than the global average. Following the introduction of the mission, the following research areas emerged as the most prominent, contributing over 1500 publications: Energy, Engineering, Computer Science. Materials Science, Chemistry, Environmental Science, Chemical Engineering, Mathematics, Physics and Astronomy.

A total of 2055 publications were recorded from the Indian Citation Index. The CAGR of Indian publications was quite higher than the total global publications before 2008. While, the CAGR of Indian publications from 2009 to 2019 is lower than the global total publications as well as than the previous period. India has contributed at a higher proportion than the global in some research areas namely Engineering Science and Technology, General Science and Technology, Computer Science and Technology, Agriculture, Artificial Intelligence, etc. After the introduction of the mission, the following research areas Engineering Science and Technology, General Science and Technology, Computer Science and Technology, Environmental Science, Agriculture, Electronic and Communication Engineering, Artificial Intelligence, Social Science were the most important and contributed more than 100 publications.

National Mission on Sustainable Habitat

A total of 1,66,865 global and 7187 Indian publications were retrieved from the Web of Science database using the final search string of "National Mission on Sustainable Habitat". India secured 7th rank globally based on the number of publications. The compound annual growth rate of Indian publications is slightly lower than the total global publications during 1987-2019. The CAGR of Indian publications from 2009 to 2019 is fairly higher than the global total publications that infer the positive impact of the mission. India has contributed at a higher proportion than the global in some research areas namely: Engineering Electrical Electronic, Engineering Chemical, Green Sustainable Science Technology, Computer Science Information Systems, Computer Science Theory Methods, Biotechnology Applied Microbiology, etc. After the introduction of the mission, the following research areas Engineering Electrical Electronic, Energy Fuels, Environmental Sciences, Engineering Environmental, Green Sustainable Science Technology, Engineering Chemical, Telecommunications were the most important which are mainly deal with the sustainable development related technology to mitigate climate change and contributed to more than 500 publications.

A total of 3,23,457 publications worldwide was retrieved from the Scopus database. India has contributed 16651 publications and secured 3rd rank globally in the publications related to the "National

Mission on Sustainable Habitat". The CAGR (17.02%) of Indian publications was higher than the total global publications up to 2008 i.e., the year of the setting of the "National Mission on Sustainable Habitat". It is very interesting to see that the CAGR (16.22%) of Indian publications is higher than the global total publications after the introduction of the mission. India has contributed at a higher proportion than the global in some research areas namely: Computer Science, Chemical Engineering, Mathematics, Agricultural and Biological Sciences Medicine, Business, Management and Accounting, Biochemistry, Genetics and Molecular Biology, etc. After the introduction of the mission, the following research areas Engineering, Environmental Science, Computer Science, Energy, Chemical Engineering, Materials Science were the most important and contributed to more than 1000 publications.

A total of 2713 Indian publications were recorded from the Indian Citation Index. India has contributed at a higher proportion than the global in some research areas namely: Engineering Science and Technology, Agriculture, Electrical Engineering, Energy and Fuel Science and Chemical Engineering which are mainly deal with technology related to sustainable habitat development. After the introduction of the mission, the following research areas Environmental Science, Engineering Science and Technology, Biological Science, Agriculture, Chemistry, General Science and Technology, Management, Social Science, Health Science were the most important and contributed more than 150 publications.

National Water Mission

A total of 103673 global and 5416 Indian publications were retrieved from the Web of Science database using the final search string of "National Water Mission". India secured 5th rank globally based on the number of publications. The compound annual growth rate of Indian publications is lower than the total global publications during 1987-2019 and before the mission. The CAGR of Indian publications from 2009 to 2019 is also lower than the global total publications. Therefore, it may infer that the "National Water Mission" of India did not instigate R&D activities on various objectives of the mission. India has contributed at a higher proportion than the global in some research areas namely: Water Resources, Geosciences Multidisciplinary, Engineering Chemical, Agronomy, Engineering Civil, Energy Fuels, Green Sustainable Science Technology, Agriculture Multidisciplinary, Chemistry Multidisciplinary, Multidisciplinary Sciences, Biotechnology Applied Microbiology which are mainly deal with the water resources management and development to mitigate the impact of climate change. After the introduction of the mission, the above-mentioned research areas were the most important and contributed more than 200 publications. After the mission initiatives "DISTRICT" was found to be the most active theme followed by "WATER-USE-EFFICIENCY" and "SOLAR-STILL" and the themes "MEMBRANE", "REGION" and "LAKE" were found to come under emerging focus.

A total of 2,08,795 publications related to "Nation Water Mission" were retrieved from the Scopus database. India has contributed 12049 publications and secured 3rd rank globally. The CAGR (12.3%) of Indian publications was higher than the total global publications up to 2008 i.e., the year of the setting of the "National Water Mission". It is very interesting to see that the CAGR (8.8%) of Indian publications is also higher than the global total publications after the introduction of the mission. India has contributed at a higher proportion than the global in some research areas namely: Agricultural and Biological Sciences, Engineering, Chemical Engineering, Biochemistry, Genetics and Molecular Biology, Energy, etc. After the introduction of the mission, the following research areas Environmental Science, Agricultural and Biological Sciences, Engineering, Earth and Planetary Sciences, Chemical Engineering were the most important and contributed to more than 1000 publications.

There were 2794 Indian publications linked to "National Water Mission" found in the Indian Citation Index. During 2005-2019 and after the mission, the compound annual growth rate of Indian publications was marginally lower than that of total global publications. Following the launch of the mission, the following research areas emerged as the most prominent, contributing over 100 publications: Environmental Science, Agriculture, Biological Science, Earth and Geological Science, Engineering Science and Technology, General Science and Technology, Water, Pollution, Chemistry, Social Science, Environmental Geology and Watershed Management.

National Mission for Sustaining the Himalayan Ecosystem

A total of 15308 global and 7291 Indian publications were retrieved from the Web of Science database. India is the leading country and contributed 7291 publications. The compound annual growth rate of Indian publications is slightly lower than the total global publications during 1987-2019. It is very interesting to see that the CAGR of Indian publications from 2009 to 2019 is fairly higher than the global total publications although it was lower than the previous period. India has contributed at a higher proportion than the global in some research areas namely: Environmental Sciences, Multidisciplinary Sciences, Water Resources, Remote Sensing, Agronomy, Forestry, Engineering Civil, Imaging Science, Holographic Technology, Soil Science, Agriculture Multidisciplinary, Entomology, Engineering Geological, Biotechnology Applied Microbiology, Microbiology those are mainly deal with the Himalayan Ecosystem development to mitigate the impact climate change. After the introduction of the mission, the following research areas Geosciences Multidisciplinary, Environmental Sciences, Multidisciplinary Sciences, Plant Sciences, Water Resources, Meteorology Atmospheric Sciences, Geography Physical were the most important and contributed more than 400 publications. During this period "CLIMATE-CHANGE" was found to be the most active theme followed by "ACTIVE-TECTONICS". The themes "PLANTS", "POPULATIONS" and "DISTRICT" were found to come under emerging focus.

A total of 18,181 publications were retrieved from the Scopus database. India is the leading country and contributed 9388 publications. The compound annual growth rate (10.35%) of Indian publications is higher than the total global publications during 1987-2019. It is very interesting to see that the CAGR (11.67%) of Indian publications is also higher than the global total publications. India has contributed at a higher proportion than the global in some research areas namely: Agricultural and Biological Sciences, Environmental Science, Biochemistry, Genetics and Molecular, Biology, Engineering, Medicine, Multidisciplinary, Pharmacology, Toxicology and Pharmaceutics, etc. After the introduction of the mission, the following research areas Agricultural and Biological Sciences, Environmental Science, Earth and Planetary Sciences, Biochemistry, Genetics and Molecular Biology, Social Sciences were the most important and contributed more than 600 publications.

About 4247 Indian publications were recorded from the Indian Citation Index. The CAGR of Indian publications from 2009 to 2019 is also lower than the global total publications like that of total as well as before the mission introduction. India has contributed at a higher proportion than the global in some subject areas namely: Environmental Science, Botany, Agriculture, Forestry, General Science and Technology, Health Science, Zoology, Pharmacology and Pharmaceutical Science, Biodiversity, Forest Botany, Economic Botany, Multidisciplinary, Pharmacology, etc. After the introduction of the mission, the following research areas Biological Science, Environmental Science, Earth and Geological Science, Botany, Agriculture, General Science and Technology, Forestry, Social Science were the most important and contributed more than 200 publications.

National Mission for a Green India

A total of 206003 global and 5499 Indian publications were retrieved from the Web of Science database. India has secured 13th rank globally based on the number of publications. The CAGR of Indian publications is slightly lower than the total global publications during 1987-2019. It is very interesting to see that the CAGR of Indian publications from 2009 to 2019 is fairly higher than the global total publications. India has contributed at a higher proportion than the global in some research areas namely: Environmental Sciences, Multidisciplinary Sciences, Remote Sensing, Water Resources, Agronomy, Imaging Science Photographic Technology, etc. After the introduction of the mission, the following research areas Environmental Sciences, Ecology, Multidisciplinary Sciences, Biodiversity Conservation, Forestry, Plant Sciences, Geosciences Multidisciplinary, Remote Sensing were the most important and contributed more than 250 publications. During this period "WESTERN-GHATS" was found to be the most active theme "POPULATION". The themes "CARBON" and "PLANTATIONS" were found to come under emerging focus.

A total of 2,54,822 publications were retrieved from the Scopus database. India has contributed 8936 publications and secured 10th rank globally in the publications related to the "National Mission for a Green India". The CAGR (12.04%) of Indian publications is higher than the total global publications during 1987-2019. The CAGR (12.17%) of Indian publications was also higher than the global total publications. India contributed at higher rate than the global in most of the research areas except Agricultural and Biological Sciences, Environmental Science, Earth and Planetary Sciences, Arts and Humanities, Veterinary, Neuroscience, Psychology, Undefined, Dentistry, etc. After the introduction of the mission, the following research areas Agricultural and Biological Sciences, Environmental Science, Earth and Planetary Sciences, Social Sciences, Engineering, Biochemistry, Genetics and Molecular Biology, Computer Science were the most important and contributed more than 500 publications.

About 4132 Indian publications were recorded from the Indian Citation Index. The compound annual growth rate of Indian publications is lower than the total global publications during 2005-2019. The CAGR of Indian publications from 2009 to 2019 is lower than the global total publications. India has contributed at a higher proportion than the global in some research areas namely: Forestry, Agriculture, Botany, General Science and Technology, Earth and Geological Science, Forest Botany, Natural Resources, Economic Botany, Soil Science, Zoology, Agricultural Botany, Multidisciplinary, Engineering Science and Technology, Forest Management, Management, Remote Sensing which are mainly deal with the forest and environment-related research. After the introduction of the mission, the following research areas Biological Science, Forestry, Environmental Science, Agriculture, Botany, Social Science, General Science and Technology, Biodiversity was the most important and contributed more than 200 publications.

National Mission for Sustainable Agriculture

A total of 2,48,369 global and 13461 Indian publications were retrieved from the Web of Science database. India secured 5th rank globally based on the number of publications. The CAGR of Indian publications is slightly lower than the total global publications during 1987-2019. the CAGR of Indian publications from 2009 to 2019 is lower than the global total publications. India has contributed at a higher proportion than the global in some research areas namely: Agronomy, Water Resources, Plant Sciences, Biotechnology Applied Microbiology, Meteorology Atmospheric Sciences, Green Sustainable Science Technology, Energy Fuels, Multidisciplinary Sciences, Remote Sensing, Engineering Electrical Electronic, Engineering Chemical, Toxicology, Engineering Civil which are mainly deal with the Sustainable Agriculture development-related research. After the introduction of the mission, the following research areas Environmental Sciences, Agronomy, Water Resources, Plant Sciences, Agriculture Multidisciplinary, Multidisciplinary Sciences, Biotechnology Applied Microbiology, Multidisciplinary Sciences, Engineering Electrical Electronic, Geosciences Multidisciplinary were the most important and contributed more than 500 publications. During this period “CLIMATE-CHANGE” was found to be the most active theme followed by “HEAVY-METALS”, “ACTIVATED-CARBON” and “AREA”. The themes “PESTICIDES”, “PLANTS” and “FOREST” were found to come under emerging focus.

A total of 5,06,446 publications were retrieved from the Scopus database. India has contributed 36033 publications and secured 3rd rank globally. The compound annual growth rate (12.26%) of Indian publications is higher than the total global publications during 1987-2019. The CAGR (13.87%) of

Indian publications is also higher than the global total publications. India has contributed at a higher proportion than the global in some research areas namely: Agricultural and Biological Sciences, Engineering, Biochemistry, Genetics and Molecular Biology, Computer Science, Energy, Chemical Engineering, Immunology and Microbiology, Business, Management and Accounting, Materials Science, Multidisciplinary, Physics and Astronomy, Pharmacology, Toxicology and Pharmaceutics, Veterinary, Mathematics, Health Professions, etc. After the introduction of the mission, the following research areas Agricultural and Biological Sciences, Environmental Science, Engineering, Biochemistry, Genetics and Molecular Biology, Social Sciences, Biochemistry, Genetics and Molecular Biology, Computer Science, Earth and Planetary Sciences, Immunology and Microbiology, Medicine were the most important and contributed more than 1500 publications.

About 24863 Indian publications were recorded from the Indian Citation Index. India has contributed at a higher proportion than the global in some research areas namely: Agriculture, General Science And Technology, Management, Botany, Agronomy, Agricultural Botany, Agricultural Economics, Agrochemicals, Horticulture, Education, Soil Science, Forestry, Agricultural Engineering, Field Crops, Crop Improvement, Zoology, Earth And Geological Science. After the introduction of the mission, the following research areas Agriculture, Biological Science, Environmental Science, Agronomy, Botany, Economics, Social Science, General Science and Technology, Management, Agricultural Botany, Zoology, Agricultural Economics were the most important and contributed more than 600 publications.

National Mission for Strategic Knowledge for Climate Change

A total of 75456 global and 2442 Indian publications were retrieved from the Web of Science database. India secured 13th rank globally based on the number of publications. The compound annual growth rate of Indian publications is lower than the total global publications during 1987-2019. The CAGR of Indian publications from 2009 to 2019 is also lower than the global total publications. India has contributed at a higher proportion than the global in some research areas namely: Meteorology Atmospheric Sciences, Geosciences Multidisciplinary, Water Resources, Multidisciplinary Sciences, Energy Fuels, Engineering Civil, Remote Sensing, Agronomy, Agriculture Multidisciplinary, Engineering Electrical Electronics. After the introduction of the mission, the following research areas Environmental Sciences, Meteorology Atmospheric Sciences, Geosciences Multidisciplinary, Water

Resources, Multidisciplinary Sciences, Engineering Civil, Ecology, Agronomy, Engineering Civil, Geography Physical were the most important and contributed more than 100 publications. During this period “CLIMATE-CHANGE” was found to be the most active “RUNOFF”. The themes “RIVER” and “INDEX” were found to come under emerging focus.

A total of 83738 publications were retrieved from the Scopus database. India has contributed 3236 publications and secured 10th rank globally in the publications related to the “National Mission for Strategic Knowledge for Climate Change”. The compound annual growth rate (21.02%) of Indian publications is higher than the total global publications during 1987-2019. The CAGR (22.93%) of Indian publications is also higher than the global total publications which infer that the mission accelerated the publications. India has contributed at a higher proportion than the global in some research areas namely: Engineering, Multidisciplinary, Computer Science, Medicine, Economics, Econometrics and Finance, Physics and Astronomy, Business, Management and Accounting, Materials Science, Decision Sciences, Chemical Engineering, Pharmacology, Toxicology and Pharmaceutics, Veterinary, Health Professions, Undefined etc. After the introduction of the mission, the following research areas Environmental Science, Earth and Planetary Sciences, Agricultural and Biological Sciences, Engineering, Social Sciences, Computer Science, Multidisciplinary, Energy, Medicine, Biochemistry, Genetics and Molecular Biology were the most important and contributed more than 100 publications.

About 2375 Indian publications were recorded from the Indian Citation Index. India has contributed at a higher proportion than the global in some research areas namely: Agriculture, General Science and Technology, Agricultural Meteorology, Botany, Meteorology, Forestry, Management, Economics, Agronomy, Agricultural Botany, Zoology, Education, Soil Science and Chemistry. After the introduction of the mission, the following research areas Agriculture, Environmental Science, Biological Science, General Science and Technology, Earth and Geological Science, Agricultural Meteorology, Botany, Meteorology, Forestry, Social Science, Management were the most important and contributed more than 90 publications.

Evolving trends of the research area and research topic of total Climate Change from the Web of Science

The number of research areas of total global publications was increased from 88 during the initial period to 239 during the last period. India's number of research areas was increased from 7 during the initial period (1985-1989) to 177 during the last period. India contributed to 200 research areas during total periods and achieved 9th position during the last period by contributing to 177 research areas. The top 30 research areas of total Indian research on climate change have contributed 79.26 % cumulatively. India has contributed at a higher proportion than the global in some research areas namely: Energy fuel, Water resource, Agronomy, Engineering Electrical Electronics, Green sustainable, Remote sensing those are mainly deal with the mitigation and adaptive measures of climate change.

The following research areas of Indian publications have contributed with higher CPGR than the global CPGR namely: Agriculture Multidisciplinary, Computer Science Theory Methods, Engineering Electrical Electronic, Forestry, Geochemistry Geophysics, Meteorology Atmospheric Sciences, Palaeontology. Throughout the periods in the following research areas namely Engineering Electrical Electronic (Rank-3), Multidisciplinary Sciences (Rank-8), Energy Fuels (Rank-9) and Remote Sensing (Rank-9) India cumulatively contributed more publications as compared with the top 20 countries. During the last period Meteorology Atmospheric Sciences, Water Resources and Energy Fuels ranked 9th and Geography Physical ranked 10th among top 20 countries and these research areas also positioned in the top ten research areas of global cumulative publications.

In the case of Indian climate change research, seven themes namely "OCEANS", "PLANTS", "ECOSYSTEMS", "SIMULATIONS", "INFECTIONS", "SEA-SURFACE-TEMPERATURES" and "SOILS" have solid links with the themes of the next period that indicates the continuity of the associated keywords vis-à-vis topics. In some of these themes have been appeared during the next period like "SEDIMENTS", "SIMULATIONS", "SOILS". During 1995-1999 the new themes have appeared like "SENSITIVITIES", and "STABLE-ISOTOPES" represent transition themes that shared the main topics. Although these themes have not appeared during the next period.

During 2000-2004 the new themes have appeared like "RECORDS", "MODELS", "CLIMATE-CHANGES", "CARBONATES", "GENERAL-CIRCULATION-MODELS", "DEPOSITS", “AEROSOLS” and “PADDY-FIELD” represent transition themes that shared the main topics. “CLIMATE-CHANGES” themes have appeared throughout the successive period from 2000-2004 to 2015-2019.

During 2005-2009 six themes namely “CLIMATE-CHANGES”, “CLIMATES”, “SENSITIVITIES”, “METHANE-EMISSIONS”, “INDIAN-MONSOONS”, “WESTERN-GHATS” have solid links with the themes of the next period that indicates the continuity of the associated keywords vis-à-vis topics. During 2010-2014 eight themes namely “GLOBAL-WARMING-POTENTIALS”, “CLIMATE-CHANGES”, “CLIMATES”, “BASINS”, “INTENSITIES”, “MASS-BALANCES” have solid links with the themes of the next period. In this period “SEA-SURFACE-TEMPERATURES” again appeared after 1990-1994 and “SIMULATIONS” appeared after 1995-1999.

During 2010-2014, three themes “CLIMATE-CHANGES”, “GLOBAL-WARMING-POTENTIALS”, “MASS-BALANCES” have appeared as transition themes among these 21 have shared the main topics with the themes of the last period (2015- 2019). It has been observed that the themes “SIMULATIONS” have shared main topics and sub-topics only with the following themes “INDIAN-SUMMER-MONSOONS” and “UNCERTAINTIES” during the last period. The themes have acted as a thematic bridge those have received topics from the previous period as well as shared its main topics of the next period “EMISSIONS” to “ENERGIES”, “INTENSITIES” to “TROPICAL-CYCLONES” and “SEA-SURFACE-TEMPERATURES” to “INDIAN-SUMMER-MONSOONS”.

During the last period “CLIMATE-CHANGES” was the most active theme followed by “GLOBAL-WARMING-POTENTIALS”, “INDIAN-SUMMER-MONSOONS”, “UNCERTAINTIES” and “GREENHOUSE-GAS-EMISSIONS”. The themes “HAZARDS”, “STABLE-ISOTOPES”, “ARTIFICIAL-NEURAL-NETWORKS” and “ABIOTIC-STRESSES” were found to come under emerging focus.

Evolving trends of the research area and research topic of total Climate Change from Scopus

The top 10 subject areas of total global research on climate change have contributed 85 % cumulatively from Scopus. India has contributed 83.34 % of total Indian publications in the global top 10 subject areas. India has contributed at a higher proportion than the global in some research areas namely: Engineering, Energy, Biochemistry, Genetics & Molecular Biology, Computer Science, Multidisciplinary, Physics and Astronomy, Materials Science, Chemical Engineering. Throughout the periods the following subject areas namely Computer Science (Rank-3), Chemical Engineering (Rank-3), Veterinary (Rank-3), Pharmacology, Toxicology and Pharmaceutics (Rank-3), Engineering (Rank-4) and Materials Science (Rank-5), and Energy (Rank-7) cumulatively contributed more publications and placed better as compared with the top 20 countries. Throughout the periods "Climate Change" has appeared in the top five keywords excluding India. During the last period, "Climate Change" has appeared as the most frequent keyword. "Global Warming", "Greenhouse Gases" and "Solar Energy" also appeared throughout the periods with increasing frequency and rank at successive periods.

Evolving trends of the research area and research topic of total Climate Change from the Indian Citation Index

The top 30 research areas of total global research on climate change have contributed 79.09% cumulatively from the Indian Citation Index. India has contributed at a higher proportion than the global in some research areas namely: Agriculture, General Science and Technology, Botany, Engineering Science and Technology, Meteorology and Agricultural Meteorology. Throughout the periods "Climate Change", "Global warming" and "India" have appeared as the top three keywords indicated that the research works were performed on those research topics focusing on the Indian context. The following keywords namely "Rainfall", "Climate", "Environment", "Agriculture", "Remote sensing", "Carbon sequestration", "Rice", "GIS", "Drought", "Conservation", "Mitigation", "Diversity", "Adaptation", "Food security", Precipitation etc. also appeared throughout the periods with increasing frequency at successive periods.

Inter-relationship among the carried-out research topics and country-specific socio-economic & environmental problems

India registered 7th position by sharing 3.08% of the total global cumulative CO_2 emission up to 2017. India is the lowest per capita CO_2 emitting country among the top 20 countries with a value of 1.73 metric tons per capita. highly positive correlation (r=0.93) was observed between the number of publications (both from WoS and Scopus database) and the share of global cumulative CO_2 emissions of the top 20 countries. The total greenhouse gas emission % change from 1990 is about 27.47 % of the top 20 countries cumulatively. India ranked 3rd with a positive acceleration value of 116.44 %. A highly positive correlation (r=0.82) was observed between total CO_2 emission and GDP current prices (2018) in billions of US dollars. India is the 3rd most emitting country with an amount of 2591323.74 kilotons. India ranked 7th by contributing 2718.732 GDP current prices (2018) in billions of US dollars.

There was no correlation (r=0.03) between GERD as % of GDP and the number of publications from both of the databases. Results depicted a highly positive correlation (0.85) between the GERD PPP in billions of US dollars and the number of publications from both of the databases. India is the 7th country with a value of 56.75 billion US dollars.

India registered the highest % of electricity production from coal sources with a value of (75.31 %) followed by China (70.31 %), Australia (62.87 %), and so on. India registered the 11th position for fossil fuel energy consumption with a value of (73.58 % of total). respect to the % of electricity production from coal sources. India ranked fifth with a value of 36.02 % of renewable energy consumption. India registered the 15th with a forest cover of 23.83 % of total land. Although, based on the total forest area, seven countries have a higher forest cover in sq km than the group average of 10449724.54 sq. km. India ranked the 7th by covering 12475033.97 sq. km of forest and also ranked the 7th in respect to the total land area.

Indian patent publications were recorded with 545 number of patent publications since 2006 and registered 5th position. A highly positive correlation (r=0.97) was observed between the number of publications (both from WoS and Scopus database) and the number of global patent publications. A highly positive correlation (r=0.95) was also observed between the number of publications (both from WoS and Scopus database) and the number of Indian patent publications. A lower positive correlation (r=0.45) was observed between the number of publications (both from WoS and Scopus database) and the number of patent publications of the top 20 countries. India registered 14th position with 34 patent publications from the WIPO GREEN database. A moderate positive correlation (r=0.71) was observed between the number of publications (both from WoS and Scopus database) and the number of patent publications from the WIPO GREEN database of the top 20 countries.

Policy implication, suggestions & recommendations

It is suggested to give more importance on climate change research for the betterment of this field of research and to reach parity with the top countries.

The participation of more authors from more organisations is required to accelerate the growth of publications and to address various issues related to climate change.

The contribution at a higher proportion is required in the global top journals in this field and in some high-impact journals.

It is also recommended that the quality of research work on climate change should be improved to be published more research work in high-impact journals.

It is predicted that more research collaboration with the top 20 collaborative countries will elevate the impact of the Indian research publications.

The maintenance of the research activity related to the different missions is suggested and some extra attention should be taken for the following missions namely "National Water Mission", "National Mission for Sustainable Agriculture" and "National Mission for Strategic Knowledge for Climate Change".

Further in-depth bibliometric and scientometric analysis for all the missions is required to identify the major contributors for different bibliometric parameters, citation impact, research collaboration along with the innovation study through in-depth patent analysis.

It is suggested that Indian researchers should also perform better in the global top ten research areas.

Interrelationship study among environmental and socioeconomic parameters suggested some care should be taken like the reduction of electricity generation from a coal source, more power consumption from renewable sources and promotion of more afforestation to increase forest cover as compared to the others.

Finally, it is also suggested to accelerate the innovation of green technology to mitigate the impact of climate change.

Chapter 1

Introduction

Climate change is described as a statistically significant change in the climate's mean state or variability that lasts for an extended period (typically decades or longer). Climate change may be caused by natural internal processes or external forcing, or by persistent anthropogenic changes in the composition of the atmosphere or landuse. Climate change has longsince drawn to be a scientific interest and is no longer just one of many environmental and regulatory concerns. Annual global temperatures have increased by 0.4°C since 1980, with even larger changes observed in several regions (IPCC, 2001). During the last several decades' human activities have increased the concentrations of atmospheric trace gases. These increased trace gas concentrations are blocking the escape of thermal infrared radiation which in turn has elevated global surface temperatures (Dickinson & Cicerone, 1986). Modern climate change is dominated by human influences, which are now large enough to exceed the bounds of natural variability. These perturbations primarily result from emissions associated with energy use, but on local and regional scales, urbanization and land-use changes are also important. Anthropogenic climate change is now likely to continue for many centuries. We are venturing into the unknown with climate, and its associated impacts could be quite disruptive (Karl & Trenberth, 2003).

If global warming occurs, every day or every place will not be warmer uniformly, but on average, most places will be warmer. This will cause changes in the amount and pattern of rain and snow, in the length of growing seasons, in the frequency and severity of storms and sea level. Grasslands, forests, oceans, and other ecosystems and their flora and fauna in the natural environment will all be affected. There are several pieces of evidence of recent climate change namely: sea-level rise, global temperature rise, warming oceans, shrinking ice sheets, declining Arctic Sea ice, glacial retreat, extreme events, ocean acidification, and decreased snow cover, etc. Rising sea levels due to the melting of the polar ice caps (again, caused by climate change) contribute to greater storm damage; warming ocean temperatures are associated with stronger and more frequent storms; additional rainfall, particularly during severe weather events, leads to flooding and other damage; an increase in the incidence and severity of wildfires threatens habitats, homes, and lives; and heat waves contribute to human deaths and other consequences. Even small increases in Earth's temperature due to climate change can have severe effects. There is some evidence for changes in the frequency of weather extremes over recent decades. Studies have suggested that science the beginning of the Industrial Revolution, the acidity of surface ocean waters has increased by about 30 percent. Ocean acidification is expected to impact ocean species to varying degrees thus, it is an emerging global problem. Photosynthetic algae and seagrasses may benefit from higher CO_2 conditions in the ocean. On the other hand, a more acidic environment has a risk on some calcifying species, including oysters, clams, sea urchins, shallow water corals, deep-sea corals, and calcareous plankton.

Climate change has revived debates around the concept of limits to growth, 45 years after it was first proposed. Many citizens, scientists, and politicians fear that stringent climate policy will harm economic growth. Some are anti-growth, whereas others believe green growth is compatible with a transition to a low-carbon economy (Jeroen C. J. M. &van den Bergh,2017). Agricultural suitability is changing, with important consequences for production and conservation (Hannah et al. 2013), while at the same time species and ecosystems are moving to track suitable climatic conditions (Parmesan &Yohe, 2003). The effects of the past changes on agriculture remain unclear. It is likely that warming has improved yields (food production per unit of land area) in some areas, reduced them in others, and had negligible impacts in still others. Climate change may affect health through a range of pathways e.g., as a result of increased frequency and intensity of heatwaves, reduction in cold-related deaths, increased floods and droughts, changes in the distribution of vector-borne diseases, and effects on the risk of disasters and malnutrition. The overall balance of effects on health is likely to be negative and populations in low-income countries are likely to be particularly vulnerable to the adverse effects (Haines et al., 2006).

Mitigation of climate change requires a good scientific understanding as well as coordinated action at the national and global levels. The most effective way to address climate change is to adopt a sustainable development pathway by shifting to environmentally sustainable technologies and promoting energy efficiency, renewable energy, forest conservation, reforestation, water conservation, etc. The issue of the highest importance to developing countries is reducing the vulnerability of their natural and socioeconomic systems to the projected climate change. For a developing country such as

India, this means adopting measures that are compatible with present-day development goals. Although there has been progressing in monitoring and understanding climate change, there remain many scientific, technical, and institutional impediments to precisely planning for, adapting to, and mitigating the effects of climate change. There is still considerable uncertainty about the rates of change that can be expected, but these changes will be increasingly manifested in important and generous ways, such as changes in extremes of temperature and precipitation, decreases in seasonal and perennial snow and ice extent, and sea-level rise (Karl & Trenberth, 2003).

Recognizing the fact that climate change is a major environmental problem that affects the whole world, India has participated actively in multilateral negotiations under the United Nations Framework Convention on Climate Change in an optimistic, constructive, and forward-thinking manner. India has agreed that it's per capita greenhouse gas emissions would never surpass those of developed countries in this regard. India has primarily focused on maintaining a high growth rate to raise the living standards of the vast majority of Indians and reduce their vulnerability to climate change impacts. The National Action Plan for Climate Change (NAPCC) addressed the country's immediate and vital issues through a directional shift in the development pathway, including the expansion of existing and planned programmes, to pursue a sustainable development path that simultaneously advances economic and environmental objectives. The National Action Plan on Climate Change (NAPCC) of India aimed to promote climate change awareness, adaptation, and mitigation, as well as energy efficiency and natural resource conservation. The NAPCC consists of "Eight National Missions," which embody multi-pronged, long-term, and coordinated strategies for achieving key climate change goals. The eight missions are as follows: National Solar Mission, National Mission for Enhanced Energy Efficiency, National Mission on Sustainable Habitat, National Water Mission, National Mission for Sustaining the Himalayan Ecosystem, National Mission for a “Green India”, National Mission for Sustainable Agriculture, and National Mission on Strategic Knowledge for Climate Change.

Climate change research is one of the areas of science that is rapidly evolving. Various bibliometric and scientometric methods can be used to quantify and chart the scientific impetus for the significant effort and attention now devoted to climate change study. Therefore, this study aims to quantify the contribution of India to climate change research in comparison with major countries through bibliometric and scientometric for the last thirty-five years by setting the following objectives:

Objectives

1) To evaluate the period-wise evolving trends of research productivity and contributions by different bibliometric parameters of India and other countries
2) To evaluate the impact of the research conducted by India in comparison with other countries using citation analysis
3) To analyse the research collaboration of India with different countries
4) To evaluate the interrelationship among the national goal on climate change and the research publications of India covering Indian and international journals
5) To evaluate the comparative evolving trends of the research area and research topic of the select countries including India using scientometric techniques
6) To understand the inter-relationship among the carried-out research topics and country-specific socio-economic & environmental problems

Limitations

Data has been collected from the Web of Science, Scopus, and Indian Citation Index using a search string that was prepared in various combinations of keywords justifiably related to climate change to retrieve maximum publication data. Rigorous manual verifications of the publication data were also performed to check the noise. There were some limitations in downloading and analysis of publications data from Scopus and the Indian Citation Index. Therefore, all types of analysis were not possible for these two databases as compared to the Web of Science.

Chapter 2:

Review of Literature

National status:

There are several pieces of evidence of climate change in India in the twentieth century (Dash et al., 2007). Important weather events due to climate change affecting India are floods and droughts, monsoon depressions and cyclones, heat waves, cold waves, prolonged fog and snowfall. Extreme rainfall and flood risk are increasing significantly in the country except in some parts of central India due to recent climate change (Guhathakurta et al., 2011). A study has been predicted that Kerala is vulnerable to increasing the probability of water scarcity in the pre-monsoon time and a delaying monsoon onset (Pal & AlTabbaa 2009). Meteorological measurements in India showed a trend of increasing temperature over the past quarter-century, but significant variations in these trends during different seasons and over different regions of India (Dash & Hunt,.2007). A study of local perception and response to climate change in the Western Himalayas of India found out the temporal displacement of the weather cycle and its effect on the crop yield (Vedwan& Rhoades, 2001). The Vulnerability Resilience Indicator Prototype (VRIP) modelling study showed that nine Indian states to be moderately resilient to climate change, principally because of low sulphur emissions and a relatively large percentage of unmanaged land and six states are more vulnerable than India as a whole, attributable largely to sensitivity to sea storm surges (Brenkert& Malone 2005). Several modelling and simulation studies have also been performed to understand or assess the impact of climate change in various subfields (Rao et al., 1996; Singh & Kumar, 1997; Lal et al., 1997; Chattopadhyay & Hulme, 1997).

The impacts of climate change on world food security in general and its regional impacts, in particular, have come to the forefront of the scientific community in recent years. A simulation of the impact of projected climate change on wheat in India revealed yield enhancements of the order of 29-37%and 16-28% under tainted and irrigated conditions respectively in different genotypes were observed under a modified climate (Attri& Rathore, 2003). InfoCropMAIZE model analyzed the impacts of an increase in temperature, carbon dioxide (CO_2) and change in rainfall due to climate change suggested that monsoon yield is reduced most in Southern Plateau (up to 35%), winter yield is reduced most in Mid Indo Gangetic Plains (up to 55%), while Upper Indo Gangetic Plain yields are relatively unaffected (Byjesh et al., 2010). The simulation models suggested the complex effects of climate change on rice production in the tropical humid climate of Kerala, India (Saseendran et al., 2000; Mall & Aggarwal, 2002). Fish production has shown a distinct change in the last two decades in the middle stretch of river Ganga where the contribution of Indian Major Carps has decreased from 41.4% to 8.3% and that of miscellaneous and catfish species increased (Vass et al., 2009). A case study of fishing communities from Chilika lagoon, India inferred that climate change combined with human activities poses significant risks to people's livelihood especially in developing countries (Iwasaki et al. 2009). Other studies in this regard include; deforestation, climate change, and sustainable nutrition security in India (Sinha & Swaminathan, 1991), the nature of climate change, and the uncertainties in the yields simulated by crop models (Gadgil, 1995). A mapping study in Indian agriculture examined regional vulnerability to climate change in combination with other global stressors climate change and globalization in India (O'Brien et al. 2004).

Global assessments have shown that future climate change is likely to significantly impact forest ecosystems and species diversity. Some assessment of the impact of projected climate change on forest ecosystems in India have been studied and suggested the increased productivity, and shift forest type boundaries along attitudinal and rainfall gradients, with species migrating from lower to higher elevations and the drier forest types bring transformed to moister types (Ravindranath& Sukumar 1998; Ravindranath et al. 2006). One modelling assessment projected 30% of teak grids in India are vulnerable to climate change (Gopalakrishnan et al. 2011). The oscillating climate and vegetation have influenced the structure and composition of the montane ecosystem in southern India (Sukumar et al., 1995).

It is incontrovertible that climate change is resulting in the expansion of the geographical distribution of several vector-borne diseases to higher altitudes and latitudes. The upcoming issue of climate change has been raised as a new threat and challenge for ongoing efforts to contain vector-borne diseases (Dhiman et al. 2010). India is endemic for six major vector-borne diseases namely malaria, dengue, chikungunya, filariasis, Japanese encephalitis and visceral leishmaniasis as well as chronic diseases and the recent climate change has exacerbated the level of outbreaks (Bush et al., 2011). The projection of climatic factors indicates a wider exposure to malaria for the Indian population in the future (Garg et al., 2009). Climate change that leads to warmer and more humid conditions may increase the risk of transmission of airborne zoonoses (Singh et al., 2011).

India and other developing countries are facing the challenge of promoting mitigation and adaptation strategies, bearing the cost of such an effort, and its implications for economic development (Sathaye et al. 2006). A study is argued the Indian energy policy for necessary changes to mitigate the impacts of climate change (Parikh &Gokarn, 1993). In 1991 A. Jagadeesh, was argued the Montreal Protocol in his paper "Climate change and policy implications" which suggested the incorporation of some significant issues regarding the reduction of global CFC and halons consumption. Recently various mitigation measures have been designed and tested for their feasibility in India such as a climate change mitigation option for two different land-use categories based on short and long rotation forestry in India (Kaul et al. 2010); Opportunities in India for Carbon Capture to mitigate climate change (Kapila &Haszeldine, 2009); the relative land-use efficiency of two options for climate change mitigation (Rootzen et al. 2010); mitigation potentiality for Indian forest sectors (Ravindranath et al., 2011).

Although various aspects of the causes of climate change, the impact of climate and mitigation of climate change have been studied in India, the quantification of the field through bibliometric mapping is remained untouched. The bibliometric and scientometric analysis of this field will substantially contribute towards the insight of the research output. Therefore, this will identify the strength and weaknesses of the topic, this will give further dimensions in the climate change research policy formulation.

International status:

Climate Change is a serious global environmental concern. Advances in the science and observation of climate change are providing a clearer understanding of the inherent variability of Earth's climate system and its likely response to human and natural influences (Karl & Trenberth, 2003). Extensive uncertainties exist in future forcing of and responses to climate change, necessitating the use of scenarios of the future to explore the potential consequences of different response options. A new process for creating plausible scenarios has been described to investigate some of the most challenging and important questions about climate change confronting the global community (Moss R. H. et al. 2010). This study has shown the exchange of information among physical, biological, and social scientists. WCRP CMIP3 multi-model dataset has been developed by the World Climate Research Programme (WCRP) Climate Variability and Predictability (CLIVAR) Working Group on Coupled Models (WGCM) Climate Simulation Panel, which represents the largest and most comprehensive international global coupled climate model experiment and multi-model analysis (Meehl et al., 2007). An investigation of climate change over the past 1000 years suggested that the 21st-century global warming due to the greenhouse effect projection far exceeds the natural variability of the past 1000 years and is greater than the best estimate of global temperature change for the last interglacial (Crowley, 2000). Climate change projections for the Mediterranean region showed that the Mediterranean might be an especially vulnerable region to global change (Giorgi &Lionello 2008). It has been observed that atmospheric temperatures do not drop significantly for at least 1,000 years (Solomon et al., 2009). Various studies on the causes and states of climate change were also performed such as the velocity of climate change (Loarie et al. 2009), Climate change hotspots (Giorgi, 2006), trace gas trends and their potential role in climate change (Ramanathan et al., 1985), abrupt climate change (Alley et al. 2003), etc.

There is now ample evidence of the ecological and evolutionary impacts of recent climate change (Parmesan et al. 2006), from polar terrestrial (Cramer et al., 2001; Menzel et al., 2006) to tropical marine ecosystems (Hoegh-Guldberg & Bruno, 2010). The responses of both flora and fauna span an array of ecosystems (Walther et al., 2002) and organizational hierarchies, from the species to the community levels. Although it is widely accepted that future climatic change—if unabated—is likely to have major impacts on biodiversity (Bellard et al., 2012; Field et al. 2014), few studies have attempted to quantify the number of species whose populations have already been impacted by climate change (Parmesan et al., 2003; Chen et al., 2011). A diagnostic fingerprint of temporal and spatial 'signs witching' responses for 279 species uniquely predicted by twentieth-century climate trends and using Global meta-analyses (Parmesan &Yohe, 2003). Although the complexity of the natural system presents fundamental limits to predictive modelling, the bioclimatic envelope approach can provide a useful first approximation as to the potentially dramatic impact of climate change on biodiversity (Pearson & Dawson, 2003). The marine pelagic community responding to climate changes as well as the level of response differs throughout the community and the seasonal cycle, leading to a mismatch between trophic levels and functional groups (Edwards & Richardson, 2004). The populations of migratory pied flycatcher, long-distance migratory bird, Ficedulahypoleuca have declined by about 90% over the past two decades (Both et al., 2006). While many studies have considered the impacts of future climate changes on food production (Rosenzweig C and Parry M L 1994; Parry et al. 2005; Fischer et al. 2005; Edmonds J A and Rosenberg N J 2005).

Many prevalent human diseases are linked to climate fluctuations, from cardiovascular mortality and respiratory illnesses due to heatwaves to the altered transmission of infectious diseases and malnutrition from crop failures (Patz et al., 2005). Some vector-borne diseases, such as malaria, also display considerable year-to-year variation in some regions that can also be partly explained by climatic factors (Kovats et al., 2003). There is for example reasonably strong evidence for an association with El Nin˜o and malaria epidemics in parts of South Asia and South America and with cholera in coastal areas of Bangladesh (Kovats et al. 2003).

Climatologists now consider it ‘very likely that human influence on the global climate has at least doubled the risk of a heatwave such as that experienced in 2003 (Stott et al. 2004). Mortality rises in hot weather, especially in elderly people. Climate change will likely be associated with increases in the frequency of heatwaves (Hulme et al., 2002). Recent evidence has also emerged about a possible causal role of climate change (and specifically the warming of sea surface temperatures) in increasing the intensity of tropical cyclones (Emanuel, 2005; Webster et al. 2005), although a single event such as Hurricane Katrina cannot be attributed to climate change. Natural disasters have a variety of health impacts. (Ahern et al., 2005; Noji, 1997).

The increase in the atmospheric concentration of CO2 by 31% since 1750 from fossil fuel combustion and land-use change necessitates the identification of strategies for mitigating the threat of the attendant global warming. Recently various climate change mitigation measures have now been proposed for adoption after several studies and validation. One study reviewed soil carbon sequestration to mitigate climate change, through conversion of marginal lands into restorative land uses adoption of conservation tillage with cover crops and crop residue mulch, nutrient cycling including the use of compost and manure, and other systems of sustainable management of soil and water resources (Lal, 2004). The tropical forests can contribute to climate change protection through carbon sequestration as forests can absorb billions of tons of CO_2 (Canadell, JG &Raupach, 2008; Zorner et al., 2008). Biomass from cellulosic bio-energy crops is expected to play a substantial role in future energy systems, especially if climate policy aims at stabilizing greenhouse gas concentration at low levels (Popp et al. 2011). A study suggested that government policy must eliminate economic, structural, and social barriers to change and advance accessible and economic alternatives to facilitate individual-level mitigation (Semenza et al., 2008).

Co-citation analysis of the IPCC Third Assessment Report demonstrated that it is best characterized by its multidisciplinarity where the physical, biological, bodily, and societal dimensions are separated, therefore, the problem scope of climate change necessitates interdisciplinarity (Bjurstro¨m& Polk 2011a, b). A quantitative study identified the growth of climate change science based on the increase in the number of abstracts of scientific publications dealing with the many aspects of this broad subject and the total global cost of current climate change research is estimated at three billion U.S. dollars annually (G. Stanhill (2001).

Bibliometric and scientometric analysis related to “Climate Change”:

There are some recent research publications on scientometric and bibliometric analysis related to “climate change”. One study analyzed research trends in carbon capture technologies for climate change mitigation and identified the following parameters publication trends, participation of countries, organisations, journals, co-authorship networks and Co-occurrence of author keywords (Omoregbe et al., 2020). The bibliometric study and content analysis on multidimensional flood risk management under climate change revealed research patterns and strategic recommendations for decision-making in flood risk management in urban areas (da Silva et al., 2020). A bibliometric analysis covering historical growth, keyword, citation and co-citation, organisations, and country-by-country comparisons on disaster and climate change resilience revealed its emerging and rapidly growing trends along with the development of key concepts (Rana, 2020). Another bibliometric study on adaptation, mitigation and resilience of climate change identified clusters of publications in different subfields (Einecker& Kirby 2020). Based on data from PubMed for two decades (1999-2008 and 2009-2018), an analysis of bibliometrics, co-word bi-clustering, and a strategic diagram was used to understand the science production, hotspots, and emerging trends in climate change and infectious diseases (Li et al. 2020). Another research was visualised the bibliometric networks of polar tourism and climate change research using thematic and co-authorship networks, as well as a study area-based bibliography and an overview of emerging hot spots (Demiroglu et al. 2020). Combining a standard literature review, bibliometric analysis, and empirical information mapping, a scientometric review of studies on the impacts of climate change on water quality from 1998 to 2018 examined and visualised historical pattern progression, existing research hotspots, and interesting ideas for potential research (Li et al., 2020). Bibliometric analysis of peer-reviewed literature on climate change and human health with an emphasis on infectious diseases revealed the leading country, organisation, collaborators and research themes (Sweileh, 2020). One bibliometric analysis evaluated the scientific production through the evaluation of the typology, historical evolution, spatial distribution, primary sources, related authors and publications, and recurring keywords on coastal communities' social vulnerability to climate change and the impact of extreme events (Lima et al.2020). One scientometric analysis on climate change and carbon sinks characterised the intellectual landscape by defining and disclosing the fundamental characteristics, research capacity, intellectual base, research topic evolution, and research hotspots in this area (Huang et al. 2020). Another bibliometric analysis assessed country, source, and organisation productivity, partnership statistics, the impact of published research, and citation rates of climate change research in the Arab world (Zyoud et al., 2020). A scientometric study investigated the scientific status of previous research activities in the area of underground CO2 sequestration and encapsulation and identified the most productive authors, journals, countries, and categories (Davarazar et al., 2019). Emerging trends and the current situation of subtropical climate change research of China were explored through scientometric analysis (Meng et al. 2018). A bibliometric study on urban environmental governance and a particular emphasis on climate change revealed the dynamic trends, academic collaboration and research hotspots (Wu et al., 2018). The current situation, hotspots, and development trends of climate change adaptation was investigated along with the identification of the most productive journal, author, and institution through a bibliometric analysis (Wang et al., 2018). The reference publication year spectroscopy identified the most frequently cited research literature in climate change related to the discovery of the greenhouse effect and the role of carbon dioxide (Marx et al., 2017). One bibliometric study on climate change research quantified the publication growth, most productive journals and countries as well as their citation impact, and illustrated the evolving trends of research topic during 1980 and 2014 (Haunschild et al., 2016). Another study quantitatively analysed the global scientific performance and hot research areas of climate change vulnerability through bibliometric analysis based on Web of Science database from 1991 to 2012 (Wang et al., 2014). No previous scientometric or bibliometric analysis of Indian climate change research was observed from the Web of Science database.

Chapter 3:

Methodology – Sampling Design, Data Sources, etc.

3.1.1. Methodology for Bibliometric parameters analysis of total climate change

3.1.1. Generation of a valid search string and publication data collection for total climate change

3.1.1.1. Generation of an initial search string

Primarily the search string was generated using a database supported by Thomson Reuters (presently belongs to the Clarivate Analytics), Web of Science (WoS) which is a well-known online subscription-based citation indexing scientific service. It allows in-depth research and exploration with access to multiple databases facilitating the inter-disciplinary study of various sub-fields of academic and scientific disciplines. Thus, it is believed that this study has adequately considered journals to represent the global picture of the research activities in climate change. Various combinations of important keywords, related to climate change were used to generate different search strings to retrieve the publication data in this topic from Web of Science (WoS). The detailed methods of the final search string are described below.

Step 1:

Initial search string was developed by combining the most relevant keywords in the climate change research viz. "climat* chang*", "warm* Climat*", "Glob* Climat*", "glob* warm*", "greenhouse gas", "Glob* temperature rise", "climat* variability", "recent climate", "impact climat*", "effect climat*", "mitigat* climat*", "adapt* climat*" etc. Along with these various keywords were also included from the index of books on climate change viz. climate change past, present, future by Marie-Antoinette Melieres and Chloe Marechal (2015), Climate change biological and human aspects by Jonathan Cowie (2013), Modern climate change by Andrew E. Dessler (2012). Climate change financial and societal implications by Raj S. Dhankar (2017). Organic agriculture and climate change mitigation by URS Niggli and Nadia EL-HageScialabba (2011).

The initial search string was as follows:

TS=("CO2 emission" OR "GREENHOUSE GAS" OR "Carbon* emission" OR "glob* warm*" OR "climat* chang*" OR "Glob* Climat*" OR "fossil fuel" OR "sea level rise" OR "glob* average temperature" OR "ocean acidification" OR "sea level rise" OR "climat* variability" OR "carbon sequest*" OR "climat* mitigat*" OR "climat* adapt*" OR "extreme event" OR "IPCC" OR "UNFCC" OR "green technology" OR "chang* climat*" OR "climat* factor*" OR "climat* warm*" OR "warm* Climat*" OR "Glob* temperature rise" OR "Warm* ocean*" OR "Shrink* ice sheet*" OR "Glacia* retreat" OR "Decreas* snow cover" OR "Declin* sea ice" OR "atmospheric CO2" OR "melt glacier" OR "Earth warm" OR "greenhouse effect" OR "Climat* impact" OR "climat* effect" OR "Sensitiv* climat*" OR "climat* Resilien*" OR "SEA SURFACE TEMPERATURE" OR "recent climate" OR "trend climat*" OR "climat* sensitiv*" OR "impact climat*" OR "effect climat*" OR "mitigat* climat*" OR "adapt* climat*" OR "climat* forc* agent*")

Step 2:

Using this search string about 3,38,000 publications data were retrieved from the Web of Science database. Among them, the most recent 10,000 publication data and the most cited 2000 publication data were downloaded in plaintext format. Keywords were extracted from the publication data with the help of Sci2 software. New keywords related to climate change in terms of their causal factors, impacts, mitigative measures, issues, etc. were incorporated from the extracted keywords list to prepare a new search string. Extracted keywords having a frequency of more than 10 were considered for inclusion in the final search string.

Table 3.1.1: List of extracted keywords from recent 10,000 publications and most cited 2000 publications retrieved from Web of Science using initial search string, frequency of the extracted keywords and justifications for their inclusion in the final search string.

Keyword	Frequency	Remarks
Climate Change	1427	Included as “Climat* Chang*” and “Chang* Climat*”
Global Warming	157	Included as “global warm*”.
Drought	144	Not included due to noise.
Temperature	137	Included in combinations with many other keywords
Sustainability	127	This is a regular word, not included as created noise
Adaptation	116	This is a regular word, not included as created noise
Climate	113	Included in various combinations
Carbon Sequestration	112	This is covered by various combinations of “carbon”
Remote Sensing	111	Not included as it is a methodology and not directly related to “climate change”

Precipitation	109	Not included due to noise.
China	100	Not included.
Life Cycle Assessment	99	Not due to noise.
Renewable Energy	98	Included in combination with climat*.
Biodiversity	96	Included in combination with climat*.
Carbon Dioxide	91	This is covered by various combinations of “carbon”
Global Change	88	Not included due to noise.
Climate Variability	87	Included in combination with climat*
Greenhouse Gas	84	Included as GHG and “Greenhouse Gas
Resilience	81	Included in combination with climat*
Biomass	76	Not included due to noise.
Methane	75	Included in combination with climat*
Ocean Acidification	75	Included in combination with climat*
Agriculture	74	Not included due to noise.
Phenology	71	Not included due to noise.
Ecosystem Services	70	Not included due to noise.
Arctic	67	Included in combination with climat*
Holocene	64	Not included due to noise.
Photosynthesis	62	Not included due to noise.
Conservation	57	Not included due to noise.
Energy Efficiency	57	Included in combination with climat*
Sea Surface Temperature	56	Included in combination with climat*
Nitrogen	55	Included in combination with climat*
Carbon Cycle	53	This is covered by various combinations of “carbon”
Greenhouse Gases	53	Included
Vulnerability	51	Included in combination with climat*
Food Security	51	Not included due to noise.
Co2	50	Included in combination with climat*
Nitrous Oxide	49	Included in combination with climat*
Rainfall	49	Not included due to noise.
Uncertainty	47	Included in combination with climat*
Energy Consumption	47	Not included due to noise.
Carbon Emission	47	This is covered by various combinations of “carbon”
Co2 Emissions	46	This is covered by various combinations of “carbon”
Tibetan Plateau	45	Not included due to noise.
Carbon	45	Included in combination with climat*

Greenhouse Gas Emissions	45	This is covered by many combinations of “Greenhouse Gas”
Land Use	43	Not included due to noise.
Co2 Emission	43	This is covered by various combinations of “CO2”
Sustainable Development	42	Included in combination with climat*
Soil Organic Carbon	42	Not included due to noise.
Enso	42	Modified in combination with (El-nino AND climat*)
Biochar	41	Not included due to noise.
Sea Level Rise	41	Modified in combination with (sea level AND climat*)
Eutrophication	40	Included in combination with climat*
Climate Change Mitigation	39	Included
Soil Respiration	38	Not included due to noise.
Air Pollution	38	Not included due to noise.
NDVI	38	Not included due to noise.
Soil Moisture	38	Not included due to noise.
Disturbance	37	Included in combination with climat*
Evapotranspiration	37	Not included due to noise.
Water Quality	36	Not included due to noise.
Electric Vehicle	36	Not included due to noise.
Heat Stress	36	Not included due to noise.
Biogeography	35	Not included due to noise.
Land Use Change	35	Not included due to noise.
Invasive Species	35	Modified in various combination of species with climat*)
Warming	35	Included in combination with climat*
Carbon Footprint	35	This is covered by various combinations of “carbon”
Salinity	35	Not included due to noise.
El Nino	34	Included in combination with climat*
Environment	34	Included in combination with climat*
Hydrology	34	Not included due to noise.
GIS	33	Not included as it is a methodology and not directly related to “climate change”
Nutrients	33	Not included due to noise.
Mitigation	33	Included in combination with climat*
Modis	33	Not included as it is a methodology and not directly related to “climate change”
Optimization	33	Not included due to noise.

Cmip5	33	Not included
Paleoclimate	33	Not included due to noise.
Climate Warming	32	Included in combination with climat*
Energy	32	Included in various combinations with climat*.
Climate Models	31	Included
Growth	31	Not included due to noise.
Stable Isotopes	31	Not included due to noise.
Permafrost	30	Not included due to noise.
Climate Change Adaptation	30	It already covered by “climat* chang*”
Electric Vehicles	30	Not included due to noise.
Irrigation	30	Not included due to noise.
Competition	29	Not included due to noise.
Forest Management	29	Not included due to noise.
Soil Organic Matter	29	Not included due to noise.
Fire	29	Not included due to noise.
Runoff	28	Not included due to noise.
Biodiesel	28	Not included due to noise.
Extreme Events	28	Included in combination with climat*
Sea Ice	27	Included in combination with climat*
Meta-analysis	27	Included in combination with climat*
Genetic Diversity	27	Not included due to noise.
Greenhouse Gas Emission	27	It covered by “Greenhouse Gas *”
Antarctica	27	Included in combination with climat*
Phosphorus	26	Not included due to noise.
Governance	26	Not included due to noise.
Bioenergy	26	Not included due to noise.
Modeling	26	Included in combination with climat*
Africa	26	Not included due to noise.
Yield	26	Not included due to noise.
Decomposition	26	Not included due to noise.
Dispersal	25	Not included due to noise.
Adaptive Capacity	25	Not included due to noise.
Global Climate Change	25	Included in combination with climat*
Swat	25	Not included due to noise.
Species Richness	25	Included in combination with climat*
Time Series	25	Not included due to noise.

Maxent	25	Not included due to noise.
Management	25	Not included due to noise.
Sea-level Rise	25	Included in combination with climat*
Migration	25	Not included due to noise.
Maize	25	Not included due to noise.
Solar Energy	25	Included in combination with climat*
Carbon Emissions	25	This is covered by various combinations of "carbon"
Denitrification	24	Not included due to noise.
Mangrove	24	Not included due to noise.
Emissions	24	Not included due to noise.
Urbanization	24	Not included due to noise.
Eddy Covariance	24	Not included due to noise.
Policy	24	Not included due to noise.
Coral Reefs	24	Not included due to noise.
Global Warming Potential	24	This is covered by various combinations of "Global Warm*"
Soil	24	Not included due to noise.
Ghg Emissions	24	This covered by various combinations of "GHG"
Water	24	Not included due to noise. But used in other combination
Simulation	24	Not included due to noise.
Landsat	24	Not included due to noise.
Interannual Variability	24	Not included due to noise.
Environmental Change	23	Included in combination with "climat*"
Modeling	23	Included in combination with climat*
LCA	23	Not included due to noise.
Machine Learning	23	Not included due to noise.
Grassland	23	Not included due to noise.
Water Resources	23	Not included due to noise.
Blue Carbon	23	This covered by various combinations of "carbon"
Land-use Change	22	Not included due to noise.
Forest	22	Not included due to noise.
Deforestation	22	Not included due to noise.
Livestock	22	Not included due to noise.
Ocean Warming	22	Included in combination with (climat* AND warm*)
Water Use Efficiency	22	Not included due to noise.
Dendrochronology	22	Not included due to noise.

Model	21	Included in combination with climat*
Population Dynamics	21	Not included due to noise.
Europe	21	Not included due to noise.
Monitoring	21	Not included due to noise.
Review	21	Not included due to noise.
Sea Level	21	Included in combination with climat*
Restoration	21	Not included due to noise.
Hydrogen	21	Not included due to noise.
Streamflow	21	Not included due to noise.
Green Infrastructure	21	Included in other combinations
Groundwater	21	Included in combination with climat*
Soil Carbon	20	This is covered by various combinations of "carbon"
Diversity	20	Not included due to noise.
Species Distribution Model	20	Not included due to noise.
Carbon Cycling	20	This covered by various combinations of "carbon"
Fish	20	Included in combination with climat* AND "fish production"
Sensitivity Analysis	20	Not included due to noise.
Cyanobacteria	20	Not included due to noise.
Elevated Co2	20	This is covered by various combinations of "CO2"
Pollution	20	Not included due to noise.
Wheat	20	Not included due to noise.
Redd	20	Not included due to low data coverage.
Seasonality	20	Not included due to noise.
Pollen	20	Not included due to noise.
Australia	20	Not included due to noise.
Wetlands	20	Not included due to noise.
Calcification	19	Not included due to noise.
Weather	19	Not included due to noise.
Biofuel	19	Not included due to noise.
Downscaling	19	Not included due to noise.
Tundra	19	Not included due to noise.
Risk	19	Not included due to noise.
Environmental Impact	19	Included in combination with climat*
Phenotypic Plasticity	19	Not included due to noise.
Fisheries	19	Not included due to noise.

Diatoms	19	Not included due to noise.
Bacteria	19	Not included due to noise.
Water Management	19	Not included due to noise.
Baltic Sea	19	Not included due to noise.
Species Distribution Models	18	Not included due to noise.
Black Carbon	18	This is covered by various combinations of "carbon"
Biofuels	18	Not included due to noise.
Aerosols	18	Not included due to noise.
Nitrogen Deposition	18	This is covered by various combinations of "nitrogen"
Photocatalysis	18	Not included due to noise.
Acclimation	18	Not included due to noise.
Connectivity	18	Not included due to noise.
Ph	18	Not included due to noise.
Grazing	18	Not included due to noise.
Random Forest	18	Not included due to noise.
Energy Storage	18	Not included due to noise.
Trend Analysis	18	Not included due to noise.
Risk Assessment	18	Not included due to noise.
Water Stress	18	Not included due to noise.
Forecasting	18	Not included due to noise.
Environmental Impacts	18	Included in combination with climat*
Flooding	18	Not included due to noise.
Flood	18	Not included due to noise.
Phytoplankton	18	Not included due to noise.
Charcoal	17	Not included due to noise.
Seagrass	17	Not included due to noise.
Anaerobic Digestion	17	Not included due to noise.
Co2 Reduction	17	This is covered by various combinations of "co2"
Wildfire	17	Not included due to noise.
Boreal Forest	17	Not included due to noise.
Climate Changes	17	Included
Wind	17	Not included due to noise.
Thermal Tolerance	17	Not included due to noise.
Paris Agreement	17	Included
Multiple Stressors	17	Not included due to noise.
Energy Policy	17	Included in combination with climat*

Crop Yield	16	Included in combination with climat*
Data Assimilation	16	Not included due to noise.
Salt Marsh	16	Not included due to noise.
Prediction	16	Included in combination with “climat* AND chang*”
Hypoxia	16	Not included due to noise.
Productivity	16	Included as "crop production" OR "fish production"
Respiration	16	Not included due to noise.
Tree Rings	16	Not included due to noise.
Ozone	16	Included as “(climat* AND ozone)”
Functional Traits	16	Not included due to noise.
Local Adaptation	16	This is regular word, not included as created noise
Lidar	16	Not included as it is a methodology and not directly related to “climate change”
Brazil	16	Not included due to noise.
Drought Stress	16	Not included due to noise.
Storm Surge	16	Not included due to noise.
Loess Plateau	16	Not included due to noise.
Economic Growth	16	Not included due to noise.
Human Activities	16	Not included due to noise.
Gene Expression	16	Not included due to noise.
Paleoclimatology	16	Not included due to noise.
South China Sea	16	Not included due to noise.
Range Shift	15	Not included due to noise.
Coral	15	Not included due to noise.
Adsorption	15	Not included due to noise.
Land Cover	15	Not included due to noise.
Sensitivity	15	Included in combination with climat*
Climate Change Impacts	15	Included in combination with climat*
Biogas	15	Not included due to noise.
Evolution	15	Not included due to noise.
Floods	15	Not included due to noise.
Wetland	15	Not included due to noise.
Mortality	15	Not included due to noise.
Soil Carbon Sequestration	15	This is covered by various combinations of “carbon”
Carbon Storage	15	This is covered by various combinations of “carbon”
Green Technology	15	Included in combination with climat*

Vegetation	15	Not included due to noise.
Co2 Capture	15	This is covered by various combinations of “co2”
Dissolved Organic Carbon	15	Not included due to noise.
Human Impact	15	Not included due to noise.
Distribution	15	Not included due to noise.
System Dynamics	15	Not included due to noise.
Iran	15	Not included due to noise.
Carbon Tax	15	This is covered by various combinations of “carbon”
Snow Cover	15	Included in combination with climat*
Palynology	15	Not included due to noise.
Water Balance	15	Not included due to noise.
Variability	14	Included in combination with climat*
Microalgae	14	Not included due to noise.
Biogeochemistry	14	Not included due to noise.
Climate Impacts	14	Included in combination with climat*
Organic Carbon	14	Not included due to noise.
Air Quality	14	Not included due to noise.
Renewable Energy Sources	14	Included as “(climat* AND renewable energy)”
Health	14	Not included due to noise.
Primary Production	14	Not included due to noise.
Organic Matter	14	Not included due to noise.
Trends	14	Included in combination with climat*
Atmosphere-ocean Interaction	14	Not included due to noise.
Recovery	14	Not included due to noise.
Development	14	Included as (climat* AND “sustainable development”)
Snow melt	14	Included in combination with climat*
Ecology	14	Not included due to noise.
Canada	14	Not included due to noise.
Protected Areas	14	Not included due to noise.
Mediterranean Sea	14	Not included due to noise.
Upwelling	14	Not included due to noise.
Recruitment	14	Not included due to noise.
Performance	14	Included as (climat* AND “energyperformance”)
North Atlantic	14	Not included due to noise.
Abiotic Stress	14	Not included due to noise.

Supply Chain	14	Not included due to noise.
Greenhouse Effect	13	This is covered by various combinations of "greenhouse"
Electricity	13	Not included due to noise.
Carbon Capture and Storage	13	This is covered by various combinations of "carbon"
Atmosphere	13	Not included due to noise.
Trend	13	Included in combination with climat*
Growing Season	13	Not included due to noise.
Demography	13	Not included due to noise.
Extinction	13	Not included due to noise.
Herbivory	13	Not included due to noise.
Nitrate	13	Not included due to noise.
Erosion	13	Not included due to noise.
Rice	13	Not included due to noise.
Body Size	13	Not included due to noise.
Photovoltaic	13	Not included due to noise.
Phylogeography	13	Not included due to noise.
Pleistocene	13	Not included due to noise.
Oxidative Stress	13	Not included due to noise.
Ecosystem Function	13	Not included due to noise.
General Circulation Models	13	Not included due to noise.
Thermal Comfort	13	Not included due to noise.
North America	13	Not included due to noise.
Scenario Analysis	13	Not included due to noise.
Principal Component Analysis	13	Not included due to noise.
Circular Economy	13	Not included due to noise.
Composting	13	Not included due to noise.
Acidification	13	Included in combination with (climat* AND "ocean acidification")
Metabolism	13	Not included due to noise.
India	13	Not included due to noise.
Survival	13	Not included due to noise.
Ecosystem	12	Not included due to noise.
Physiology	12	Not included due to noise.
Impact	12	This is covered by various combinations of "climat* AND impact"

Global Carbon Cycle	12	This is covered by various combinations of “carbon”
Rhizosphere	12	Not included due to noise.
Emission	12	Not included due to noise.
Pollination	12	Not included due to noise.
Zooplankton	12	Not included due to noise.
Stress	12	Not included due to noise.
Lignin	12	Not included due to noise.
Stability	12	Not included due to noise.
Sedimentation	12	Not included due to noise.
Methanol	12	Not included due to noise.
Transport	12	Not included due to noise.
Tillage	12	Not included due to noise.
Heat Wave	12	Included in combination with climat*
Conservation Planning	12	Not included due to noise.
Global	12	Included in combination with climat* and warm*
Nutrient Cycling	12	Not included due to noise.
Macroecology	12	Not included due to noise.
Leaf Area Index	12	Not included due to noise.
Atmospheric Circulation	12	Not included due to noise.
Paleolimnology	12	Not included due to noise.
Temperature Sensitivity	12	Not included due to noise.
Microbial Biomass	12	Not included due to noise.
Soil Water	12	Not included due to noise.
Last Glacial Maximum	12	Not included due to noise.
Amazon	12	Not included due to noise.
Teleconnections	12	Not included due to noise.
Afforestation	12	Not included due to noise.
Climatic Factors	12	Included as “climat* factor*”
Dendroclimatology	12	Not included due to noise.
Demand Response	12	Not included due to noise.
Risk Management	12	Not included due to noise.
Spatial Pattern	12	Not included due to noise.
Water Footprint	12	Not included due to noise.
Peatland	12	Not included due to noise.
Pm2.5	12	Not included due to noise.
Community Ecology	12	Not included due to noise.

Sediment	12	Not included due to noise.
Climate Sensitivity	12	Included as "climat* sensitiv*"
Macroalgae	12	Not included due to noise.
Species Distribution	12	Not included due to noise.
Extreme Precipitation	12	Covered by “extreme event”
Carbon Flux	12	This is covered by various combinations of “carbon”
Morphology	12	Not included due to noise.
Drylands	12	Not included due to noise.
Biomass Burning	11	Not included due to noise.
Quaternary	11	Not included due to noise.
Radiocarbon	11	Not included due to noise.
Microclimate	11	Not included due to noise.
Model Evaluation	11	Not included due to noise.
Vegetation Change	11	Not included due to noise.
Statistical Downscaling	11	Not included due to noise.
Phylogeny	11	Not included due to noise.
Heat	11	Not included due to noise.
Ocean Circulation	11	Not included due to noise.
Bleaching	11	Not included due to noise.
Monsoon	11	Not included due to noise.
Soil Erosion	11	Not included due to noise.
North Atlantic Oscillation	11	Not included due to noise.
Ethanol	11	Not included due to noise.
Efficiency	11	Not included due to noise.
Tropical Forests	11	Not included due to noise.
Classification	11	Not included due to noise.
Environmental Kuznets Curve	11	Not included due to noise.
Symbiodinium	11	Not included due to noise.
Anthropocene	11	Not included due to noise.
Forests	11	Not included due to noise.
Range Expansion	11	Not included due to noise.
Geochemistry	11	Not included due to noise.
Palaeoecology	11	Not included due to noise.
Artificial Neural Network	11	Not included due to noise.
Ecosystems	11	Not included due to noise.

Landscape Ecology	11	Not included due to noise.
Pyrolysis	11	Not included due to noise.
Heavy Metals	11	Not included due to noise.
Hydrometeorology	11	Not included due to noise.
Sst	11	Not included due to noise.
Snow	11	Included in various combinations.
Coastal	11	Not included due to noise.
Particle Swarm Optimization	11	Not included due to noise.
Regression Analysis	11	Not included due to noise.
Citizen Science	11	Not included due to noise.
Pinus Sylvestris	11	Not included due to noise.
Seasonal Variation	11	Not included due to noise.
Big Data	11	Not included due to noise.
N_2O	11	Included in combination with climat*
Community Composition	11	Not included due to noise.
Agroforestry	11	Not included due to noise.
Soil Temperature	11	Not included due to noise.
Life Cycle Analysis	11	Not included due to noise.
Spatial Distribution	11	Not included due to noise.
Monsoons	11	Not included due to noise.
Estuary	10	Not included due to noise.
Social-ecological Systems	10	Not included due to noise.
Fossil Fuel	10	Included in combination with climat*
Speciation	10	Not included due to noise.
Landscape	10	Not included due to noise.
Elevated Carbon Dioxide	10	This is covered by various combinations of "carbon"
Facilitation	10	Not included due to noise.
Land Surface Model	10	Not included due to noise.
Validation	10	Not included due to noise.
Production	10	Included in combination with (climat* AND (crop OR fish)
Droughts	10	Not included due to noise.
Coal	10	Not included due to noise.
Natural Gas	10	Not included due to noise.
Litter Decomposition	10	Not included due to noise.
Wind Speed	10	Not included due to noise.

Net Primary Productivity	10	Not included due to noise.
Ecosystem Functioning	10	Not included due to noise.
Endangered Species	10	Not included due to noise.
Distributed Generation	10	Not included due to noise.
Carbon Budget	10	This is covered by various combinations of "carbon".
Storage	10	Included in combination with (climat* AND carbon).
Stomatal Conductance	10	Not included due to noise.
Arctic Ocean	10	Included in combination with climat*.
Sub-saharan Africa	10	Not included due to noise.
Antioxidants	10	Not included due to noise.
Succession	10	Not included due to noise.
Harmful Algal Blooms	10	Not included due to noise.
Aquaculture	10	Not included due to noise.
Ammonia	10	Not included due to noise.
Innovation	10	Not included due to noise.
Spatial Analysis	10	Not included due to noise.
Sustainable Agriculture	10	Not included due to noise.
Reliability	10	Not included due to noise.
Microgrid	10	Not included due to noise.
Economic Analysis	10	Not included due to noise.
Land Cover Change	10	Not included due to noise.
Life-cycle Assessment	10	Not included due to noise.
Elevation	10	Not included due to noise.
Carbon Stock	10	This is covered by various combinations of "carbon".
Tropical Cyclones	10	Not included due to noise.
Turkey	10	Not included due to noise.
Indian Ocean	10	Not included due to noise.
Sea Surface Temperature	10	Included in combination with climat*.
Fungi	10	Not included due to noise.
Cap-and-trade	10	Not included due to noise.
Microbial Community	10	Not included due to noise.
Hydropower	10	Not included due to noise.
Carbon Emission Reduction	10	This is covered by various combinations of "carbon".

Table 3.1.2: Combinations of keywords, publication data retrieval result of individual keyword combinations, and justifications for their inclusion or deletion or modifications of the initial search string

Keyword/combination	Result	Noise status	Present or absent in initial search string	Deleted or Included in the final search string
“Co2 emission”	9,196	No	Present	Included and modified as (climat* AND CO_2), Resulted more data coverage
“Greenhouse gas”	35545	No	Present	Included
“Carbon* emission”	4612	Yes, observable noise count	Present	Included as (Climate AND carbon), Resulted more data coverage
“global warm*”	33018	no	Present	Included, modified
“climat* chang*”	187574	No	Present	Included
"globalclimat*"	24017	no	Present	Included, modified
"fossil fuel"	14293	Yes	Present	Deleted
"sea level rise"	12283	Yes, observable	Present	Deleted
"glob* average temperature"	225	Yes, negligible	Present	Deleted
(climat* AND "ocean acidification")	2,628	No	Present	Included, modified
"climat* variab*"	25,703	Negligible	Present	Included, modified
"carbonsequest*"	13075	Yes, observable	Present	Deleted, because the result came under the addition of (carbon stock) and its deletion from the string doesn’t change the result
"climat* mitigat*"	886	No	Present	Deleted, and modified as (climat* AND mitigat*)
(climat* AND mitigat*)	21242	negligible	Absent	Included
"climat* adapt*"	1909	Yes	Present	Deleted

"extreme event"	1187	No	Present	Included, modified as (climat* AND “extreme event”)
"IPCC"	5887	No	Present	Included
"UNFCCC"	758	No	Present	Included
"green technology"	1476	Negligible	Present	Included
“chang* climat*”	8599	No	Absent	Included, gives more data coverage
"climat* factor*"	7,879	Yes	Present	Deleted
"climat* warm*"	8093	No	Present	Included, gives more data coverage
"warm* Climat*”	6242	No	Present	Included, gives more data coverage
"Glob* temperature rise"	138	No	Present	Deleted, no new data coverage
"Warm* ocean*"	758	No	Present	Included
"Shrink* ice sheet*"	4	No	Present	Deleted, due to low data coverage
"Glacia* retreat"	574	Yes	Present	Deleted
"Decreas* snow cover"	34	No	Present	Deleted, low data coverage
"Declin* sea ice"	49	No	Present	Deleted, low data coverage
"atmospheric CO2"	20196	Yes, observable	Present	Deleted
"melt glacier"	4	No	Present	Deleted
"Earth warm"	5	No	Present	Deleted, Modified as (warm* And earth)
"greenhouse effect"	3677	No	Present	Included after modification as (climat* AND "greenhouse effect")
"Climat* impact"	1903	No	Present	Included
"climat* effect"	541	Negligible	Present	Deleted, no new data coverage
"Sensitiv* climat*"	78	Yes	Present	Deleted, no new data coverage
"climat* Resilien*"	460	No	Present	Included

"sea surface temperature"	24998	Negligible	Present	Included after modification as (climate AND "sea surface temperature")
"recent climate"	2472	No	Present	Included after modification as “recent climat*”
"trendclimat*"	12	No	Present	Deleted, no new data coverage
"impactclimat*"	144	No	Present	Deleted, no new data coverage
"effectclimat*"	40	Negligible	Present	Deleted, no new data coverage
"climat* forc* agent*"	53	No	Present	Deleted, no new data coverage
Newly added keywords or combinations of keywords. (Some single keywords had created noise although these are relevant. Therefore, these were combined or modified.)				
“variab* climat*”	964	No	Absent	Included, gives more coverage
"globalclimat*"	23,976	No	Absent	Included
(warm* AND earth)	6,832	No	Absent	Included
(warm* AND planet)	1,845	No	Absent	Included
“presentclimat*”	1473	No	Absent	Included
“pastclimat*”	3014	No	Absent	Included
“Montreal protocol”	798	No	Absent	Included
“Kyoto protocol”	2581	No	Absent	Included
“Paris agreement”	755	No	Absent	Included
“Copenhagen meeting”	9	No	Absent	Included
GOSAT	550	No	Absent	Included
GHG	11,893	No	Absent	Included
"climat* model"	16,562	Negligible	Absent	Included
"climat* oscillat*"	2,146	No	Absent	Included
"fluctuat* climat*"	158	No	Absent	Included

"climat* fluctuat*"	3,016	No	Absent	Included
"climat* polic*"	2,698	No	Absent	Included
"climat* stress"	453	Negligible	Absent	Included
"project* climat*"	1,807	No	Absent	Included
“greenhouse effect”	3,682	Negligible	Absent	Included
(climat* AND CO2)	35501	Negligible	Absent	Included
(climat* AND impact)	115105	Negligible	Absent	Included
(climat* AND ((shrink* OR retreat* OR decreas* OR declin* OR melt*) AND ("ice sheet" OR *glacia* OR "snow cover" OR "ice cap" OR "sea ice" OR "polar ice" OR "antarctic ice" OR "arctic ice")))	14,985	No	Absent	Included
(climat* AND “average temperature")	1973	No	Absent	Included
(climat* AND “mean temperature")	4803	No	Absent	Included
(climat* AND “global temperature")	1668	No	Absent	Included
(climat* AND “sea level”)	18356	Very Negligible	Absent	Included
(Climat* AND (warm* AND ocean))	15,979	Very Negligible	Absent	Included, high data coverage
(climat* AND "sea surface temperature")	14,329	No	Absent	Included
(climat* AND “air temperature")	17023	Very Negligible	Absent	Included
(climat* AND "global cool*")	795	No	Absent	Included
(climat* AND "solar power")	610	No	Absent	Included
(climat* AND "meta-analysis")	1,300	No	Absent	Included
TS=(climat* AND "green technology")	75	No	Absent	Included
TS=(climat* AND "conventional energy")	179	No	Absent	Included

(climat* AND "heat wave")	1,334	No	Absent	Included
(climat* AND "energy efficiency")	4,396	No	Absent	Included
(climat* AND "renewable energy")	5,550	No	Absent	Included
(climat* AND ozone)	9,348	No	Absent	Included
(climat* AND O3)	207	No	Absent	Included
(climat* AND "Nitrogen input")	139	No	Absent	Included
(climat* AND "solar energy")	2,704	No	Absent	Included
(climat* AND biodiversity)	19,108	Negligible	Absent	Included
(climat* AND uncertainty)	27,126	Negligible	Absent	Included
(climat* AND "ocean acidification")	2,628	No	Absent	Included
(climat* AND "atmospheric circulation")	7,448	Negligible	Absent	Included
(climat* AND "environmental change")	8,391	Negligible	Absent	Included
(climat* AND "species richness")	7,261	Negligible	Absent	Included
(climat* AND "El nino")	13,505	Negligible	Absent	Included
(climat* AND "sustainable development")	4,372	Negligible	Absent	Included
(climat* AND anthropogenic)	20,284	Negligible	Absent	Included
(climat* AND disturbance)	13,427	Negligible	Absent	Included
(climat* AND agricultur*)	32,461	Negligible	Absent	Included
(climat* AND (chang* AND predict*))	46,363	Negligible	Absent	Included
(climat* AND eutrophication)	3,477	Negligible	Absent	Included
(climat* AND "ground water")	1,208	No	Absent	Included
(climat* AND (global AND pattern*))	18,769	No	Absent	Included
(climat* AND "energy polic*")	1,425	No	Absent	Included

(climat* AND "energy performance")	1,810	No	Absent	Included
(climat* AND "carbon stock")	960	No	Absent	Included
(climat* AND methane)	6,423	Negligible	Absent	Included
(climat* AND NO2)	1,029	No	Absent	Included
(climat* AND carbon*)	71,676	Negligible	Absent	Included
(climat* AND "nitrous oxide")	2,729	No	Absent	Included
(climat* AND mitigat*)	21,234	No	Absent	Included
(climat* AND warm*)	73,961	Negligible	Absent	Included
(climat* AND global)	99,515	Negligible	Absent	Included
(climat* AND "species diversity")	3,233	No	Absent	Included
(climat* AND "species abundance")	728	No	Absent	Included
(climat* AND "crop production")	3,075	No	Absent	Included
(climat* AND "fish production")	208	No	Absent	Included
(climat* AND volcan*)	7,264	No	Absent	Included
(climat* AND disease)	15,689	Negligible	Absent	Included
(climat* AND "clean energy")	536	No	Absent	Included
(climat* AND "green energy")	226	No	Absent	Included
(climat* AND "temperature rise")	1,037	No	Absent	Included
(climat* AND shift*)	34,201	Negligible	Absent	Included
Some keywords or combinations of keywords deleted after verification as these had created either more noise or less result				
(climat* AND “fossil fuel”)	3146	Yes, negligible	Absent	Deleted, low data coverage plus no change in the final result on deletion
(climat* AND fluctuat*)	21,971	Yes, observable	Absent	Deleted

(climat* AND "sea level rise")	6309	no	Absent	Deleted, very low data coverage
"climat* variability"	18220	Yes, observable	Present	Deleted
“climat* AND variability”	108	No	Absent	Deleted, very low data coverage. On deletion no change in final result
(climat* AND variability)	87462	Yes	Absent	Deleted
"climat* adapt*"	1909	Observable	Present	Deleted
"climat* factor*”	7877	Yes	Present	Deleted
"climat* effect"	541	Observable	Present	Deleted
"Sensitiv* climat*"	78	Yes	Present	Deleted

3.1.1.2. Generation of the final search string to retrieved publication data from the Web of Science and Scopus:

These keywords or keyword combinations were individually searched and manually checked for maximum validation. Many alternatives were used for coverage of maximum data (journal cover). Sometimes the keywords were used as pre and post form such as “climat* variab*” and “variab* climat*”, “warm* planet” and “planet warm*” etc. This is because both the terms might have used in different journals and articles and it may give the full coverage of all kinds of papers related to climate change. The use of asterisk mark, also increase the coverage that is sometimes the keywords might be used in different tenses or have different prefix or suffix, in that case, we can use asterisk mark. For example, climat* can be used for climate, climatic, climatology, etc. in a different journal. The use of climate might limit the journal coverage. Other examples can be variab* as variable, variability. Chang* as change, changes, changing, changeable, etc. The Boolean operators were used to combine the keywords for specific results (Table 3.1.2). Table 3.1.3 shows the publication data retrieved from Web of Science and Scopus using the final and individual keyword combinations.

The final Search string to retrieved publicationdata from the Web of Science and Scopus:

TS=("climat* variab*" OR "variab* climat*" OR "climat* chang*" OR "chang* climat*" OR "warm* climat*" OR "climat* warm*" OR "global warm*" OR "global climat*" OR (warm* AND earth) OR (warm* AND planet) OR "future climat*" OR "recent Climat*" OR "present Climat*" OR "past climat*" OR "greenhouse gas" OR IPCC OR "Montreal protocol" OR "Paris agreement" OR "Kyoto protocol" OR "Copenhagen meeting" OR GOSAT OR UNFCCC OR GHG OR "climat* model" OR "climat* oscillat*" OR "climat* fluctuat*" OR "fluctuat* climat*" OR "climat* polic*" OR "climat* stress" OR "project* climat*" OR "climat* resilien*" OR "climat* vulnerable" OR "climat* feedback" OR "climat* predict" OR "climat* project*" OR “greenhouse effect” OR (climat* AND (CO2 OR impact OR ((shrink* OR retreat* OR decreas* OR declin* OR melt*) AND ("ice sheet" OR *glacia* OR "snow cover" OR "ice cap" OR "sea ice" OR "polar ice" OR "antarctic ice" OR "arctic ice")) OR "average temperature" OR "mean temperature" OR "sea level" OR (warm* AND ocean) OR "air temperature" OR "global temperature" OR "global cool*" OR "solar power" OR "meta-analysis" OR "green technology" OR "conventional energy" OR "heat wave" OR "energy efficiency" OR "renewable energy" OR ozone OR

O3 OR "Nitrogen input" OR "solar energy" OR biodiversity OR uncertainty OR "ocean acidification" OR "atmospheric circulation" OR "environmental change" OR "species richness" OR "El nino" OR "sustainable development" OR anthropogenic OR disturbance OR "extreme events" OR agricultur* OR (chang* AND predict*) OR eutrophication OR "ground water" OR (global AND pattern*) OR "energy polic*" OR "energy performance" OR "carbon stock" OR methane OR NO2 OR carbon* OR "nitrous oxide" OR mitigat* OR warm* OR global OR "species diversity" OR "species abundance" OR "crop production" OR "fish production" OR volcan* OR disease OR "clean energy" OR "green energy" OR "temperature rise" OR shift*)))

Table 3.1.3: Publication data retrieved from Web of Science and Scopus using the final and individual keyword combinations

SEARCH STRING	**Web of Science**	**SCOPUS**
TS=("climat* variab*" OR "variab* climat*" OR "climat* chang*" OR "chang* climat*" OR "warm* climat*" OR "climat* warm*" OR "global warm*" OR "global climat*" OR (warm* AND earth) OR (warm* AND planet) OR "future climat*" OR "recent Climat*" OR "present Climat*" OR "past climat*" OR "greenhouse gas" OR IPCC OR "Montreal protocol" OR "Paris agreement" OR "Kyoto protocol" OR "Copenhagen meeting" OR GOSAT OR UNFCCC OR GHG OR "climat* model" OR "climat* oscillat*" OR "climat* fluctuat*" OR "fluctuat* climat*" OR "climat* polic*" OR "climat* stress" OR "project* climat*" OR "climat* resilien*" OR "climat* vulnerable" OR "climat* feedback" OR "climat* predict" OR "climat* project*" OR “greenhouse effect” OR (climat* AND (CO2 OR impact OR ((shrink* OR retreat* OR decreas* OR declin* OR melt*) AND ("ice sheet" OR *glacia* OR "snow cover" OR "ice cap" OR "sea ice" OR "polar ice" OR "antarctic ice" OR "arctic ice")) OR "average temperature" OR "mean temperature" OR "sea level" OR (warm* AND ocean) OR "air temperature" OR "global temperature" OR "global cool*" OR "solar power" OR "meta-analysis" OR "green technology" OR "conventional energy" OR "heat wave" OR "energy efficiency" OR "renewable energy" OR ozone OR O3 OR "Nitrogen input" OR "solar energy" OR biodiversity OR uncertainty OR "ocean acidification" OR "atmospheric circulation" OR "environmental change" OR "species richness" OR "El nino" OR "sustainable development" OR anthropogenic OR disturbance OR "extreme events" OR agricultur* OR (chang* AND predict*) OR eutrophication OR "ground water" OR (global AND pattern*) OR "energy polic*" OR "energy performance" OR "carbon stock" OR methane OR NO2 OR carbon* OR "nitrous oxide" OR mitigat* OR warm* OR global OR "species diversity" OR "species abundance" OR "crop production" OR "fish production" OR volcan* OR disease OR "clean energy" OR "green energy" OR "temperature rise" OR shift*)))	466,426	649,544
TS=(climat* AND ((shrink* OR retreat* OR decreas* OR declin* OR melt*) AND ("ice sheet" OR *glacia* OR "snow cover" OR "ice cap" OR	14,936	14,942

"sea ice" OR "polar ice" OR "antarctic ice" OR "arctic ice")))		
TS="climat* variab*"	25,667	26,411
TS="variab* climat*"	963	1,342
TS= "climat* chang*"	185,851	248,223
TS="chang* climat*"	8,496	11,550
TS="warm* climat*"	6,221	7,576
TS= "climat* warm*"	8,103	9,576
TS= "global warm*"	33,058	63,256
TS= "global climat*"	23,887	33,003
TS=(warm* AND earth)	6,813	10,133
TS=(warm* AND planet)	1,841	3,261
TS="future climat*"	12,438	14,545
TS= "recent Climat*"	2,302	2,177
TS= "present Climat*"	1,473	1,965
TS="past climat*"	3,013	2,489
TS= "greenhouse gas"	35,520	52,737
TS= IPCC	5,871	5,716
TS= "Montreal protocol"	793	1,120
TS="Paris agreement"	754	1,433
TS= "Kyoto protocol"	2,573	5,227
TS="Copenhagen meeting"	9	27
TS= GOSAT	549	380
TS=UNFCCC	757	1,303
TS=GHG	11,902	12,909
TS= "climat* model"	16,442	27,473
TS= "climat* oscillat*"	2,143	2,071
TS= "climat* fluctuat*"	3,008	2,962
TS= "fluctuat* climat*"	158	178
TS="climat* polic*"	2,679	3,798
TS= "climat* stress"	453	601
TS= "project* climat*"	1,808	1,377
TS= "climat* resilien*"	462	463
TS= "climat* vulnerable"	56	55
TS= "climat* feedback"	656	1,315
TS="climat* predict"	26	24
TS= "climat* project*"	4,018	2,585

TS= “greenhouse effect”	3,685	21,254
TS= (climat* AND CO2)	35,621	20,574
TS= (climat* AND impact)	115,699	78,653
TS=(climat* AND ((shrink* OR retreat* OR decreas* OR declin* OR melt*) AND ("ice sheet" OR *glacia* OR "snow cover" OR "ice cap" OR "sea ice" OR "polar ice" OR "antarctic ice" OR "arctic ice")))	14,936	14,942
TS= (climat* AND "average temperature")	4,789	3598
TS= (climat* AND "mean temperature")	4,789	4812
TS= (climat* AND "sea level")	18,192	15011
TS= (climat* AND warm* AND ocean)	15,850	12,890
TS= (climat* AND "air temperature")	16,906	18,504
TS= (climat* AND "global temperature")	1,663	2,022
TS= (climat* AND "global cool*")	794	644
TS= (climat* AND "solar power")	613	2129
TS= (climat* AND "meta-analysis")	1,291	1,061
TS= (climat* AND "green technology")	76	175
TS= (climat* AND "conventional energy")	181	243
TS= (climat* AND "heat wave")	1,335	1962
TS= (climat* AND "energy efficiency")	4,378	6,974
TS= (climat* AND ozone)	9,332	7,166
TS= (climat* AND O3)	207	1,389
TS= (climat* AND "Nitrogen input")	137	187
TS= (climat* AND "solar energy")	2,702	4,864
TS= (climat* AND biodiversity)	19,067	14,826
TS= (climat* AND uncertainty)	27,065	19,391
TS= (climat* AND "ocean acidification")	2,595	1,006
TS= (climat* AND "atmospheric circulation")	7,362	6,410
TS= (climat* AND "environmental change")	8,281	15,863
TS= (climat* AND "species richness")	7,231	7,121
TS= (climat* AND "El nino")	13,358	14,467
TS= (climat* AND "sustainable development")	4,350	18,017
TS= (climat* AND anthropogenic)	20,229	28,496
TS= (climat* AND disturbance)	13,445	14,906
TS= (climat* AND "extreme events")	3,663	9,862
TS= (climat* AND agricultur*)	32,343	60,586
TS= (climat* AND chang* AND predict*)	46,211	56,226
TS= (climat* AND eutrophication)	3,478	4,156

TS= (climat* AND "ground water")	1,204	4,521
TS= (climat* AND global AND pattern*)	18,797	19,946
TS= (climat* AND "energy polic*")	1,420	5,873
TS= (climat* AND "energy performance")	1,794	2,826
TS= (climat* AND "carbon stock")	958	2,780
TS= (climat* AND methane)	6,413	7,731
TS= (climat* AND NO2)	1,040	1,251
TS= (climat* AND carbon*)	71,595	95,167
TS= (climat* AND "nitrous oxide")	2,724	3,108
TS= (climat* AND mitigat*	21,194	35,206
TS= (climat* AND warm*)	73,843	101,342
TS= (climat* AND global)	99,080	143,636
TS= (climat* AND "species diversity")	3,192	7,590
TS= (climat* AND "species abundance")	724	995
TS= (climat* AND "crop production")	3,048	6,821
TS= (climat* AND "fish production	209	235
TS= (climat* AND volcan*)	7,225	9,227
TS= (climat* AND disease)	15,616	35,009
TS= (climat* AND "clean energy")	536	1,336
TS= (climat* AND "green energy")	227	512
TS= (climat* AND "temperature rise")	1,037	2,107
TS= (climat* AND shift*)	34,201	41,507

3.1.1.3. Generation of the final search string to retrieved data from the Indian Citation index:

The Boolean operators and searching method are different in the case of the Indian Citation Index as compared to the other two databases. The keywords or keyword combinations, that were used to retrieve the publication data from The Web of Science and Scopus, were individually searched and manually checked for validation. were used (Table 3.1.4). Table 3.1.4 shows the publication data retrieved from the Indian Citation Index using the boolean operators to combine the keywords for the final and individual keyword combinations.

Table 3.1.4: Publication data retrieved from Indian Citation Index using the final and individual keyword combinations

Search String	**ICI**
((Topic=climat* And ((Topic=shrink* OR Topic=retreat* ORTopic=decreas* OR Topic=declin* OR Topic=melt*) And(Topic=ice-sheet OR Topic=*glacia* OR Topic=snow-coverOR Topic=ice-cap OR Topic=sea-ice OR Topic=polar-iceOR Topic=antarctic-ice OR Topic=arctic-ice))) OR (Topic=climat* And Topic=warm* And Topic=ocean) OR (Topic=climat* And Topic=global And Topic=pattern*) OR (Topic=climat* And Topic=chang* And Topic=predict*) OR (Topic=climat* And (Topic=eutrophication OR Topic=ground-water OR Topic=energy*-polic* OR Topic=energy-performance OR Topic=carbon-stock OR Topic=methaneOR Topic=NO2 OR Topic=carbon* OR Topic=nitrous-oxideOR Topic=mitigat* OR Topic=warm* OR Topic=global ORTopic=species-diversity OR Topic=species-abundance ORTopic=crop-production OR Topic=fish-production ORTopic=volcan* OR Topic=disease OR Topic=clean-energyOR Topic=green-energy OR Topic=temperature-rise ORTopic=shift*)) OR (Topic=climat* And (Topic=conventional-energy ORTopic=heat-wave OR Topic=energy-efficiency ORTopic=renewable-energy OR Topic=ozone OR Topic=O3OR Topic=Nitrogen-input OR Topic=solar-energy ORTopic=biodiversity OR Topic=uncertainty OR Topic=ocean-acidification OR Topic=atmospheric-circulation ORTopic=environmental-change OR Topic=species-richnessOR Topic=El-nino OR Topic=sustainable-development ORTopic=anthropogenic OR Topic=disturbance ORTopic=extreme-events OR Topic=agricultur*)) OR (Topic=climat* And (Topic=CO2 OR Topic=impact ORTopic=average-temperature OR Topic=mean-temperatureOR Topic=sea-level OR Topic=air-temperature ORTopic=global-temperature OR Topic=global-cool* ORTopic=solar-power OR Topic=meta-analysis ORTopic=green-technology)) OR (Topic=GOSAT OR Topic=UNFCCC OR Topic=GHG ORTopic=climat*-model OR Topic=climat*-oscillat* ORTopic=climat*-fluctuat* OR Topic=fluctuat*-climat* ORTopic=climat*-polic* OR Topic=project*-climat* ORTopic=climat*-resilien* OR Topic=climat*-vulnerable ORTopic= climat*-feedback OR Topic=climat*-predict ORTopic=climat*-project* OR Topic=greenhouse-effect) OR (Topic=future-climat* OR Topic=recent-Climat* ORTopic=present-Climat* OR Topic=past-climat* ORTopic=greenhouse-gas OR Topic=IPCC ORTopic=Montreal-protocol OR Topic=Paris-agreement ORTopic=Kyoto-protocol OR Topic=Copenhagen-meeting) OR (Topic=future-climat* OR Topic=recent-Climat* ORTopic=present-Climat* OR Topic=past-climat* ORTopic=greenhouse-gas OR Topic=IPCC ORTopic=Montreal-protocol OR Topic=Paris-agreement ORTopic=Kyoto-protocol OR Topic=Copenhagen-meeting) OR (Topic=warm* And Topic=planet) OR (Topic=warm* And Topic=earth) OR (Topic=climat*-variab* OR Topic=variab*-climat* ORTopic=climat*-chang* OR Topic=chang*-climat* ORTopic=warm*-climat* OR Topic=climat*-warm* ORTopic=global-warm* OR Topic=global-climat*))	9845
(Topic=climat* And ((Topic=shrink* OR Topic=retreat* ORTopic=decreas* OR Topic=declin* OR Topic=melt*) And(Topic=ice-sheet OR Topic=*glacia* OR Topic=snow-coverOR Topic=ice-cap OR Topic=sea-ice OR Topic=polar-iceOR Topic=antarctic-ice OR Topic=arctic-ice)))	88
(Topic=climat* And Topic=warm* And Topic=ocean)	67
(Topic=climat* And Topic=global And Topic=pattern*)	205
(Topic=climat* And Topic=chang* And Topic=predict*)	463
(Topic=climat* And (Topic=eutrophication OR Topic=ground-water OR Topic=energy*-polic* OR Topic=energy-performance OR Topic=carbon-stock OR Topic=methaneOR Topic=NO2 OR Topic=carbon* OR Topic=nitrous-oxideOR Topic=mitigat* OR	4641

Topic=warm* OR Topic=global ORTopic=species-diversity OR Topic=species-abundance ORTopic=crop-production OR Topic=fish-production ORTopic=volcan* OR Topic=disease OR Topic=clean-energyOR Topic=green-energy OR Topic=temperature-rise ORTopic=shift*))	
(Topic=climat* And (Topic=conventional-energy ORTopic=heat-wave OR Topic=energy-efficiency ORTopic=renewable-energy OR Topic=ozone OR Topic=O3OR Topic=Nitrogen-input OR Topic=solar-energy ORTopic=biodiversity OR Topic=uncertainty OR Topic=ocean-acidification OR Topic=atmospheric-circulation ORTopic=environmental-change OR Topic=species-richnessOR Topic=El-nino OR Topic=sustainable-development ORTopic=anthropogenic OR Topic=disturbance ORTopic=extreme-events OR Topic=agricultur*))	3874
(Topic=climat* And (Topic=CO2 OR Topic=impact ORTopic=average-temperature OR Topic=mean-temperatureOR Topic=sea-level OR Topic=air-temperature ORTopic=global-temperature OR Topic=global-cool* ORTopic=solar-power OR Topic=meta-analysis ORTopic=green-technology))	2870
(Topic=GOSAT OR Topic=UNFCCC OR Topic=GHG ORTopic=climat*-model OR Topic=climat*-oscillat* ORTopic=climat*-fluctuat* OR Topic=fluctuat*-climat* ORTopic=climat*-polic* OR Topic=project*-climat* ORTopic=climat*-resilien* OR Topic=climat*-vulnerable ORTopic= climat*-feedback OR Topic=climat*-predict ORTopic=climat*-project* OR Topic=greenhouse-effect)	747
(Topic=future-climat* OR Topic=recent-Climat* ORTopic=present-Climat* OR Topic=past-climat* ORTopic=greenhouse-gas OR Topic=IPCC ORTopic=Montreal-protocol OR Topic=Paris-agreement ORTopic=Kyoto-protocol OR Topic=Copenhagen-meeting)	896
(Topic=warm* And Topic=planet)	71
(Topic=warm* And Topic=earth)	156
(Topic=climat*-variab* OR Topic=variab*-climat* ORTopic=climat*-chang* OR Topic=chang*-climat* ORTopic=warm*-climat* OR Topic=climat*-warm* ORTopic=global-warm* OR Topic=global-climat*)	5561

3.1.2. Bibliometric parameters

Total publications data were primarily analysed for the individual countries, Institutes, authors, journals and research areasin Web of Science and Scopus. The total period was divided into seven periods of 5-years each through the refine key. Further, the timespans from 1990 to 2019 were also divided into three periods of 10-years each to understand the decadal growth of the bibliometric parameters. Publication data from each period were analysed for the individual countries, institutes, authors, journals, and research areas and downloaded separately in Excel format and plotted graphically. Care was taken to examine the collected data to assure their identity. All the bibliometric parameter data of the top 20 countries were also downloaded and analysed from both of the databases. The total data from Indian Citation Index were downloaded and analysed in Excel.

3.2. Methodology for Impact analysis

3.2.1. Citation and h-index analysis to evaluate the impact of the research conducted

Citation data of the total publications were obtained by selecting the "Create Citation Reports" key of Web of Science. The citation report of the individual countries has also been created and downloaded for further analysis. The citation data from Scopus and the Indian Citation Index were exported and analysed in Excel. Graphs were plotted to show the period-wise trends of the h-index, citation of publications for quality analysis. Five-year impact factors for countries were also calculated from WoS for the qualitative analyses of the ongoing research performance. The complete citation data from Scopus and Indian Citation Index were not downloaded as it was not possible for all data therefore the average citation and five-year impact factor were not studied.

3.2.2. Impact Factor analysis of top 100 journals and

Impact factors of country-specific top 100 journals as per the number of publications were collected from the InCites Journal Citation Reports (JCR) Selected JCR Year: 2018. The impact factors of individual publications of top 100 journals were also calculated for the top 20 countries. Alongside, the frequency distributions of the top 100 journals among different impact factor categories were also studied for the top 20 countries and plotted graphically.

3.3. Methodology for Research collaboration of top 20 countries and collaboration network

3.3.1. Research collaboration of top 20 countries and collaboration network

The impact of any scientific and technological endeavour depends largely on how the research network is evolved and utilized. Collaborations in research provide an opportunity to increase the impact and scope of research. Countries with more cooperation linkages are better placed to address the technological issues as they can utilize the power of collective wisdom and are less dependent on any particular country. Collaborative partners enjoy an opportunity to study local issues to produce a global solution. The number of collaborating countries was identified during different periods and presented graphically from the Web of Science database. The network analysis techniques were used to understand the patterns of the interactions among the top 20 countries in climate change research from the Web of Science database. It provides mathematical evidence that there are physical laws that govern the structure, evolution, and characteristics of a network of all types. The effectiveness of any scientific endeavour depends largely on how this network structure is understood and appropriately utilized. Apart from giving visibility to the scientists, collaboration provides flexibility to the countries to address multidisciplinary and multi-spatial problems. The most productive countries were chosen to form co-occurrence matrices to which a multidimensional scaling algorithm (Pajek and VOSviewer) was applied to produce the network maps. The size of the circles is proportional to the size of the attributes and the lines between the attributes indicate the presence of collaboration links. The network map of collaboration with the top 50 collaborating countries of Indian research was also drawn from both of the Web of Science and Scopus database.

3.3.2. Impact analysis of Indian collaborative research

A comparative study was performed to understand the impact of Indian collaborative research by analysing the number of publications, total citations, average citations, h-index and % of publications without any citation among the collaborative publications with top 20 countries, the collaborative publications with rest of the countries and total Indian publications from both of the WoS and Scopus databases. The results were represented graphically.

3.3.3. Research collaboration of the top organizations and authors of Indian publications

The research collaborations were visualized through generating a network map with the help of VOSviewer among the top 500 authors, the top 100 organisations of total Indian publications. The number of collaboration links, total link strength, number of documents, total citations and average citations of the top 500 authors, the top 100 organisations of total Indian publications were also represented in tables.

3.3.4. Bibliographic coupling analysis

Bibliographic coupling identifies relationships between authors whose contributions share references (Garfield E, 2001). A reference is made within a citing document and represents an acknowledgment of another study. This analysis will be useful to identify authors whose research is related, as they reuse or are influenced by the same documents. Coupling analysis provides insights on groups of scientists having similar interests and using the same sources to conduct research. This technique identifies those authors or works that are cited together quite often, in the same document. The bibliometric analysis tool Vos Viewer was used to generate the coupling network map of the top 100 organizations and the top 500 authors. The number of shared links, total link strength, number of documents, total citations and average citations of the top 500 authors, the top 100 organisations of total Indian publications were also represented in tables.

3.4. Methodology to evaluate National Missions:

3.4.1. Publication data collection

India's National Action Plan on Climate Change (NAPCC) focused on promoting understanding of climate change, adaptation and mitigation, energy efficiency, and natural resources conservation. The core of the NAPCC is comprised of "Eight National Missions" representing multi-pronged, long-term, and integrated strategies to achieve key goals in the context of climate change. The eight missions are as follows:

1. National Solar Mission
2. National Mission for Enhanced Energy Efficiency
3. National Mission on Sustainable Habitat
4. National Water Mission
5. National Mission for Sustaining the Himalayan Ecosystem
6. National Mission for a "Green India"
7. National Mission for Sustainable Agriculture
8. National Mission on Strategic Knowledge for Climate Change

The interrelationship among the national goals on climate change and the research publications of India were studied for eight national missions. Various search strings were generated by combining keywords related to the topics on the different national missions. The research publications in eight different national missions were retrieved using the search strings from both the Web of Science, Scopus, and Indian Citation Index databases, and the growth of publications and contributions in different research areas were analysed.

3.4.1.1. Search-string for National Solar Mission

Consequent to the announcement of the National Action Plan on Climate Change in June 2008, which identified the development of solar energy technologies in the country as a National Mission. The National Solar Mission was launched to significantly increase the share of solar energy in the total energy mix while recognizing the need to expand the scope of other renewable and non-fossil options such as nuclear energy, wind energy, and biomass.

Main target and aim of the mission:

1. Development and deployment of solar energy technologies in the country to achieve parity with grid power tariff by 2022.
2. To establish India as a global leader in solar energy, by creating the policy conditions for its diffusion across the country as quickly as possible.
3. To create favourable conditions for solar manufacturing capability, particularly solar thermal for indigenous production and market leadership.
4. Besides, the Mission will support various activities, as considered necessary, on R&D, Human Resource Development, Technical Assistance, training, publicity and awareness etc. for successful implementation of the Mission

A major R&D initiative to focus: firstly, on the improvement of efficiencies in existing materials, devices, and applications and on reducing costs of a balance of systems, establishing new applications by addressing issues related to integration and optimization; secondly, on developing cost-effective storage technologies which would address both variability and storage constraints, and on targeting space intensity through the use of better concentrators, application of nano-technology and use of better and improved materials.

The initial search string was generated through various combinations of keywords relevant to the Solar mission. Keeping all objectives, aims, and targets of the National Solar Mission in mind, the relevant keyword were selected to generate the initial search string. Various modifications, additions, deletions of keywords in the initial search string were performed to get the comprehensive publication data from Web of Science and Scopus. A similar methodology of search string generation which is mentioned in Objective-1 was followed to generate the final search string for data retrieval from publication's databases on National Solar Mission. Table 3.4.1.1 and Table 3.4.1.2 represent the result of publication data retrieved from the Web of Science, Scopus and the Indian Citation Index database using the final search string and individual search strings. More than 10 % of the retrieved publications were checked manually for validation of the search strings in Web of Science database. Manual verification was also exercised for the retrieved publications using individual search strings.

Table 3.4.1.1: Publication data retrieved from Web of Science and Scopus using final search string and individual keyword combinations

SEARCH STRING	Web of Science	Scopus
TS=((Solar AND ("power plant" OR electricity OR capacity OR "photo voltaic" OR "green energy" OR panel OR "thermal power plant" OR "thermal energy" OR reflector OR "water heat*" OR cooker OR power OR "air heater" OR collector OR cell OR irradiance OR thermals)) OR "solar grid" OR "commercial solar plant" OR "solar energy" OR "solar park" OR "hybrid solar plant" OR "renewable solar energy" OR "solar power storage" OR "solar technolog*" OR "solar chimney power plant" OR "clean energy" OR "solar array" OR "solar cooling" OR "solar mirror" OR "solar home system" OR "solar illumination")	291,071	348,464
TS=(Solar AND "power plant")	3,652	12,274
TS=(Solar AND electricity)	15,032	23,164
TS=(Solar AND capacity)	10,732	15,549
TS=(Solar AND "photo voltaic")	828	1,767
TS=(Solar AND"green energy")	735	1,206
TS=(Solar AND panel)	10,594	16,825
TS=(Solar AND "thermal power plant")	404	1,198
TS=(Solar AND "thermal energy")	6,357	8,271
TS=(Solar AND reflector)	3,274	4,434
TS=(Solar AND "water heat*")	2,735	5,380
TS=(Solar AND cooker)	484	635
TS=(Solar AND power)	78,876	122,982
TS=(Solar AND "air heater")	875	1,277
TS=(Solar AND collector)	13,670	19,304
TS=(Solar AND cell)	159,037	162,503
TS=(Solar AND irradiance)	15,056	15,358
TS=(Solar AND thermals)	52,385	65,169
TS="solar grid"	57	90
TS="commercial solar plant"	2	9
TS= "solar energy"	33,994	83,883
TS="solar park"	46	130
TS="hybrid solar plant"	3	10
TS= "renewable solar energy"	148	181

TS= "solar power storage"	11	14
TS= "solar technolog*"	829	1,426
TS="solar chimney power plant"	194	309
TS= "clean energy"	5,196	8,919
TS= "solar array"	1,858	8,919
TS= "solar cooling"	799	1,130
TS= "solar mirror"	37	137
TS= "solar home system"	140	483
TS= "solar illumination"	1,313	1,591

Table 3.4.1.2: Publication data retrieved from the Indian Citation Index using final search string and individual keyword combinations

Search String	ICI
((Topic=solar-grid OR Topic=commercial-solar-plant OR Topic=solar-energy OR Topic=solar-park OR Topic=hybrid-solar-plant OR Topic=renewable-solar-energy OR Topic=solar-power-storage OR Topic=solar-technolog* OR Topic=solar-chimney-power-plant OR Topic=clean-energy OR Topic=solar-array OR Topic=solar-cooling OR Topic=solar-mirror OR Topic=sola- home-system OR Topic=solar-illumination) OR (Topic=Solar And (Topic=power-plant OR Topic=electricity OR Topic=capacity OR Topic=photo-voltaic OR Topic=green-energy OR Topic=panel OR Topic=thermal-power-plant OR Topic=thermal-energy OR Topic=reflector OR Topic=water-heat* OR Topic= cooker OR Topic=power OR Topic=air-heater OR Topic=collector OR Topic=cell OR Topic=irradiance OR Topic= thermals)))	2127
(Topic=solar-grid OR Topic=commercial-solar-plant OR Topic=solar-energy OR Topic=solar-park OR Topic=hybrid-solar-plant OR Topic=renewable-solar-energy OR Topic=solar-power-storage OR Topic=solar-technolog* OR Topic=solar-chimney-power-plant OR Topic=clean-energy OR Topic=solar-array OR Topic=solar-cooling OR Topic=solar-mirror OR Topic=sola- home-system OR Topic=solar-illumination)	904
(Topic=Solar And (Topic=power-plant OR Topic=electricity OR Topic=capacity OR Topic=photo-voltaic OR Topic=green-energy OR Topic=panel OR Topic=thermal-power-plant OR Topic=thermal-energy OR Topic=reflector OR Topic=water-heat* OR Topic= cooker OR Topic=power OR Topic=air-heater OR Topic=collector OR Topic=cell OR Topic=irradiance OR Topic= thermals))	1693

3.4.1.2. Search string for National Mission for Enhanced Energy Efficiency

As a part of the “National Action Plan on Climate Change” the “National Mission for Enhanced Energy Efficiency” aimed to enhance energy efficiency by adopting four new initiatives as follows:

1. A market-based mechanism to enhance cost-effectiveness of improvements in energy efficiency in energy-intensive large industries and facilities, through certification of energy savings that could be traded.
2. Accelerating the shift to energy-efficient appliances in designated sectors through innovative measures to make the products more affordable.
3. Creation of mechanisms that would help finance demand-side management programmes in all sectors by capturing future energy savings.
4. Developing fiscal instruments to promote energy efficiency

The "National Mission for Enhanced Energy Efficiency" approved by the Union Cabinet in June 2010, falls under the domain of the Bureau of Energy Efficiency the Energy Conservation Act of 2001 provides a legal mandate for the implementation of the energy efficiency measures through the institutional mechanism of the Bureau of Energy Efficiency in the Central Government and designated agencies in each state. National Mission for Enhanced Energy Efficiency aims to strengthen the market for energy efficiency through the implementation of innovative business models in the energy efficiency sector. Enhance energy efficiency consist of four initiatives in energy-intensive industries which are as follows:

1. Perform Achieve and Trade (PAT) **-** improving efficiency in energy intensive sectors.
2. Energy Efficiency Financing Platform (EEFP) **-** providing platform for capacity enhancement of stakeholders related to Energy Efficiency financing.
3. Framework for Energy Efficient Economic Development (FEEED) – development of fiscal instrument to promote energy efficiency.
4. Market Transformation for Energy Efficiency (MTEE) – accelerating shift towards energy efficient appliances.

Energy Efficiency refers to any process, technique or equipment that helps to achieve reduction in energy consumption while performing an operation, while achieving the same or better level of output and also is one of the strategic missions to reduce the energy intensity as well as the carbon intensity so that sustainable growth can be achieved.

The initial search string was generated through various combinations of keywords relevant to the "National Mission for Enhanced Energy Efficiency". Keeping all objectives, aims and targets of the

“National Mission for Enhanced Energy Efficiency” in mind, the relevant keyword were selected to generate the initial search string. Various modifications, additions, deletions of keywords in the initial search string were performed to get the comprehensive publication data from Web of Science and Scopus. Similar methodology of search string generation which is mentioned in Objective-1 was followed to generate the final search string for data retrieval from publication’s databases on the “National Mission for Enhanced Energy Efficiency”. Table 3.4.2.1 and Table 3.4.2.2 represents the result of publication data retrieved from Web of Science, Scopus and Indian Citation Index database using the final search string and individual search strings. More than 10 % of the retrieved publications were checked manually for validation of the search strings in Web of Science database. Manual verification was also exercised for the retrieved publications using individual search strings.

Table 3.4.2.1: Publication data retrieved from Web of Science and Scopus using final search string and individual keyword combinations

SEARCH STRING	Web of Science	SCOPUS
TS=("energy efficien*" OR "energy-efficien*" OR (exerg* AND (efficien* OR analysis)) OR "energy optimization" OR ("low* energy consumption" OR "reduce* energy consumption" OR "low* power consumption" OR "reduce* power consumption") OR "ENERGY SUSTAINABL*" OR "SUSTAINABL* ENERGY")	157,811	272,519
TS=("energy efficien*" OR "energy-efficien*")	94,512	174,757
TS="energy efficien*"	94,512	174,757
TS=energy-efficien*	94,539	174,757
TS=(exerg* AND (efficien* OR analysis))	12,135	15,000
TS="exerg* efficien* "	4,824	6,354
TS="exerg* analysis"	6,298	7,238
TS="energy optimization"	2,901	4,699
TS=("low* energy consumption" OR "reduce* energy consumption" OR "low* power consumption" OR "reduce* power consumption")	31,274	47,259
TS="low* energy consumption"	5,944	9,297
TS= "reduce* energy consumption"	5,951	9,854
TS="low* power consumption"	16,312	23,625
TS="ENERGY SUSTAINABL*"	168	289
TS="SUSTAINABL* ENERGY"	6,574	10,037
TS="reduce* power consumption"	3,563	5,259

Table 3.4.2.2: Publication data retrieved from the Indian Citation Index using final search string and individual keyword combinations

Search String	ICI
((Topic=exerg* And (Topic=efficien* OR Topic=analysis)) OR (Topic=energy-efficien* OR Topic=energy-optimization ORTopic=Energy-Sustainabl* OR Topic=Sustainabl*-energy) OR (Topic=energy-consumption AND (Topic=Reduce* OR Topic=low*)) OR (Topic=Power-Consumption AND (Topic=Reduce* OR Topic=low*)))	2649
(Topic=exerg* And (Topic=efficien* OR Topic=analysis))	76
(Topic=energy-efficien* OR Topic=energy-optimization OR Topic=Energy-Sustainabl* OR Topic=Sustainabl*-energy)	1543
(Topic=energy-consumption AND (Topic=Reduce* OR Topic=low*))	742
(Topic=Power-Consumption AND (Topic=Reduce* OR Topic=low*))	591

3.4.1.3. Search string for the "National Mission on Sustainable Habitat"

In 2010, the National Mission for Sustainable Habitat was created. This programme focuses on how communities should deal with the emerging problems that urban residents will face as a result of climate change. The key aim of the National Mission for Sustainable Habitat is to ensure that cities are resilient to the consequences of climate change.

The National Mission on Sustainable Habitat seeks to promote:

Improvements in energy efficiency in buildings through extension of the energy conservation building code - which addresses the design of new and large commercial buildings to optimize their energy demand;

Better urban planning and modal shift to public transport - make long term transport plans to facilitate the growth of medium and small cities in such a way that ensures efficient and convenient public transport;

Improved management of solid and liquid waste, e.g., recycling of material and urban waste management – with special focus on development of technology for producing power from waste;

Improved ability of habitats to adapt to climate change by improving resilience of infrastructure, community-based disaster management, and measures for improving advance warning systems for extreme weather events; and

Conservation through appropriate changes in legal and regulatory framework.

The initial search string was generated through various combinations of keywords relevant to the "National Mission on Sustainable Habitat". Keeping all objectives, aims, and targets of "National Mission on Sustainable Habitat" in mind, the relevant keyword were selected to generate the initial search string. Various modifications, additions, deletions of keywords in the initial search string were performed to get the comprehensive publication data from Web of Science and Scopus. Similar methodology of search string generation which is mentioned in Objective-1 was followed to generate the final search string for data retrieval from the publication's databases on "National Mission on Sustainable Habitat". Table 3.4.3.1 and Table 3.4.3.2 represent the result of publication data retrieved from the Web of Science, Scopus, and the Indian Citation Index database using the final search string and individual search strings. More than 10 % of the retrieved publications were checked manually for validation of the search strings in the Web of Science database. Manual verification was also exercised for the retrieved publications using individual search strings.

Table 3.4.3.1.: Publication data retrieved from Web of Science and Scopus using final search string and individual keyword combinations of "National Mission on Sustainable Habitat"

SEARCH STRING	Web of Science	Scopus
TS=((("energy efficien*" OR "energy consum*" OR "energy sav*" OR "energy conserv*" OR "energy price*") AND (resident* OR commercial OR office OR building* OR industr* OR construct* OR applianc* OR equipment OR fan OR lamp OR "tube light" OR chiller* OR insulat* OR electric*)) OR (transport* AND (vehicle* OR passenger* OR freight OR motorcycle* OR scooter* OR cars OR personal* OR road OR buses OR railway* OR infrastructureOR automobile OR urban)) AND (GHG OR CNG OR CO2 OR biofule* OR bio-diesel OR "greenhouse gas*" OR ethanol OR gasoline OR "reduc* energy" OR price* OR electric* OR diesel OR petrol)) OR (manage* OR recycl* OR reuse OR dispos* OR treatment OR collection OR compost*) AND (waste AND (solid OR municipal OR "bio hazard" OR medical OR plastic))))	166865	323457
TS=("energy efficien*" AND resident*	4,572	7904
TS=("energy efficien*" AND commercial	3,825	7517
TS=("energy efficien*" AND office	2,125	5126
TS=("energy efficien*" AND building*	14,926	29042
TS=("energy efficien*" AND industr*	12,125	27973
TS=("energy efficien*" AN9D construct*	0	14911
TS=("energy efficien*" AND applianc*	1,315	2884
TS=("energy efficien*" AND equipment	3,990	13136

TS=("energy efficien*" AND fan	901	1807
TS=("energy efficien*" AND lamp	835	1622
TS=("energy efficien*" AND chiller*	758	1395
TS=("energy efficien*" AND insulat*	2,608	5021
TS=("energy efficien*" AND electric*)	15,372	47888
TS= (“energy consum*”AND resident*	6,155	8097
TS= (“energy consum*”AND commercial	4310	6521
TS= (“energy consum*”AND office	2863	5286
TS= (“energy consum*”AND building*	16891	25052
TS= (“energy consum*”AND industr*	15329	27423
TS= (“energy consum*”AND construct*	8468	13529
TS= (“energy consum*”AND appliance*	2064	3187
TS= (“energy consum*”AND equipment	4663	15329
TS= (“energy consum*”AND fan	1034	1618
TS= (“energy consum*”AND lamp	504	877
TS= (“energy consum*”AND chiller*	748	977
TS= (“energy consum*”AND insulat*	2444	3619
TS= (“energy consum*”AND electric*)	19505	40353
TS=(“energy sav*” AND resident*	3084	4259
TS=(“energy sav*” AND commercial	2119	3324
TS=(“energy sav*” AND office	1895	3467
TS=(“energy sav*” AND building*	10315	12867
TS=(“energy sav*” AND industr*	6496	13379
TS=(“energy sav*” AND construct*	3974	6928
TS=(“energy sav*” AND applianc*	824	1513
TS=(“energy sav*” AND equipment	2620	8566
TS=(“energy sav*” AND fan	821	1468
TS=(“energy sav*” AND lamp	737	1249
TS=(“energy sav*” AND chiller*	706	978
TS=(“energy sav*” AND insulat*	2159	3393
TS=(“energy sav*” AND electric*)	7730	17526
TS=(“energy conserv*” AND resident*	1038	5064
TS=(“energy conserv*” AND commercial	627	3860
TS=(“energy conserv*” AND office	428	3863
TS=(“energy conserv*” AND building*	3043	18328
TS=(“energy conserv*” AND industr*	2237	15663

TS=("energy conserv*" AND construct*	1810	8649
TS=("energy conserv*" AND appliance*	345	1724
TS=("energy conserv*" AND equipment	684	9389
TS=("energy conserv*" AND fan	147	1312
TS=("energy conserv*" AND lamp	103	1092
TS=("energy conserv*" AND chiller*	135	957
TS=("energy conserv*" AND insulat*	612	3474
TS=("energy conserv*" AND electric*)	2766	23476
TS=("energy price*"AND resident*	337	486
TS=("energy price*"AND commercial	149	304
TS=("energy price*"AND office	41	104
TS=("energy price*"AND building*	411	692
TS=("energy price*"AND industr*	791	2130
TS=("energy price*"AND construct*	228	439
TS=("energy price*"AND appliance*	80	121
TS=("energy price*"AND equipment	130	386
TS=("energy price*"AND fan	6	19
TS=("energy price*"AND lamp	5	15
TS=("energy price*"AND chiller*	32	53
TS=("energy price*"AND insulat*	64	118
TS=("energy price*"AND electric*)	1476	2693
TS= ("energy efficien*" AND "tube light")	2	10
TS= ("energy sav*" AND "tube light")	2	9
TS=("energy conserv*" AND "tube light")	4	5
TS=("energy price*"AND "tube light")	0	0
TS= ("energy consum*" AND "tube light")	1	4
TS=(transport* AND vehicle* AND GHG)	730	1185
TS=(transport* AND vehicle* AND CNG)	190	541
TS=(transport* AND vehicle* AND CO2)	1901	2950
TS=(transport* AND vehicle* AND biofule*)	1	1
TS=(transport* AND vehicle* AND bio-diesel)	22	56
TS=(transport* AND vehicle* AND "greenhouse gas*")	1735	3030
TS=(transport* AND vehicle* AND ethanol)	505	875
TS=(transport* AND vehicle* AND gasoline)	1132	2572
TS=(transport* AND vehicle* AND "reduc* energy")	185	316
TS=(transport* AND vehicle* AND price*)	1313	2592

TS=(transport* AND vehicle* AND electric*)	6482	14,758
TS=(transport* AND vehicle* AND diesel)	1402	3563
TS=(transport* AND vehicle* AND petrol)	1316	455
TS=(transport* AND passenger* AND GHG)	195	275
TS=(transport* AND passenger* AND CNG)	28	87
TS=(transport* AND passenger* AND CO2)	602	832
TS=(transport* AND passenger* AND biofule*)	1	1
TS=(transport* AND passenger* AND bio-diesel)	2	11
TS=(transport* AND passenger* AND "greenhouse gas*")	4152	643
TS=(transport* AND passenger* AND ethanol)	51	85
TS=(transport* AND passenger* AND gasoline)	185	415
TS=(transport* AND passenger* AND "reduc* energy")	65	111
TS=(transport* AND passenger* AND price*)	469	1274
TS=(transport* AND passenger* AND electric*)	768	2346
TS=(transport* AND passenger* AND diesel)	320	850
TS=(transport* AND passenger* AND petrol)	230	86
TS=(transport* AND freight AND GHG)	114	189
TS=(transport* AND freight AND CNG)	13	28
TS=(transport* AND freight AND CO2)	337	453
TS=(transport* AND freight AND biofule*)	0	0
TS=(transport* AND freight AND bio-diesel)	0	4
TS=(transport* AND freight AND "greenhouse gas*")	239	420
TS=(transport* AND freight AND ethanol)	14	34
TS=(transport* AND freight AND gasoline)	35	74
TS=(transport* AND freight AND "reduc* energy")	27	41
TS=(transport* AND freight AND price*)	378	1101
TS=(transport* AND freight AND electric*)	269	971
TS=(transport* AND freight AND diesel)	152	465
TS=(transport* AND freight AND petrol)	42	28
TS=(transport* AND motorcycle* AND GHG)	10	23
TS=(transport* AND motorcycle* AND CNG)	2	6
TS=(transport* AND motorcycle* AND CO2)	36	54
TS=(transport* AND motorcycle* AND biofule*)	0	0
TS=(transport* AND motorcycle* AND bio-diesel)	0	0
TS=(transport* AND motorcycle* AND "greenhouse gas*")	23	48
TS=(transport* AND motorcycle* AND ethanol)	12	17

TS=(transport* AND motorcycle* AND gasoline)	32	85
TS=(transport* AND motorcycle* AND "reduc* energy")	1	2
TS=(transport* AND motorcycle* AND price*)	22	49
TS=(transport* AND motorcycle* AND electric*)	51	157
TS=(transport* AND motorcycle* AND diesel)	25	58
TS=(transport* AND motorcycle* AND petrol)	44	25
TS=(transport* AND scooter* AND GHG)	3	5
TS=(transport* AND scooter* AND CNG)	0	2
TS=(transport* AND scooter* AND CO2)	3	13
TS=(transport* AND scooter* AND biofule*)	0	0
TS=(transport* AND scooter* AND bio-diesel)	0	1
TS=(transport* AND scooter* AND "greenhouse gas*")	7	12
TS=(transport* AND scooter* AND ethanol)	0	6
TS=(transport* AND scooter* AND gasoline)	10	22
TS=(transport* AND scooter* AND "reduc* energy")	1	0
TS=(transport* AND scooter* AND price*)	4	10
TS=(transport* AND scooter* AND electric*)	74	179
TS=(transport* AND scooter* AND diesel)	2	15
TS=(transport* AND scooter* AND petrol)	13	5
TS=(transport* AND cars AND GHG)	219	338
TS=(transport* AND cars AND CNG)	36	124
TS=(transport* AND cars AND CO2)	711	1166
TS=(transport* AND cars AND biofule*)	0	0
TS=(transport* AND cars AND bio-diesel)	7	15
TS=(transport* AND cars AND "greenhouse gas*")	534	941
TS=(transport* AND cars AND ethanol)	110	243
TS=(transport* AND cars AND gasoline)	349	902
TS=(transport* AND cars AND "reduc* energy")	55	112
TS=(transport* AND cars AND price*)	462	1183
TS=(transport* AND cars AND electric*)	1365	4206
TS=(transport* AND cars AND diesel)	366	1131
TS=(transport* AND cars AND petrol)	457	285
TS=(transport* AND personal* AND GHG)	35	80
TS=(transport* AND personal* AND CNG)	8	13
TS=(transport* AND personal* AND CO2)	134	166
TS=(transport* AND personal* AND biofule*)	0	0

TS=(transport* AND personal* AND bio-diesel)	0	1
TS=(transport* AND personal* AND "greenhouse gas*")	113	201
TS=(transport* AND personal* AND ethanol)	33	50
TS=(transport* AND personal* AND gasoline)	64	120
TS=(transport* AND personal* AND "reduc* energy")	22	30
TS=(transport* AND personal* AND price*)	138	330
TS=(transport* AND personal* AND electric*)	390	1028
TS=(transport* AND personal* AND diesel)	77	126
TS=(transport* AND personal* AND petrol)	71	24
TS=(transport* AND road AND GHG)	368	567
TS=(transport* AND road AND CNG)	59	164
TS=(transport* AND road AND CO2)	1145	1572
TS=(transport* AND road AND biofule*)	1	1
TS=(transport* AND road AND bio-diesel)	11	28
TS=(transport* AND road AND "greenhouse gas*")	836	1401
TS=(transport* AND road AND ethanol)	134	218
TS=(transport* AND road AND gasoline)	416	881
TS=(transport* AND road AND "reduc* energy")	93	141
TS=(transport* AND road AND price*)	735	1796
TS=(transport* AND road AND electric*)	1435	4173
TS=(transport* AND road AND diesel)	734	1555
TS=(transport* AND road AND petrol)	513	258
TS=(transport* AND buses AND GHG)	92	139
TS=(transport* AND buses AND CNG)	85	227
TS=(transport* AND buses AND CO2)	244	394
TS=(transport* AND buses AND biofule*)	0	0
TS=(transport* AND buses AND bio-diesel)	11	26
TS=(transport* AND buses AND "greenhouse gas*")	212	376
TS=(transport* AND buses AND ethanol)	35	71
TS=(transport* AND buses AND gasoline)	81	210
TS=(transport* AND buses AND "reduc* energy")	29	48
TS=(transport* AND buses AND price*)	228	575
TS=(transport* AND buses AND electric*)	891	2251
TS=(transport* AND buses AND diesel)	384	999
TS=(transport* AND buses AND petrol)	115	72
TS=(transport* AND railway* AND GHG)	39	71

TS=(transport* AND railway* AND CNG)	3	9
TS=(transport* AND railway* AND CO2)	130	250
TS=(transport* AND railway* AND biofule*)	0	0
TS=(transport* AND railway* AND bio-diesel)	1	7
TS=(transport* AND railway* AND "greenhouse gas*")	76	187
TS=(transport* AND railway* AND ethanol)	11	20
TS=(transport* AND railway* AND gasoline)	10	51
TS=(transport* AND railway* AND "reduc* energy")	28	76
TS=(transport* AND railway* AND price*)	192	741
TS=(transport* AND railway* AND electric*)	559	3833
TS=(transport* AND railway* AND diesel)	105	448
TS=(transport* AND railway* AND petrol)	14	14
TS=(transport* AND infrastructure AND GHG)	265	409
TS=(transport* AND infrastructure AND CNG)	43	113
TS=(transport* AND infrastructure AND CO2)	842	1130
TS=(transport* AND infrastructure AND biofule*)	0	0
TS=(transport* AND infrastructure AND bio-diesel)	3	11
TS=(transport* AND infrastructure AND "greenhouse gas*")	632	1141
TS=(transport* AND infrastructure AND ethanol)	138	243
TS=(transport* AND infrastructure AND gasoline)	205	512
TS=(transport* AND infrastructure AND "reduc* energy")	72	116
TS=(transport* AND infrastructure AND price*)	737	1741
TS=(transport* AND infrastructure AND electric*)	1981	4675
TS=(transport* AND infrastructure AND diesel)	229	545
TS=(transport* AND infrastructure AND petrol)	234	73
TS=(transport* AND automobile AND GHG)	44	283
TS=(transport* AND automobile AND CNG)	13	140
TS=(transport* AND automobile AND CO2)	137	796
TS=(transport* AND automobile AND biofule*)	0	0
TS=(transport* AND automobile AND bio-diesel)	5	24
TS=(transport* AND automobile AND "greenhouse gas*")	154	776
TS=(transport* AND automobile AND ethanol)	34	186
TS=(transport* AND automobile AND gasoline)	159	814
TS=(transport* AND automobile AND "reduc* energy")	16	82
TS=(transport* AND automobile AND price*)	108	772
TS=(transport* AND automobile AND electric*)	296	3555

TS=(transport* AND automobile AND diesel)	106	1043
TS=(transport* AND automobile AND petrol)	169	160
TS=(transport* AND urban AND GHG)	316	519
TS=(transport* AND urban AND CNG)	71	154
TS=(transport* AND urban AND CO2)	1101	1370
TS=(transport* AND urban AND biofule*)	0	0
TS=(transport* AND urban AND bio-diesel)	4	9
TS=(transport* AND urban AND "greenhouse gas*")	863	1450
TS=(transport* AND urban AND ethanol)	82	131
TS=(transport* AND urban AND gasoline)	396	718
TS=(transport* AND urban AND "reduc* energy")	98	169
TS=(transport* AND urban AND price*)	602	1621
TS=(transport* AND urban AND electric*)	1648	4054
TS=(transport* AND urban AND diesel)	586	1051
TS=(transport* AND urban AND petrol)	459	156
TS=(manage* AND waste AND solid)	11052	33,979
TS=(manage* AND waste AND municipal)	6470	16,447
TS=(manage* AND waste AND "bio hazard")	1	2
TS=(manage* AND waste AND plastic)	1852	5,090
TS=(recycl*AND waste AND solid)	1	3
TS=(recycl*AND waste AND municipal)	0	1
TS=(recycl*AND waste AND "bio hazard")	0	0
TS=(recycl*AND waste AND plastic)	0	0
TS=(reuse AND waste AND solid)	2725	3,275
TS=(reuse AND waste AND municipal)	1277	1,628
TS=(reuse AND waste AND "bio hazard")	0	0
TS=(reuse AND waste AND plastic)	581	802
TS=(dispos* AND waste AND solid)	8228	25,878
TS=(dispos* AND waste AND municipal)	3988	12,993
TS=(dispos* AND waste AND "bio hazard")	1	2
TS=(dispos* AND waste AND plastic)	1615	4,529
TS=(treatment AND waste AND solid)	18617	33,427
TS=(treatment AND waste AND municipal)	10167	17,193
TS=(treatment AND waste AND "bio hazard")	1	2
TS=(treatment AND waste AND plastic)	1840	3,941
TS=(collection AND waste AND solid)	2775	4,969

TS=(collection AND waste AND municipal)	2095	3,168
TS=(collection AND waste AND "bio hazard")	1	2
TS=(collection AND waste AND plastic)	514	1,030
TS=(compost* AND waste AND solid)	4559	5,921
TS=(compost* AND waste AND municipal)	3383	3,939
TS=(compost* AND waste AND "bio hazard")	0	0
TS=(compost* AND waste AND plastic)	486	858

Table 3.4.3.2.: Publication data retrieved from the Indian Citation Index using final search string and individual keyword combinations of "National Mission on Sustainable Habitat"

Search String	ICI
(((Topic=recycl* And (Topic=waste And (Topic=solid OR Topic=municipal OR Topic=bio-hazard OR Topic=medical OR Topic=plastic))) OR (Topic=manage* And (Topic=waste And (Topic=solid OR Topic=municipal OR Topic=bio-hazard OR Topic=medicalOR Topic=plastic))) OR (Topic=dispos* And (Topic=waste And (Topic=solid OR Topic=municipal OR Topic=bio-hazard OR Topic=medical OR Topic=plastic))) OR (Topic=treatment And (Topic=waste And (Topic=solid ORTopic=municipal OR Topic=bio-hazard OR Topic=medical OR Topic=plastic))) OR (Topic=treatment And (Topic=waste And (Topic=solid OR Topic=municipal OR Topic=bio-hazard OR Topic=medical OR Topic=plastic))) OR (Topic=collection And (Topic=waste And (Topic=solid OR Topic=municipal OR Topic=bio-hazard OR Topic=medical OR Topic=plastic))) OR (Topic=compost* And (Topic=waste And (Topic=solid ORTopic=municipal OR Topic=bio-hazard OR Topic=medicalOR Topic=plastic)))) OR ((Topic=energy-efficien* And (Topic=resident* OR Topic=commercial OR Topic=office OR Topic=building* OR Topic=industr* OR Topic=construct* OR Topic=applianc* ORTopic=equipment OR Topic=fan OR Topic=lamp ORTopic=chiller* OR Topic=insulat* OR Topic=electric* OR Topic=tube-light)) OR (Topic=energy consum* And (Topic=resident* ORTopic=commercial OR Topic=office OR Topic=building* OR Topic=industr* OR Topic=construct* OR Topic=applianc* OR Topic=equipment OR Topic=fan OR Topic=lamp OR Topic=chiller* OR Topic=insulat* OR Topic=electric* OR Topic=tube-light)) OR (Topic=energy conserv* And (Topic=resident* OR Topic=commercial OR Topic=office OR Topic=building* OR Topic=industr* OR Topic=construct* OR Topic=applianc* ORTopic=equipment OR Topic=fan OR Topic=lamp ORTopic=chiller* OR Topic=insulat* OR Topic=electric* OR Topic=tube-light)) OR (Topic=energy-price* And (Topic=resident* OR Topic=commercial OR Topic=office OR Topic=building* OR Topic=industr* OR Topic=construct* OR Topic=applianc* OR Topic=equipment OR Topic=fan OR Topic=lamp OR Topic=chiller* OR Topic=insulat* OR Topic=electric* OR Topic=tube-light)) OR (Topic=energy-sav* And (Topic=resident* OR Topic=commercial OR Topic=office OR Topic=building* OR Topic=industr* OR Topic=construct* OR Topic=applianc* OR Topic=equipment OR Topic=fan OR Topic=lamp OR Topic=chiller* OR Topic=insulat* OR Topic=electric* OR Topic=tube-light)))OR ((Topic=transport* And (Topic=vehicle* And (Topic=GHG OR Topic=CO2 OR Topic=CHG OR Topic=bio-diesel OR Topic=ethanol OR Topic=gasoline OR Topic=biofule* OR Topic=price* OR Topic=electric* OR Topic=diesel OR Topic=petrol OR Topic=reduc*-energy OR Topic=greenhouse-gas*))) OR (Topic=transport* And (Topic=passenger* And (Topic=GHGOR Topic=CO2 OR Topic=CHG OR Topic=bio-diesel OR Topic=ethanol OR Topic=gasoline OR Topic=biofule* OR Topic=price* OR Topic=electric* OR Topic=diesel OR Topic=petrol	3239

OR Topic=reduc*-energy OR Topic=greenhouse-gas*))) OR (Topic=transport* And (Topic=freight And (Topic=GHG OR Topic=CO2 OR Topic=CHG OR Topic=bio-diesel OR Topic=ethanol OR Topic=gasoline OR Topic=biofule* OR Topic=price* OR Topic=electric* OR Topic=diesel ORTopic=petrol OR Topic=reduc*-energy ORTopic=greenhouse-gas*))) OR (Topic=transport* And (Topic=motorcycle* And (Topic=GHG OR Topic=CO2 OR Topic=CHG OR Topic=bio-diesel OR Topic=ethanol OR Topic=gasoline OR Topic=biofule* ORTopic=price* OR Topic=electric* OR Topic=diesel OR Topic=petrol OR Topic=reduc*-energy OR Topic=greenhouse-gas*))) OR (Topic=transport* And (Topic=scooter* And (Topic=GHG OR Topic=CO2 OR Topic=CHG OR Topic=bio-diesel OR Topic=ethanol OR Topic=gasoline OR Topic=biofule* OR Topic=price* OR Topic=electric* OR Topic=diesel OR Topic=petrol OR Topic=reduc*-energy OR Topic=greenhouse-gas*))) OR (Topic=transport* And (Topic=cars And (Topic=GHG OR Topic=CO2 OR Topic=CHG OR Topic=bio-diesel OR Topic=ethanol OR Topic=gasoline OR Topic=biofule* OR Topic=price* OR Topic=electric* OR Topic=diesel OR Topic=petrol OR Topic=reduc*-energy OR Topic=greenhouse-gas*))) OR (Topic=transport* And (Topic=personal* And (Topic=GHGOR Topic=CO2 OR Topic=CHG OR Topic=bio-diesel OR Topic=ethanol OR Topic=gasoline OR Topic=biofule* OR Topic=price* OR Topic=electric* OR Topic=diesel OR Topic=petrol OR Topic=reduc*-energy OR Topic=greenhouse-gas*))) OR (Topic=transport* And (Topic=road And (Topic=GHG OR Topic=CO2 OR Topic=CHG OR Topic=bio-diesel OR Topic=ethanol OR Topic=gasoline OR Topic=biofule* OR Topic=price* OR Topic=electric* OR Topic=diesel OR Topic=petrol OR Topic=reduc*-energy OR Topic=greenhouse-gas*))) OR (Topic=transport* And (Topic=buses And (Topic=GHG OR Topic=CO2 OR Topic=CHG OR Topic=bio-diesel OR Topic=ethanol OR Topic=gasoline OR Topic=biofule* OR Topic=price* OR Topic=electric* OR Topic=diesel OR Topic=petrol OR Topic=reduc*-energy OR Topic=greenhouse-gas*))) OR (Topic=transport* And (Topic=railway* And (Topic=GHG OR Topic=CO2 OR Topic=CHG OR Topic=bio-diesel OR Topic=ethanol OR Topic=gasoline OR Topic=biofule* OR Topic=price* OR Topic=electric* OR Topic=diesel OR Topic=petrol OR Topic=reduc*-energy OR Topic=greenhouse-gas*))) OR (Topic=transport* And (Topic=infrastructure And(Topic=GHG OR Topic=CO2 OR Topic=CHG OR Topic=bio-diesel OR Topic=ethanol OR Topic=gasoline OR Topic=biofule* OR Topic=price* OR Topic=electric* OR Topic=diesel OR Topic=petrol OR Topic=reduc*-energy OR Topic=greenhouse-gas*))) OR (Topic=transport* And (Topic=automobile And (Topic=GHGOR Topic=CO2 OR Topic=CHG OR Topic=bio-diesel OR Topic=ethanol OR Topic=gasoline OR Topic=biofule* OR Topic=price* OR Topic=electric* OR Topic=diesel OR Topic=petrol OR Topic=reduc*-energy OR Topic=greenhouse-gas*))) OR (Topic=transport* And (Topic=urban And (Topic=GHG OR Topic=CO2 OR Topic=CHG OR Topic=bio-diesel OR Topic=ethanol OR Topic=gasoline OR Topic=biofule* ORTopic=price* OR Topic=electric* OR Topic=diesel OR Topic=petrol OR Topic=reduc*-energy OR Topic=greenhouse-gas*)))))	
(Topic=recycl* And (Topic=waste And (Topic=solid ORTopic=municipal OR Topic=bio-hazard OR Topic=medicalOR Topic=plastic)))	324
(Topic=manage* And (Topic=waste And (Topic=solid ORTopic=municipal OR Topic=bio-hazard OR Topic=medicalOR Topic=plastic)))	88
(Topic=dispos* And (Topic=waste And (Topic=solid ORTopic=municipal OR Topic=bio-hazard OR Topic=medicalOR Topic=plastic)))	826
(Topic=treatment And (Topic=waste And (Topic=solid ORTopic=municipal OR Topic=bio-hazard OR Topic=medicalOR Topic=plastic)))	493
(Topic=collection And (Topic=waste And (Topic=solid ORTopic=municipal OR Topic=bio-hazard OR Topic=medicalOR Topic=plastic)))	223

(Topic=compost* And (Topic=waste And (Topic=solid ORTopic=municipal OR Topic=bio-hazard OR Topic=medicalOR Topic=plastic)))	257
(Topic=energy-efficien* And (Topic=resident* ORTopic=commercial OR Topic=office OR Topic=building* ORTopic=industr* OR Topic=construct* OR Topic=applianc* ORTopic=equipment OR Topic=fan OR Topic=lamp ORTopic=chiller* OR Topic=insulat* OR Topic=electric* ORTopic=tube-light))	491
(Topic=energy-conserv* And (Topic=resident* ORTopic=commercial OR Topic=office OR Topic=building* ORTopic=industr* OR Topic=construct* OR Topic=applianc* ORTopic=equipment OR Topic=fan OR Topic=lamp ORTopic=chiller* OR Topic=insulat* OR Topic=electric* ORTopic=tube-light))	201
(Topic=energy-consum* And (Topic=resident* ORTopic=commercial OR Topic=office OR Topic=building* ORTopic=industr* OR Topic=construct* OR Topic=applianc* ORTopic=equipment OR Topic=fan OR Topic=lamp ORTopic=chiller* OR Topic=insulat* OR Topic=electric* ORTopic=tube-light))	569
(Topic=energy-price* And (Topic=resident* ORTopic=commercial OR Topic=office OR Topic=building* ORTopic=industr* OR Topic=construct* OR Topic=applianc* ORTopic=equipment OR Topic=fan OR Topic=lamp ORTopic=chiller* OR Topic=insulat* OR Topic=electric* ORTopic=tube-light))	23
(Topic=energy-sav* And (Topic=resident* ORTopic=commercial OR Topic=office OR Topic=building* ORTopic=industr* OR Topic=construct* OR Topic=applianc* ORTopic=equipment OR Topic=fan OR Topic=lamp ORTopic=chiller* OR Topic=insulat* OR Topic=electric* ORTopic=tube-light))	247
(Topic=transport* And (Topic=vehicle* And (Topic=GHG ORTopic=CO2 OR Topic=CHG OR Topic=bio-diesel ORTopic=ethanol OR Topic=gasoline OR Topic=biofule* ORTopic=price* OR Topic=electric* OR Topic=diesel ORTopic=petrol OR Topic=reduc*-energy ORTopic=greenhouse-gas*)))	131
(Topic=transport* And (Topic=passenger* And (Topic=GHGOR Topic=CO2 OR Topic=CHG OR Topic=bio-diesel ORTopic=ethanol OR Topic=gasoline OR Topic=biofule* ORTopic=price* OR Topic=electric* OR Topic=diesel ORTopic=petrol OR Topic=reduc*-energy ORTopic=greenhouse-gas*)))	21
(Topic=transport* And (Topic=freight And (Topic=GHG OR Topic=CO2 OR Topic=CHG OR Topic=bio-diesel ORTopic=ethanol OR Topic=gasoline OR Topic=biofule* ORTopic=price* OR Topic=electric* OR Topic=diesel ORTopic=petrol OR Topic=reduc*-energy ORTopic=greenhouse-gas*)))	11
(Topic=transport* And (Topic=motorcycle* And (Topic=GHG OR Topic=CO2 OR Topic=CHG OR Topic=bio-diesel ORTopic=ethanol OR Topic=gasoline OR Topic=biofule* ORTopic=price* OR Topic=electric* OR Topic=diesel ORTopic=petrol OR Topic=reduc*-energy ORTopic=greenhouse-gas*)))	2
(Topic=transport* And (Topic=scooter* And (Topic=GHG ORTopic=CO2 OR Topic=CHG OR Topic=bio-diesel ORTopic=ethanol OR Topic=gasoline OR Topic=biofule* ORTopic=price* OR Topic=electric* OR Topic=diesel ORTopic=petrol OR Topic=reduc*-energy ORTopic=greenhouse-gas*)))	1
(Topic=transport* And (Topic=cars And (Topic=GHG ORTopic=CO2 OR Topic=CHG OR Topic=bio-diesel ORTopic=ethanol OR Topic=gasoline OR Topic=biofule* ORTopic=price* OR Topic=electric* OR Topic=diesel ORTopic=petrol OR Topic=reduc*-energy ORTopic=greenhouse-gas*)))	22
(Topic=transport* And (Topic=personal* And (Topic=GHGOR Topic=CO2 OR Topic=CHG OR Topic=bio-diesel ORTopic=ethanol OR Topic=gasoline OR Topic=biofule* OR Topic=price* OR Topic=electric* OR Topic=diesel OR Topic=petrol	28

OR Topic=reduc*-energy OR Topic=greenhouse-gas*)))	
(Topic=transport* And (Topic=road And (Topic=GHG OR Topic=CO2 OR Topic=CHG OR Topic=bio-diesel OR Topic=ethanol OR Topic=gasoline OR Topic=biofule* OR Topic=price* OR Topic=electric* OR Topic=diesel ORTopic=petrol OR Topic=reduc*-energy OR Topic=greenhouse-gas*)))	86
(Topic=transport* And (Topic=buses And (Topic=GHG ORTopic=CO2 OR Topic=CHG OR Topic=bio-diesel ORTopic=ethanol OR Topic=gasoline OR Topic=biofule* ORTopic=price* OR Topic=electric* OR Topic=diesel ORTopic=petrol OR Topic=reduc*-energy ORTopic=greenhouse-gas*)))	17
(Topic=transport* And (Topic=railway* And (Topic=GHG OR Topic=CO2 OR Topic=CHG OR Topic=bio-diesel ORTopic=ethanol OR Topic=gasoline OR Topic=biofule* OR Topic=price* OR Topic=electric* OR Topic=diesel ORTopic=petrol OR Topic=reduc*-energy ORTopic=greenhouse-gas*)))	17
(Topic=transport* And (Topic=infrastructure And(Topic=GHG OR Topic=CO2 OR Topic=CHG OR Topic=bio-diesel OR Topic=ethanol OR Topic=gasoline ORTopic=biofule* OR Topic=price* OR Topic=electric* ORTopic=diesel OR Topic=petrol OR Topic=reduc*-energy ORTopic=greenhouse-gas*)))	114
(Topic=transport* And (Topic=automobile And (Topic=GHGOR Topic=CO2 OR Topic=CHG OR Topic=bio-diesel ORTopic=ethanol OR Topic=gasoline OR Topic=biofule* ORTopic=price* OR Topic=electric* OR Topic=diesel ORTopic=petrol OR Topic=reduc*-energy ORTopic=greenhouse-gas*)))	19
(Topic=transport* And (Topic=urban And (Topic=GHG ORTopic=CO2 OR Topic=CHG OR Topic=bio-diesel ORTopic=ethanol OR Topic=gasoline OR Topic=biofule* ORTopic=price* OR Topic=electric* OR Topic=diesel ORTopic=petrol OR Topic=reduc*-energy ORTopic=greenhouse-gas*)))	74

3.4.1.4. Search string for the "National Water Mission"

The National Action Plan on Climate Change (NAPCC) describes the major five goals of "National Water Mission" to the development and management of water resources in the country:

1. Comprehensive water database in public domain and assessment of the impact of climate change on water resource
2. Promotion of citizen and state action for water conservation, augmentation, and preservation
3. Focused attention to vulnerable areas including over-exploited areas
4. Increasing water use efficiency by 20%
5. Promotion of basin level integrated water resources management

The "National Water Mission" was mounted to ensure integrated water resource management helping to conserve water, minimize wastage and ensure more equitable distribution both across and within states. Increasing the water use efficiency through regulatory mechanisms with differential entitlements and pricing. The Mission was sought to a considerable share of the water needs of urban areas are met through recycling of wastewater and storage of the water for both above and below ground, rainwater harvesting, coupled with equitable and efficient management structures.

A well-developed information system for water-related data in its entirety at the national / state level is a prime requisite for resource planning. A standardised national information system should be established with a network of data banks and databases, integrating and strengthening the existing Central and State level agencies and improving the quality of data and the processing capabilities.

The initial search string was generated through various combinations of keywords relevant to the "National Water Mission". Keeping all objectives, aims and targets of the "National Water Mission" in mind, the relevant keyword were selected to generate the initial search string. Various modifications, additions, deletions of keywords in the initial search string were performed to get the comprehensive publication data from Web of Science and Scopus. A similar methodology of search string generation which is mentioned in Objective-1 was followed to generate the final search string for data retrieval from publication's databases on National Water Mission. Table 3.4.4.1 and Table 3.4.4.2 represent the result of publication data retrieved from the Web of Science, Scopus, and the Indian Citation Index database using the final search string and individual search strings. More than 10 % of the retrieved publications were checked manually for validation of the search strings in the Web of Science database. Manual verification was also exercised for the retrieved publications using individual search strings.

Table 3.4.4.1: Publication data retrieved from Web of Science and Scopus using final search string and individual keyword combinations of the "National Water Mission"

SEARCH STRING	Web of Science	SCOPUS
TS=(((management OR resource* OR recycl*) AND ("surface water" OR groundwater)) OR "water irrigat*" OR (rainwater AND harvest*) OR "water use efficien*" OR (wastewater AND (management OR recycl* OR drainage)) OR (water AND desalination) OR (freshwater AND (resource* OR storage OR recycl*)) OR (wetland* AND conserv*) OR (groundwater AND (recharge OR recycl*)))	103,673	208,795
TS=(management AND "surface water")	6,253	15,133
TS=(management AND groundwater)	15,542	27,534

TS=(resource* AND "surface water")	4.671	13,374
TS=(resource* AND groundwater)	13,306	37,751
TS=(recycl* AND "surface water")	557	1,683
TS=(recycl* AND groundwater)	1,048	2,347
TS="water irrigat*"	1,734	2,282
TS=(rainwater AND harvest*)	1,597	2,511
TS="water use efficien*"	14,599	16,183
TS=(wastewater AND management)	7,559	50,082
TS=(wastewater AND recycl*)	5,797	16,571
TS=(wastewater AND drainage)	1,725	3,944
TS= (water AND desalination)	13,569	21,348
TS=(freshwater AND resource*)	6,219	10,771
TS=(freshwater AND storage)	1,597	2,149
TS=(freshwater AND recycl*)	742	1,222
TS=(wetland* AND conserv*)	7,431	10,900
TS=(groundwater AND recharge)	12,958	15,841
TS=(groundwater AND recycl*)	1,048	2,347

Table 3.4.4.2: Publication data retrieved from Indian Citation Index using final search string and individual keyword combinations of the "National Water Mission"

Search String	ICI
(((Topic=management OR Topic=resource* OR Topic=recycl*) And (Topic=surface-water OR Topic=groundwater)) OR (Topic=water-irrigat* OR Topic=water-use-efficien*) OR (Topic=rainwater And Topic=harvest*) OR (Topic=water And Topic=desalination) OR (Topic=wetland* And Topic=conserv*) OR (Topic=wastewater And (Topic=management ORTopic=recycl* OR Topic=drainage)) OR (Topic=freshwater And (Topic=resource* OR Topic=recycl*OR Topic=storage)) OR (Topic=groundwater And (Topic=recharge ORTopic=recycl*)))	3497
((Topic=management OR Topic=resource* OR Topic=recycl*) And (Topic=surface-water OR Topic=groundwater))	1558
(Topic=water-irrigat* OR Topic=water-use-efficien*)	365
(Topic=rainwater And Topic=harvest*)	356
(Topic=water And Topic=desalination)	105
(Topic=wetland* And Topic=conserv*)	326
(Topic=wastewater And (Topic=management ORTopic=recycl* OR Topic=drainage))	347
(Topic=freshwater And (Topic=resource* OR Topic=recycl*OR Topic=storage))	263
(Topic=groundwater And (Topic=recharge ORTopic=recycl*))	625

3.4.1.5. Search-string for the “National Mission for Sustaining the Himalayan Ecosystem”

The National Mission for Sustaining the Himalayan Ecosystem (NMSHE) was launched as part of the eight missions under the National Action Plan on Climate Change (NAPCC). NMSHE is the only mission under NAPCC with a geographic focus, all the others being theme-based. NMSHE intends to evolve suitable management and policy measures for sustaining and safeguarding the Himalayan ecosystem along with developing capacities at the national level to continuously assess its health status. NMSHE’s action plan was approved by the Union Cabinet in 2014. It was attempted to address a variety of important issues. These are Himalayan glaciers and associated hydrological consequences, prediction and management of natural hazards, biodiversity and wildlife conservation and protection, traditional knowledge societies and their livelihood, capacity in the regulation of science, and critical peer evaluation to help governance issues related to sustenance of the Himalayan ecosystem, assist in restoration and rehabilitation process.

The initial search string was generated through various combinations of keywords relevant to the “National Mission for Sustaining the Himalayan Ecosystem”. Keeping all objectives, aims and targets of the “National Mission for Sustaining the Himalayan Ecosystem” in mind, the relevant keyword were selected to generate the initial search string. Various modifications, additions, deletions of keywords in the initial search string were performed to get the comprehensive publication data from Web of Science and Scopus. A similar methodology of search string generation which is mentioned in Objective-1 was followed to generate the final search string for data retrieval from publication’s databases on National Mission for Sustaining the Himalayan Ecosystem. Table 3.4.5.1 Table 3.4.5.2 represent the result of publication data retrieved from the Web of Science, Scopus, and the Indian Citation Index database using the final search string and individual search strings. More than 10 % of the retrieved publications were checked manually for validation of the search strings in the Web of Science database. Manual verification was also exercised for the retrieved publications using individual search strings.

Table 3.4.5.1: Publication data retrieved from Web of Science and Scopus using final search string and individual keyword combinations of the “National Mission for Sustaining the Himalayan Ecosystem”

SEARCH STRING	Web of Science	Scopus

TS=(Himalaya* AND (ecosystem* OR *glaci* OR mitigat* OR biodiversit* OR "wild life" OR livelihood OR rehabilitation OR (climat* AND chang*) OR ethni* OR herb* OR "land slide" OR precipitation OR touris* OR water OR "natural resource*" OR adapt* OR impact* OR mission* OR agricult* OR "biological diversity" OR fragmentation OR deforestation OR flora OR fauna OR flood OR conservation OR threat* OR "soil erosion" OR "global warm*" OR bio-resource OR urbanization OR "mountain ecosystem" OR corridor* OR farming OR restor* OR "natural hazard*" OR endanger* OR species OR snow* OR river* OR hazard*))	15,308	18,181
TS=(Himalaya* AND ecosystem*)	812	1,246
TS=(Himalaya* AND glaci*)	2,591	2,440
TS=(Himalaya* AND biodiversity)	910	986
TS=(Himalaya* AND "wild life")	5	8
TS=(Himalaya* AND livelihood)	352	520
TS=(Himalaya* AND rehabilitation)	35	63
TS=(Himalaya* AND mitigat*)	318	394
TS=(Himalaya* AND (climat* AND chang*))	2,536	2,447
TS=(Himalaya* AND ethni*)	119	278
TS=(Himalaya* AND herb*)	742	1,148
TS=(Himalaya* AND "land slide")	0	2
TS=(Himalaya* AND precipitation)	1,768	1,580
TS=(Himalaya* AND touris*)	157	373
TS=(Himalaya* AND water)	3,093	3,458
TS=(Himalaya* AND "natural resource*")	191	465
TS=(Himalaya* AND adaptat*)	827	578
TS=(Himalaya* AND impact*)	1,958	2,114
TS=(Himalaya* AND mission*)	219	229
TS=(Himalaya* AND agricult*)	803	1,361
TS=(Himalaya* AND "biological diversity")	27	51
TS=(Himalaya* AND fragmentation)	156	185
TS=(Himalaya* AND deforestation)	206	291
TS=(Himalaya* AND flora)	359	514
TS=(Himalaya* AND fauna)	377	468
TS=(Himalaya* AND flood)	717	761
TS=(Himalaya* AND conservation)	1,437	1,850
TS=(Himalaya* AND threat*)	583	861
TS=(Himalaya* AND "soil erosion")	148	224
TS=(Himalaya* AND "global warm*")	195	260
TS=(Himalaya* AND bio-resource)	19	22

TS=(Himalaya* AND urbanization)	78	140
TS=(Himalaya* AND "mountain ecosystem")	27	86
TS=(Himalaya* AND corridor*)	104	134
TS=(Himalaya* AND farming)	316	301
TS=(Himalaya* AND restor*)	211	264
TS=(Himalaya* AND "natural hazards")	117	160
TS=(Himalaya* AND endanger*)	335	533
TS=(Himalaya* AND river)	2,950	2,913
TS=(Himalaya* AND hazard*)	1,075	1,140
TS=(Himalaya* AND species)	4,524	5,643
TS=(Himalaya* AND snow*)	1,375	1,373

Table 3.4.5.2: Publication data retrieved from the Indian Citation Index using final search string and individual keyword combinations of the "National Mission for Sustaining the Himalayan Ecosystem"

Search String	ICI
((Topic=Himalaya* And (Topic=ecosystem* OR Topic=*glaci*OR Topic=mitigat* OR Topic=biodiversit* OR Topic=wild-lifeOR Topic=livelihood OR Topic=rehabilitation ORTopic=ethni* OR Topic=herb* OR Topic=land-slide ORTopic=precipitation OR Topic=touris* OR Topic=water ORTopic=natural-resource* OR Topic=adapt* ORTopic=impact* OR Topic=mission* OR Topic=agricult* ORTopic=biological-diversity OR Topic=fragmentation ORTopic=deforestation OR Topic=flora OR Topic=fauna ORTopic=flood OR Topic=conservation OR Topic=threat* ORTopic=soil-erosion OR Topic=global-warm* OR Topic=bio-resource OR Topic=urbanization OR Topic=mountain-ecosystem OR Topic=corridor* OR Topic= farming ORTopic=restor* OR Topic=natural-hazard* ORTopic=endanger* OR Topic=species OR Topic=snow* ORTopic=river* OR Topic=hazard*)) OR (Topic=Himalaya* And Topic=climat* And Title=chang*))	4562
(Topic=Himalaya* And Topic=climat* And Title=chang*)	119
(Topic=Himalaya* And (Topic=ecosystem* OR Topic=*glaci*OR Topic=mitigat* OR Topic=biodiversit* OR Topic=wild-lifeOR Topic=livelihood OR Topic=rehabilitation ORTopic=ethni* OR Topic=herb* OR Topic=land-slide ORTopic=precipitation OR Topic=touris* OR Topic=water ORTopic=natural-resource* OR Topic=adapt* ORTopic=impact* OR Topic=mission* OR Topic=agricult* ORTopic=biological-diversity OR Topic=fragmentation ORTopic=deforestation OR Topic=flora OR Topic=fauna ORTopic=flood OR Topic=conservation OR Topic=threat* ORTopic=soil-erosion OR Topic=global-warm* OR Topic=bio-resource OR Topic=urbanization OR Topic=mountain-ecosystem OR Topic=corridor* OR Topic= farming ORTopic=restor* OR Topic=natural-hazard* ORTopic=endanger* OR Topic=species OR Topic=snow* OR Topic=river* OR Topic=hazard*))	4459

3.4.1.6. Search-string for National Mission for a Green India

The "National Mission for a Green India" is one of the eight Missions under the National Action Plan on Climate Change recognizes that climate change phenomena will seriously affect and alter the distribution, type, and quality of natural resources of the country and the associated livelihoods of the people. The Mission (henceforth referred to as GIM) acknowledges the influences that the forestry sector has on environmental amelioration through climate mitigation, food security, water security, biodiversity conservation, and livelihood security of forest-dependent communities. GIM puts the "greening" in the context of climate change adaptation and mitigation, meant to enhance ecosystem services like carbon sequestration and storage (in forests and other ecosystems), hydrological services, and biodiversity; along with provisioning services like fuel, fodder, small timber, and NTFPs.

The Mission aims at protection, restoration, and enhancement of India's forest cover in response to climate change by:

1. Enhancing carbon sinks in sustainably managed forests and other ecosystems;
2. Adaptation of vulnerable species/ecosystems to the changing climate;
3. Adaptation of forest-dependent local communities in the face of climatic variability.

The initial search string was generated through various combinations of keywords relevant to the National Mission for a Green India. Keeping all objectives, aims, and targets of the "National Mission for a Green India" in mind, the relevant keyword were selected to generate the initial search string. Various modifications, additions, deletions of keywords in the initial search string were performed to get the comprehensive publication data from Web of Science and Scopus. Similar methodology of search string generation which is mentioned in Objective-1 was followed to generate the final search string for data retrieval from publication's databases on National Mission for a Green India. Table 4.6.1 represents the result of publication data retrieved from Web of Science and Scopus database using the final search string and individual search strings. More than 10 % of the retrieved publications were checked manually for validation of the search strings in Web of Science database. Manual verification was also exercised for the retrieved publications using individual search strings.

Table 3.4.6.1.: Publication data retrieved from Web of Science and Scopus using final search string and individual keyword combinations of the "National Mission for a Green India"

Search string	**Web of Science**	**Scopus**
TS=((*forest* AND (ecosystem* OR fire* OR "land use*" OR carbon OR protecte* OR conserv* OR fragment* OR fauna OR flora OR biodivers*)) OR (wildlife AND (conserv* OR in-situ OR ex-situ OR protecte* OR "genetic diversity" OR biodivers*))OR "*forest* cover*" OR "*forest* densit*")	206,003	254,822
TS=(*forest* AND ecosystem*)	64,570	81,512
TS=(*forest* AND fire*)	28,077	31,239
TS=(*forest* AND "land use*")	28,853	34,988
TS=(*forest* AND carbon)	51,853	50,227
TS=(*forest* AND protecte*)	9,127	11,643
TS=(*forest* AND conserv*)	46,560	57,674
TS=(*forest* AND fragment*)	20,673	20,189
TS=(*forest* AND fauna)	8,331	57,674
TS=(*forest* AND flora)	5,704	7,676
TS=(*forest* AND biodivers*)	30,905	34,019
TS=(wildlife AND conserv*)	12,773	18,688
TS=(wildlife AND in-situ)	315	442
TS=(wildlife AND ex-situ)	90	150
TS=(wildlife AND protecte*)	2,773	3,952
TS=(wildlife AND "genetic diversity")	687	622
TS=(wildlife AND biodivers*)	4,127	5,378
TS= "*forest* cover*"	6,816	10,488
TS= "*forest* densit*"	404	521

Table 3.4.6.1: Publication data retrieved from Indian Citation index using final search string and individual keyword combinations of the "National Mission for a Green India"

Search String	ICI
(((Topic=*forest*-cover* OR Title=*forest*-densit*) OR (Topic=*forest* And (Topic=ecosystem* OR Topic=fire* OR Topic=land-use* OR Topic=carbon OR Topic=protecte* OR Topic=conserv* OR Topic=fragment* OR Topic=fauna OR Topic=flora OR Topic=biodivers*)) OR (Topic=wildlife And (Topic=in-situ OR Topic=conserv* OR Topic=ex-situ OR Topic=protecte* OR Topic=genetic-diversity OR Topic=biodivers*)))	5199
(Topic=*forest*-cover* OR Title=*forest*-densit*)	467

(Topic=*forest* And (Topic=ecosystem* OR Topic=fire* ORTopic=land-use* OR Topic=carbon OR Topic=protecte* ORTopic=conserv* OR Topic=fragment* OR Topic=fauna ORTopic=flora OR Topic=biodivers*))	4513
(Topic=wildlife And (Topic=in-situ OR Topic=conserv* ORTopic=ex-situ OR Topic=protecte* OR Topic=genetic-diversity OR Topic=biodivers*))	749

3.4.1.7. Search string for the "National Mission for Sustainable Agriculture"

The "National Mission for Sustainable Agriculture" is envisaged as one of the eight missions under the National Action Plan on Climate Change to promote Sustainable Agriculture. The thrust areas to be addressed under this Mission are dryland agriculture, access to information, biotechnology and risk management. This National Mission would cover both adaptation and mitigation measures in the domain of crops and animal husbandry, including research. Sustainable agricultural practices have to balance environmental health and economic profitability to promote social and economic equity.

The Vision of National Mission for Sustainable Agriculture:

1) Transform Agriculture into Climate Resilient Production system
2) Grow and Ecologically Sustain agricultural production to its Fullest Potential
3) Ensure Food Security and Equitable Access to Food Resources
4) Enhance Livelihood Opportunities
5) Contribute to Economic Stability at the National Level

The initial search string was generated through various combinations of keywords relevant to the "National Mission for Sustainable Agriculture". Keeping all objectives, aims, and targets of the "National Mission for Sustainable Agriculture" in mind, the relevant keyword were selected to generate the initial search string. Various modifications, additions, deletions of keywords in the initial search string were performed to get the comprehensive publication data from Web of Science, Scopus. and the Indian Citation Index. A similar methodology of search string generation which is mentioned in Objective-1 was followed to generate the final search string for data retrieval from publication's databases on National Mission for Sustainable Agriculture. Table 3.4.7.1 andTable 3.4.7.2 represents the result of publication data retrieved from Web of Science and Scopus database using the final search string and individual search strings. More than 10 % of the retrieved publications were checked manually for validation of the search strings in Web of Science database. Manual verification was also exercised for the retrieved publications using individual search strings.

Table 3.4.7.1.: Publication data retrieved from Web of Science and Scopus using final search string and individual keyword combinations of the "National Mission for Sustainable Agriculture"

SEARCH STRING	Web of Science	Scopus
TS=((agricult* AND ("land use" OR GHG OR "greenhouse gas*" OR environment* OR *forest* OR "food security" OR biodiversity OR CO2 OR carbon OR NO2 OR nitrogen OR "weather forecast*" OR *compost* OR GDP OR dairy OR climat* OR livelihood OR weather OR mountain* OR ecosystem OR (resistance AND (pest* OR disease)) OR (tolerance AND (drought OR salinity OR submergence OR heat)) OR "soil erosion" OR bio-control OR pesticide OR fertiliz* OR "organic farming" OR livestock OR(zone AND ("dry land" OR rain-fed)) OR sustainab* OR conserv* OR cultivation OR biotechnolog* OR technol* OR "water resource*" OR yield OR product* OR "medicinal plant" OR econom* OR intensif* OR (crop AND (rotation* OR improve* OR variety OR season OR hybrid OR greenhouse OR C-3 OR C-4)))) OR "agricult* manage*")	248,369	506,446
TS=(agricult* AND "land use")	25,731	39,482
TS=(agricult* AND GHG)	2,203	3,511
TS=(agricult* AND "greenhouse gas*")	6,607	9,805
TS=(agricult* AND environment*)	71,819	156,382
TS=(agricult* AND "food security")	6,555	12,157
TS=(agricult* AND biodiversity)	13,398	17,778
TS=(agricult* AND CO2)	7,605	9,498
TS=(agricult* AND Carbon)	26,199	38,211
TS=(agricult* AND NO2)	630	826
TS=(agricult* AND nitrogen)	27,397	40,522
TS=(agricult* AND "weather forecast*")	306	1,231
TS=(agricult* AND *compost*)	4,117	7,150
TS=(agricult* AND GDP)	904	2,233
TS=(agricult* AND dairy)	5,064	10,561
TS=(agricult* AND climat*)	32,360	52,688
TS=(agricult* AND livelihood)	3,288	7,498
TS=(agricult* AND weather)	7,375	11,392
TS=(agricult* AND mountain*)	4,732	8,456
TS=(agricult* AND ecosystem)	23,048	41,955
TS=(agricult* AND resistance AND pest*)	2,481	4,282
TS=(agricult* AND resistance AND disease)	3,052	6,286

TS=(agricult* AND tolerance AND drought)	1,515	2,108
TS=(agricult* AND tolerance AND salinity)	1,303	1,693
TS=(agricult* AND tolerance AND submergence)	46	74
TS=(agricult* AND tolerance AND heat)	398	719
TS=(agricult* AND "soil erosion")	4,305	7,685
TS=(agricult* AND bio-control)	78	161
TS=(agricult* AND pesticide)	16,338	27,629
TS=(agricult* AND fertiliz*)	22,234	43,914
TS=(agricult* AND "organic farming")	2,035	4,669
TS=(agricult* AND livestock)	9,588	22,683
TS=(agricult* AND zone AND "dry land")	26	79
TS=(agricult* AND zone AND rain-fed)	115	213
TS=(agricult* AND sustainab*)	29,650	51,663
TS=(agricult* AND conserv*)	24,715	45,734
TS=(agricult* AND cultivation)	12,315	28,838
TS=(agricult* AND biotechnolog*)	3,729	11,341
TS=(agricult* AND technol*)	25,105	58,910
TS=(agricult* AND "water resource*")	7,856	16,579
TS=(agricult* AND yield)	38,094	65,999
TS=(agricult* AND product*)	93,830	200,413
TS=(agricult* AND "medicinal plant")	245	1,844
TS=(agricult* AND econom*)	40,469	104,990
TS=(agricult* AND intensif*)	7,853	10,648
TS=(agricult* AND crop AND rotation*)	5,688	8,252
TS=(agricult* AND crop AND improve*)	14,390	27,080
TS=(agricult* AND crop AND variety)	4,940	10,187
TS=(agricult* AND crop AND season)	8,280	15,374
TS=(agricult* AND crop AND hybrid)	1,437	2,969
TS=(agricult* AND crop AND greenhouse)	4,707	7,443
TS=(agricult* AND crop AND C-3)	229	70
TS=(agricult* AND crop AND C-4)	248	80
TS="agricult* manage*"	3,144	10,758

Table 3.4.7.2: Publication data retrieved from Indian Citation Index using final search string and individual keyword combinations of the "National Mission for Sustainable Agriculture"

Search String	ICI
((Topic=agricult* And (Topic=land-use OR Topic=GHG OR Topic=greenhouse-gas* OR Topic=environment* OR Topic=*forest* OR Topic=food-security OR Topic=biodiversity OR Topic=CO2 OR Topic=carbon OR Topic=NO2 OR Topic=nitrogen OR Topic=weather-forecast*OR Topic=*compost* OR Topic=GDP OR Topic=dairy OR Topic=climat* OR Topic=livelihood OR Topic=weather OR Topic=mountain* OR Topic=ecosystem OR Topic=soil-erosion OR Topic=bio-control OR Topic=pesticide OR Topic=fertiliz* OR Topic=organic-farming OR Topic=livestock OR Topic=sustainab* OR Topic=conserv* OR Topic=cultivation OR Title= biotechnolog* OR Topic=technol* OR Title=water-resource* OR Topic=yield OR Topic=product* OR Topic=medicinal-plant OR Topic=econom* OR Topic=intensif*)) OR (Topic=agricult* And (Topic=resistance And (Topic=pest* OR Topic=disease))) OR (Topic=agricult* And (Topic=tolerance And (Topic=drought OR Topic=salinity OR Topic=submergence OR Topic=heat))) OR (Topic=agricult* And (Topic=zone And (Topic=dry-land OR Topic= rain-fed))) OR(Topic=agricult* And (Topic=crop And (Topic=rotation* OR Topic=improve* OR Topic=variety OR Topic=season OR Topic= hybrid OR Topic=greenhouse OR Topic=C-3 OR Topic=C-4))) OR(Topic=agricult*-manage*))	30043
(Topic=agricult* And (Topic=land-use OR Topic=GHG OR Topic=greenhouse-gas* OR Topic=environment* OR Topic=*forest* OR Topic=food-security OR Topic=biodiversity OR Topic=CO2 OR Topic=carbon OR Topic=NO2 OR Topic=nitrogen OR Topic=weather-forecast*OR Topic=*compost* OR Topic=GDP OR Topic=dairy OR Topic=climat* OR Topic=livelihood OR Topic=weather OR Topic=mountain* OR Topic=ecosystem OR Topic=soil-erosion OR Topic=bio-control OR Topic=pesticide OR Topic=fertiliz* OR Topic=organic-farming OR Topic=livestock OR Topic=sustainab* OR Topic=conserv* OR Topic=cultivation OR Title= biotechnolog* OR Topic=technol* OR Title=water-resource* OR Topic=yield OR Topic=product* OR Topic=medicinal-plant OR Topic=econom* OR Topic=intensif*))	29449
(Topic=agricult* And (Topic=resistance And (Topic=pest* OR Topic=disease)))	351
(Topic=agricult* And (Topic=tolerance And (Topic=drought OR Topic=salinity OR Topic=submergence OR Topic=heat)))	263
(Topic=agricult* And (Topic=zone And (Topic=dry-land OR Topic= rain-fed)))	23
(Topic=agricult* And (Topic=crop And (Topic=rotation* OR Topic=improve* OR Topic=variety OR Topic=season OR Topic= hybrid OR Topic=greenhouse OR Topic=C-3 OR Topic=C-4)))	3506
(Topic=agricult*-manage*)	72

3.4.1.8. Search string for the "National Mission for Strategic Knowledge for Climate Change"

Climate change's effects on social structures are likely to differ in various parts of the world due to a variety of regional and other local factors. In different geographical and social contexts, different modelling studies, adaptation strategies, and technology systems will be needed. Besides, due to a lack of scientific understanding of the mechanisms involved in climate change, there are several uncertainties in disaggregating the impact of global warming on various agroclimatic regions. This will necessitate building a strong capability in climate science basic and applied research by improving observational and modelling instruments and systems. Many constraints restrict the national knowledge system's ability to produce the necessary and planned outcomes for effective response at this time. The key aim of the National Mission on Strategic Knowledge would be to address these constraints through strategic measures that involve the creation of adequate institutional and human resource resources for this purpose. As a result, the Mission's goals have been defined as follows.

Formation of knowledge networks among established knowledge institutions engaged in climate science research and development, with a suitable policy framework and institutional support to promote data sharing and exchange.

Establishment of global technology watch groups with institutional capacity to conduct research on risk-averse technology selection for developmental purposes.

Building national capacity to model the regional effect of climate change on different ecological zones throughout the country for various seasons and living standards.

Creating research networks and promoting research on the effects of climate change on key socio-economic sectors such as agriculture, health, natural ecosystems, biodiversity, and coastal zones, among others.

Improving understanding and knowledge of key climate processes, as well as the resulting climate threats and implications.

Global collaboration in climate change science and technology creation under international and bilateral S&T cooperation agreements is forming alliances and partnerships.

The initial search string was generated through various combinations of keywords relevant to the "National Mission for Strategic Knowledge for Climate Change". Keeping all objectives, aims, and targets of the "National Mission for Strategic Knowledge for Climate Change" in mind, the relevant keyword were selected to generate the initial search string. Various modifications, additions, deletions of keywords in the initial search string were performed to get the comprehensive publication data from Web of Science and Scopus. A similar methodology of search string generation which is mentioned in Objective-1 was followed to generate the final search string for data retrieval from publication's databases on the "National Mission for Strategic Knowledge for Climate Change". Table 3.4.8.1 and Table 3.4.8.2 represent the result of publication data retrieved from the Web of Science and Scopus database using the final search string and individual search strings. More than 10 % of the retrieved publications were checked manually for validation of the search strings in the Web of Science database. Manual verification was also exercised for the retrieved publications using individual search strings.

Table 3.4.8.1: Publication data retrieved from Web of Science and Scopus using final search string and individual keyword combinations of the "National Mission for Strategic Knowledge for Climate Change"

Search string	Web of Science	Scopus
TS=("Climat* Chang*" AND ("monsoon dynamic*" OR "aerosol science" OR "ecosystem response*" OR projection* OR projected OR "hydrological cycle*" OR "observation network"OR (data AND (gather* OR assimialation* OR access* OR availab* OR resource*)) OR "research infrastruc*" OR compution* OR (model* AND (IPCC OR "Intergovernmental Panel on Climate Change" OR India* OR global OR "air ocean general circulation" OR AOGCM OR regional OR RCM OR "general circulation" OR GCM OR "regional model inter-comparion project" OR RMIP)) OR (database AND (Oceans OR "Sea surface temperature Salinity" OR "Sea level rise*" OR Cryosphere OR "Snow cover" OR "Glacial data" OR Meteorology OR Precipitation OR Humidity OR "Surface temperature" OR "Air temperature" OR "Evaporation data" OR "Land Surface" OR Topography OR Erosion OR Imagery OR "vegetation map" OR "Forest cover" OR Hydrological OR "Ground water" OR "water quality" OR "River water" OR "water utilization" OR Agriculture OR "Soil profile" OR cultivation OR Production OR yield OR Socio-Economic OR Demography OR "Economic status" OR Forest* OR "natural resource*" OR Plant* OR animal* OR species OR "Health Data")) OR "skil* develop*" OR training OR "human resource*" OR awareness))	75,456	83,738
TS=("Climat* Chang*" AND model* AND IPCC)	3,095	4,206
TS=("Climat* Chang*" AND (model* AND "Intergovernmental Panel on Climate Change"))	2,121	3188
TS=("Climat* Chang*" AND (model* AND India*))	2,799	3917
TS=("Climat* Chang*" AND (model* AND global))	28,733	37150
TS=("Climat* Chang*" AND (model* AND "air ocean general circulation"))	0	0
TS=("Climat* Chang*" AND (model* AND AOGCM))	224	332
TS=("Climat* Chang*" AND (model* AND regional))	15,583	19047
TS=("Climat* Chang*" AND (model* AND RCM))	926	1140
TS=("Climat* Chang*" AND (model* "general circulation"))	5,086	0
TS=("Climat* Chang*" AND (model* AND GCM))	3,136	5341
TS=("Climat* Chang*" AND (model* AND "regional model inter-comparion project"))	0	0
TS=("Climat* Chang*" AND (model* AND RMIP))	3	3
TS=("Climat* Chang*" AND "monsoon dynamic*")	56	79
TS=("Climat* Chang*" AND "aerosol science")	8	12

TS=(“Climat* Chang*” AND "ecosystem response*")	1,106	1811
TS=(“Climat* Chang*” AND "hydrological cycle*")	1,547	2162
TS=(“Climat* Chang*” AND "observation network")	90	167
TS=(“Climat* Chang*” AND projection*)	12,539	13007
TS=(“Climat* Chang*” AND projected)	23,129	13051
TS=(“Climat* Chang*” AND compution*)	0	0
TS= (“Climat* Chang*” AND "research infrastruc*")	49	34
TS=(“Climat* Chang*” AND data AND gather*)	873	1105
TS=(“Climat* Chang*” AND data AND assimialation*)	0	0
TS=(“Climat* Chang*” AND data AND access*)	2,027	3043
TS=(“Climat* Chang*” AND data AND availab*)	10,751	11661
TS=(“Climat* Chang*” AND data AND resource*)	7,886	10777
TS=(“Climat* Chang*” AND training OR awareness)	1,68,890	6109
TS=(“Climat* Chang*” AND "skil* develop*")	13	35
TS=(“Climat* Chang*” AND "human resource*")	140	375
TS=(“Climat* Chang*” AND (database AND “Sea surface temperature Salinity"))	2	2
TS=(“Climat* Chang*” AND (database AND "Sea level rise*"))	90	101
TS=(“Climat* Chang*” AND (database AND "Snow cover"))	36	35
TS=(“Climat* Chang*” AND (database AND "Glacial data"))	0	0
TS=(“Climat* Chang*” AND (database AND "Surface temperature"))	138	168
TS=(“Climat* Chang*” AND (database AND "Air temperature"))	155	220
TS=(“Climat* Chang*” AND (database AND "Evaporation data"))	1	3
TS=(“Climat* Chang*” AND (database AND "Land Surface"))	106	91
TS=(“Climat* Chang*” AND (database AND "vegetation map"))	9	10
TS=(“Climat* Chang*” AND (database AND "Forest cover"))	40	38
TS=(“Climat* Chang*” AND (database AND "Ground water"))	3	25
TS=(“Climat* Chang*” AND (database AND "water quality"))	81	103
TS=(“Climat* Chang*” AND (database AND "River water"))	4	11
TS=(“Climat* Chang*” AND (database AND "water utilization"))	0	0
TS=(“Climat* Chang*” AND (database AND "Soil profile"))	16	33
TS=(“Climat* Chang*” AND (database AND "Economic status"))	1	3
TS=(“Climat* Chang*” AND (database AND "natural resource*"))	1	194
TS=(“Climat* Chang*” AND (database AND "Health Data"))	1	2
TS=(“Climat* Chang*” AND (database AND Oceans))	329	391
TS=(“Climat* Chang*” AND (database AND Cryosphere))	9	13

TS=("Climat* Chang*" AND (database AND Meteorology))	42	225
TS=("Climat* Chang*" AND (database AND Precipitation))	702	701
TS=("Climat* Chang*" AND (database AND Humidity))	87	133
TS=("Climat* Chang*" AND (database AND Topography))	103	111
TS=("Climat* Chang*" AND (database AND Erosion))	95	125
TS=("Climat* Chang*" AND (database AND Imagery))	77	128
TS=("Climat* Chang*" AND (database AND Hydrological))	213	228
TS=("Climat* Chang*" AND (database AND Agriculture))	278	407
TS=("Climat* Chang*" AND (database AND cultivation))	63	90
TS=("Climat* Chang*" AND (database AND Production))	566	687
TS=("Climat* Chang*" AND (database AND yield))	325	271
TS=("Climat* Chang*" AND (database AND Socio-Economic))	96	128
TS=("Climat* Chang*" AND (database AND Demography))	26	53
TS=("Climat* Chang*" AND (database AND Forest*))	826	716
TS=("Climat* Chang*" AND (database AND Plant*))	714	755
TS=("Climat* Chang*" AND (database AND animal*))	122	345
TS=("Climat* Chang*" AND (database AND species))	1,004	959

Table 3.4.8.2: Publication data retrieved from Indian Citation Index using final search string and individual keyword combinations of the "National Mission for Strategic Knowledge for Climate Change"

Search Srting	ISI
((Topic=climat*-chang* And Topic=monsoon-dynamic*) OR (Topic=climat*-chang* And Topic=aerosol) OR (Topic=climat*-chang* And Topic=ecosystem-response*) OR (Topic=climat*-chang* And Topic=hydrological-cycle*) OR (Topic=climat*-chang* And Topic=research-infrastruc*) OR (Topic=climat*-chang* And Topic=projection*) OR (Topic=climat*-chang* And Topic=projection*) OR (Topic=climat*-chang* And Topic=compution*) OR (Topic=climat*-chang* And Topic=observation-network) OR (Topic=climat*-chang* And (Topic=data And (Topic=gather*OR Topic=assimialation* OR Topic=access* ORTopic=availab* OR Topic=resource*))) OR (Topic=climat*-chang* And (Topic=model* And (Topic=IPCCOR Topic=India* OR Topic=global OR Topic=AOGCM OR Topic=regional OR Topic=RCM OR Topic=GCM ORTopic=RMIP))) OR (Topic=climat*-chang* And (Topic=skil*-develop* ORTopic=training OR Topic=human-resource* ORTopic=awareness)) OR (Topic=climat*-chang* And (Topic=database OR(Topic=Oceans OR Topic=Cryosphere OR Topic=Meteorology OR Topic=Precipitation OR Topic=Humidity OR Topic=Topography OR Topic=Erosion OR Topic=Imagery OR Topic=Hydrological OR Topic=Agriculture OR Topic=cultivation OR Topic=Production OR Topic=yield OR Topic=Socio-Economic OR Topic=Demography OR Topic=Forest* OR Topic=Plant* OR Topic=animal* OR Topic=species))))	3106
(Topic=climat*-chang* And Topic=monsoon-dynamic*)	2
(Topic=climat*-chang* And Topic=aerosol)	16

(Topic=climat*-chang* And Topic=ecosystem-response*)	2
(Topic=climat*-chang* And Topic=hydrological-cycle*)	23
(Topic=climat*-chang* And Topic=research-infrastruc*)	1
(Topic=climat*-chang* And Topic=projection*)	127
(Topic=climat*-chang* And Topic=projected)	210
(Topic=climat*-chang* And Topic=compution*)	0
(Topic=climat*-chang* And Topic=observation-network)	1
(Topic=climat*-chang* And (Topic=data And (Topic=gather*OR Topic=assimialation* OR Topic=access* ORTopic=availab* OR Topic=resource*)))	322
(Topic=climat*-chang* And (Topic=model* And (Topic=IPCCOR Topic=India* OR Topic=global OR Topic=AOGCM OR Topic=regional OR Topic=RCM OR Topic=GCM ORTopic=RMIP)))	458
(Topic=climat*-chang* And (Topic=skil*-develop* ORTopic=training OR Topic=human-resource* ORTopic=awareness))	232
(Topic=climat*-chang* And (Topic=database OR(Topic=Oceans OR Topic=Cryosphere ORTopic=Meteorology OR Topic=Precipitation ORTopic=Humidity OR Topic=Topography OR Topic=ErosionOR Topic=Imagery OR Topic=Hydrological ORTopic=Agriculture OR Topic=cultivation ORTopic=Production OR Topic=yield OR Topic=Socio-Economic OR Topic=Demography OR Topic=Forest* ORTopic=Plant* OR Topic=animal* OR Topic=species)))	2767

3.4.2. Comparative quantification of total global and Indian publications

The total publication data was retrieved from the Web of Science, Scopus, and Indian Citation Index using the above-mentioned search-srtings of different National Missions. The year-wise growth of the number of total global and Indian publications related to different National Missions was graphically presented along with the total Global and Indian comparative contribution in the top 30 research areas. Besides, Indian publication contribution in the top 30 research areas before and after the adoption of the missions was also analysed.

3.4.3. The quantitative evaluation of research themes and research topics

The thematic evolution of the different missions from before the mission to the after the mission research was studied using Science Mapping Analysis Software Tool (SciMAT) (Cobo et al., 2011,2012) from the Web of Science database. Cluster's information of strategic maps was represented in tabular form by giving their centrality, density, document counts, document h-index and document citations for different periods to understand the thematic evolution. The cluster network processing parameters were applied as follows: 1) the minimum document frequencies were set at successive periods as 3,4; 2) co-occurrence was selected as the matrix preference; 3) the minimum co-occurrence frequencies were set at successive periods as 2,3; 4) the equivalence index was chosen as the normalization measure; 5) the simple centres clustering algorithm (Cobo et al., 2011,2012) was used with a maximum network size of 14 and a minimum network size of 5; 6) both the core and the secondary mappers were selected; 7) the h-index and the sum citation evaluative measures were selected for node display; and 8) Jaccard's index (Hamers et al., 1989) and the inclusion index (Tijssen et al., 1989) were chosen as measures for longitudinal and overlap mapping. The comparative thematic evolutions of Indian research are shown through an overlapping map.

Thematic evolution was represented through strategic diagrams at successive periods. Themes were plotted as circles denoting different theme clusters according to centrality and density in strategic diagrams. The size of the circle is proportional to the number of documents and referred to as document frequency (DF) in which it's linked or related keywords are present. The strategic diagrams are divided into four quadrants and they can be interpreted as follows: the top-right quadrant represents "motor themes", the top-left quadrant represents "highly developed and isolated themes", the bottom-left quadrant represents "emerging or declining themes", the bottom-right quadrant represents "basic and transversal themes".

3.5. Evolving trends analysis of research area and research topic

3.5.1 Comparative Evolving trend analysis of research area

Period-wise growth of the number of the research area of total global publications on "Climate Change" was graphically presented along with the period-wise growth of the number of the research area during different periods of top 20 countries. The total, as well as periodical Global and Indian comparative contribution in the top 30 research areas was also analysed and represented graphically with their Compound period-wise growth (CPGR).

The year-wise growth of the number of total global and Indian publications related to different National Missions was graphically presented along with the total Global and Indian comparative contribution in the top 30 research areas. Besides, Indian publication contribution in the top 30 research areas before and after the adoption of the missions was also analysed. The number of publications contributed by top 20 individual countries in top 30 individual research areas of total global climate change research during the successive periods (1985-2019) was analysed and the rank of India in the individual research area among the top 20 countries was identified and represented through tables.

3.5.2 The quantitative evaluation of research themes and research topics of Indian publications

The thematic evolution of Indian total climate change research was studied using Science Mapping Analysis Software Tool (SciMAT) (Cobo et al., 2011,2012) from the Web of Science database which provides a temporal or longitudinal analysis. As mentioned before, the total 35 years' time span was further divided into seven periods of five years each to understand the thematic evolution of the climate change research front of India at successive periods. Themes were operationally defined and labeled based on keyword clusters derived from co-word analyses. Cluster's information of strategic maps was represented in tabular form by giving their centrality, density, document counts, document h-index and document citations for different periods to understand the thematic evolution. The cluster network processing parameters were applied as follows: 1) the minimum document frequencies were set at successive periods as 0, 1, 2, 3, 4, 5, 6; 2) co-occurrence was selected as the matrix preference; 3) the minimum co-occurrence frequencies were set at successive periods as 0, 1, 2, 3, 4, 5; 4) the equivalence index was chosen as the normalization measure; 5) the simple centres clustering algorithm (Cobo et al., 2011, 2012) was used with a maximum network size of 12 and a minimum network size of 3; 6) both the core and the secondary mappers were selected; 7) the h-index and the sum citation evaluative measures were selected for node display; and 8) Jaccard's index (Hamers et al., 1989) and the inclusion index (Tijssen et al., 1989) were chosen as measures for longitudinal and overlap mapping. The comparative thematic evolutions of Indian research are shown through an overlapping map.

Thematic evolution was represented through strategic diagrams at successive periods. Themes were plotted as circles denoting different theme clusters according to centrality and density in strategic diagrams. The size of the circle is proportional to the number of documents and referred to as document frequency (DF) in which it's linked or related keywords are present. The strategic diagrams are divided into four quadrants and they can be interpreted as follows: the top-right quadrant represents "motor themes", the top-left quadrant represents "highly developed and isolated themes", the bottom-left quadrant represents "emerging or declining themes", the bottom-right quadrant represents "basic and transversal themes".

3.6. Inter-relationship study among the carried-out research topics and Country-specific socio-economic & environmental parameters

Share of global cumulative CO_2 emissions (%), CO_2 emissions (metric tons per capita, of top 20 countries) and Publication share % data of top 20 countries based on publications data (Scopus) were taken from University of OXFORD, 2017, the World Bank, 2014, and Scopus and Web of Science database respectively. Accordingly, these results were interpreted. Besides total Greenhouse gas emission % change from 1990 (The World Bank, 2012) and the inter-relationship of CO_2 emission (Our World in Data based on Global Carbon Project, 2020) and GDP current prices (2018) in billions of US dollars (International Monetary Fund,2018) was studied and explained. The GERD data of the top 20 countries were retrieved from the World Bank,2015, and its interrelation with the publication share of those countries was interpreted. Comparative analysis of electricity production from coal sources and fossil fuel energy Consumption of top 20 countries also analysed from the World Bank, 2015 along with the % renewable energy Consumption of top 20 countries. The comparative data of the land area and forest cover of the top 20 countries were collected from the World Bank, 2016 and represented graphically.

The total global patent publications were recorded from World Intellectual Property Organization (WIPO) on 31.03.2021 using the search string which was used to retrieve the publication data from the Web of Science and Scopus. Then a comparative analysis of the number of patent publications and number of global and Indian research publications on climate change from WoS and Scopus were performed. The top 20 countries were identified based on the number of patent publications and their correlation with the number of publications from the Web of Science and Scopus during 1985-2019 were identified.

Alongside, the patent data was also collected from WIPO GREEN. WIPO GREEN is an online technology sharing site. It aids global efforts to combat climate change by linking environmentally friendly technology providers and seekers. It brings together key players to catalyse green technology progress and diffusion through its database, network, and acceleration projects. The top 30 countries were identified based on the number of patents index in this database and their contributions in different sectors were represented in tabular form.

Chapter 4:

Detailed analysis of the Data

4.1. Period-wise evolving trends analysis of research productivity and contributions by different bibliometric parameters of India and other countries:

The publication data on “Climate Change” has been retrieved from the “Web of Science” and “Scopus” database from 1985 to 2019 using the following search string. Similar combinations of keywords have been used to prepare search strings for both the Web of Science and Scopus databases with their specific Boolean operators and parentheses.

TS=("climat* variab*" OR "variab* climat*" OR "climat* chang*" OR "chang* climat*" OR "warm* climat*" OR "climat* warm*" OR "global warm*" OR "global climat*" OR (warm* AND earth) OR (warm* AND planet) OR "future climat*" OR "recent Climat*" OR "present Climat*" OR "past climat*" OR "greenhouse gas" OR IPCC OR "Montreal protocol" OR "Paris agreement" OR "Kyoto protocol" OR "Copenhagen meeting" OR GOSAT OR UNFCCC OR GHG OR "climat* model" OR "climat* oscillat*" OR "climat* fluctuat*" OR "fluctuat* climat*" OR "climat* polic*" OR "climat* stress" OR "project* climat*" OR "climat* resilien*" OR "climat* vulnerable" OR "climat* feedback" OR "climat* predict" OR "climat* project*" OR “greenhouse effect” OR (climat* AND (CO2 OR impact OR ((shrink* OR retreat* OR decreas* OR declin* OR melt*) AND ("ice sheet" OR *glacia* OR "snow cover" OR "ice cap" OR "sea ice" OR "polar ice" OR "antarctic ice" OR "arctic ice")) OR "average temperature" OR "mean temperature" OR "sea level" OR (warm* AND ocean) OR "air temperature" OR "global temperature" OR "global cool*" OR "solar power" OR "meta-analysis" OR "green technology" OR "conventional energy" OR "heat wave" OR "energy efficiency" OR "renewable energy" OR ozone OR O3 OR "Nitrogen input" OR "solar energy" OR biodiversity OR uncertainty OR "ocean acidification" OR "atmospheric circulation" OR "environmental change" OR "species richness" OR "El nino" OR "sustainable development" OR anthropogenic OR disturbance OR "extreme events" OR agricultur* OR (chang* AND predict*) OR eutrophication OR "ground water" OR (global AND pattern*) OR "energy polic*" OR "energy performance" OR "carbon stock" OR methane OR NO2 OR carbon* OR "nitrous oxide" OR mitigat* OR warm* OR global OR "species diversity" OR "species abundance" OR "crop production" OR "fish production" OR volcan* OR disease OR "clean energy" OR "green energy" OR "temperature rise" OR shift*)))

4.1.1. Analysis from Web of Science database

4.1.1.1. Growth of total global publications and publications by top 30 countries

Using the final search string a total of 4,66,426 publications were retrieved globally from the Web of Science (WoS) database. The compound annual growth rate was 18.77 %. Figure 4.1.1.1 shows the year-wise number of publications from WoS. Publications considered for analysis are in the form of various reviews, articles, and editorial materials, papers presented at meetings and conferences, etc. which were contributed by more than 232 countries or regions. The total number of publications were increased from 808 during the initial period (1985-1989) to 205135 during the last period (2015-2019) with a compound period-wise growth rate (CPGR) of 151.63 % (Figure 4.1.1.2).

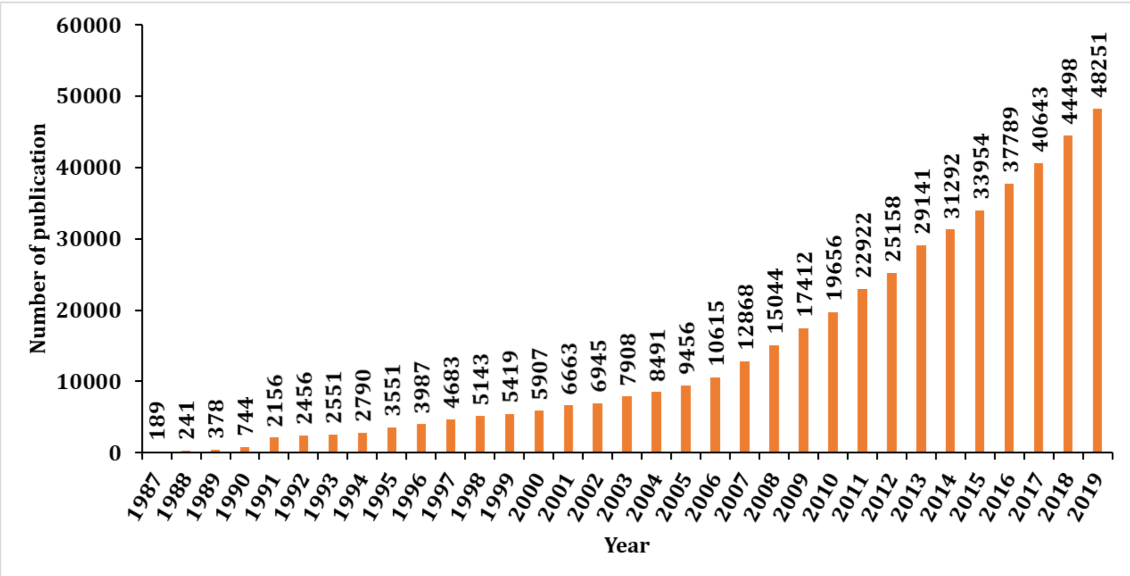


Figure 4.1.1.1: Year-wise number of total global publications.

The total number of countries or regions involved in the climate change research was increased from 48 during the initial period (1985-1989) to 218 during the last period (2015-2019) with a compound period-wise growth rate (CPGR) of 28.69 % (Figure 4.1.1.3). Among the 232 countries or regions of the total global publications, the top 30 countries contributed about 87.22% (normalized) and the top 20 countries contributed about 79% (normalised) of the total global publications (Figure 4.1.1.4). Among the top 20 countries, 7 countries contributed more than the group average (28348.05 papers). India held 13th rank by contributing 14532 publications i.e., 2 % (normalised) of the total global publications.

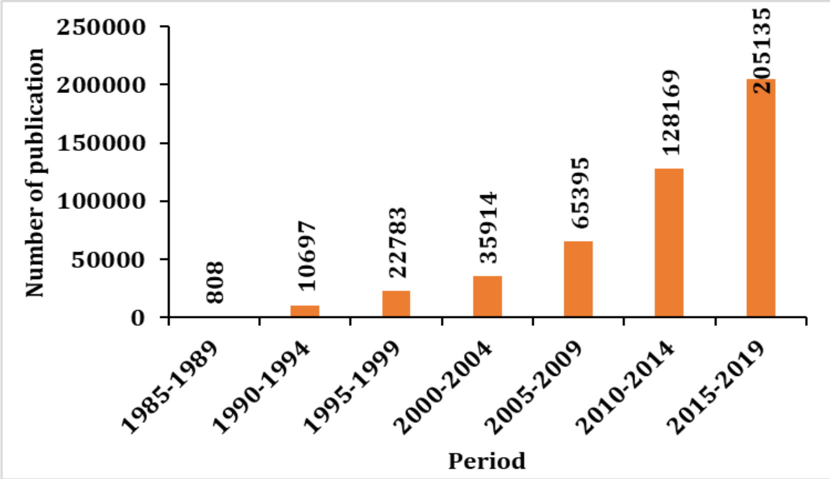


Figure 4.1.1.2: Number of total global publications during different periods.

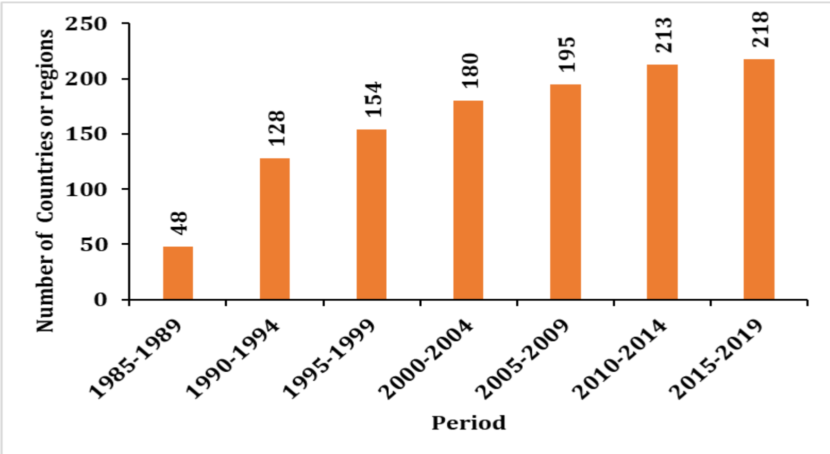


Figure 4.1.1.3: Total number of countries of publications during different periods.

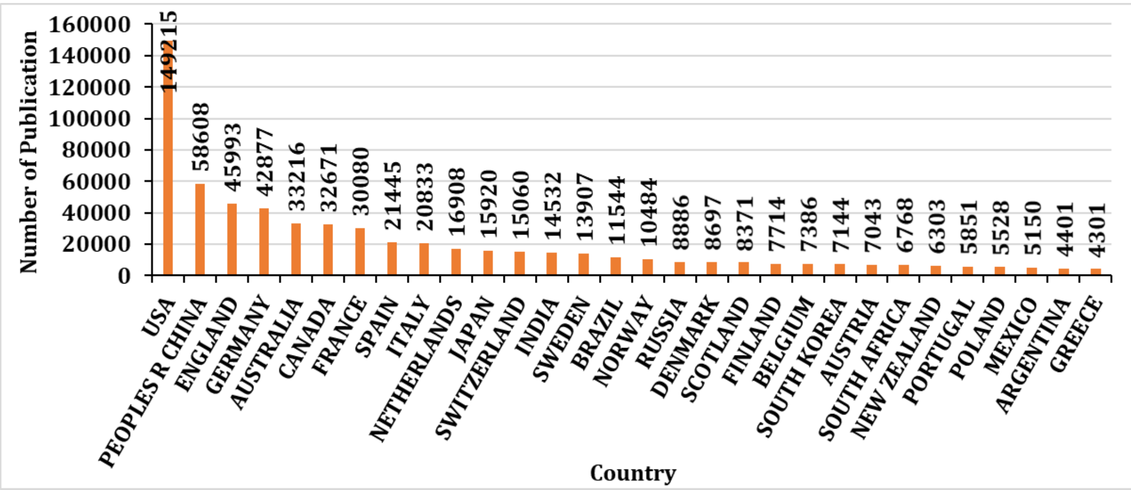


Figure 4.1.1.4: Number of total publications by top 30 countries

4.1.1.2. Period-wise growth of the number of publications of top 20 countries

4.1.1.2.1. Five year's Period-wise growth of the number of Publications of top 20 countries

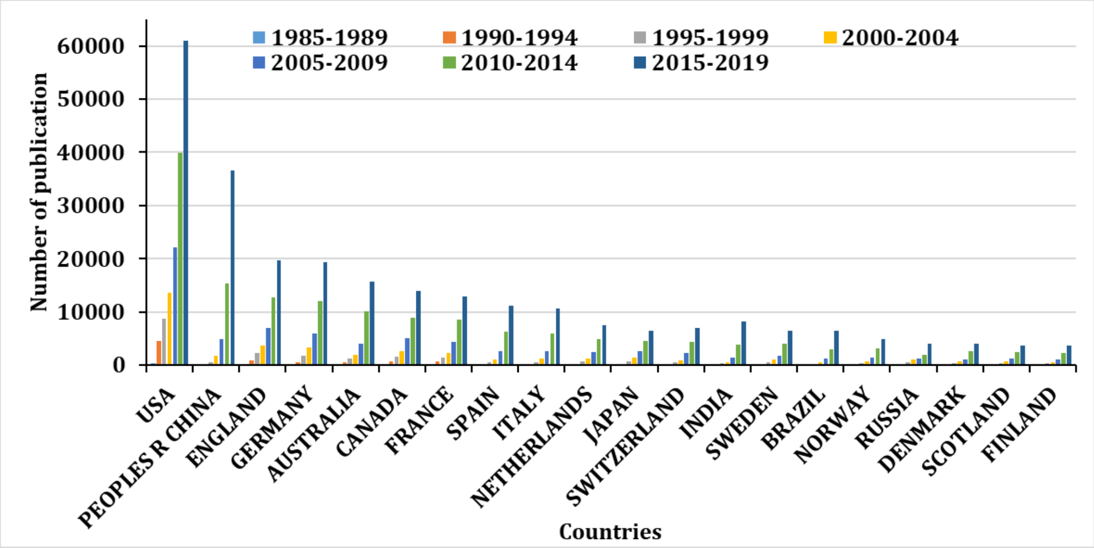


Figure 4.1.1.5: Number of publications during different periods by top 20 countries

Table 4.1.1.1: Average number of publications by the top 20 countries, number of countries having more publications than the group average number of publications among the top 20 countries, India's rank and name of the top countries during different periods.

	Periods						
	1985-1989	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014	2015-2019
Group average number of publications of the top 20 countries	32.3	489.55	1167.75	2017.65	3818.9	7824.75	13157.1
Number of countries having more publications than the group average	3	6	6	5	7	7	6
India's Rank	9	10	15	18	14	14	10
Group Top	USA	USA	USA	USA	USA	USA	USA
Indian publications	11	194	387	576	1439	3883	8140

Figure 4.1.1.5 exhibits the period-wise publications by the top 20 countries. Average publications of the top 20 countries were increased from 32.30 during the initial period (1985-1989) to 13157.1 during the last period (2015-2019) with a compound period-wise growth rate (CPGR) of 172.26 % (Table 4.1.1.1).

The USA ranked the 1st throughout the periods. Six countries have contributed more than the group average publications during the last periods and India secured 10th position (Table 4.1.1.1) by contributing 8140 publications during the last period (Figure 4.1.1.6). Nine countries having more CPGR than the group's average CPGR and India's rank was 13th with a CPGR of 200.74% (Figure 4.1.1.7).

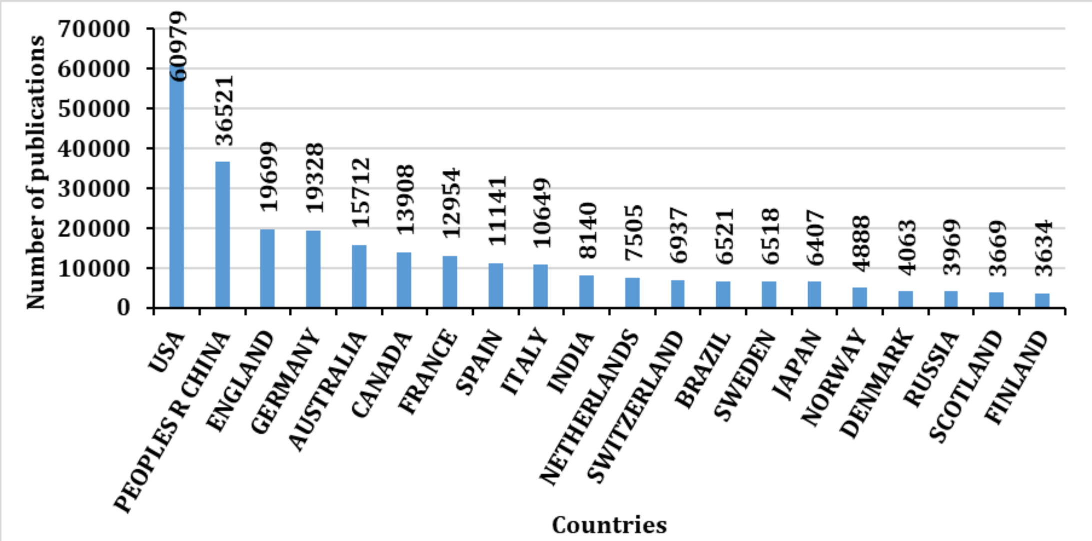


Figure 4.1.1.6: Publication numbers of top 20 countries during last period (2015-2019)

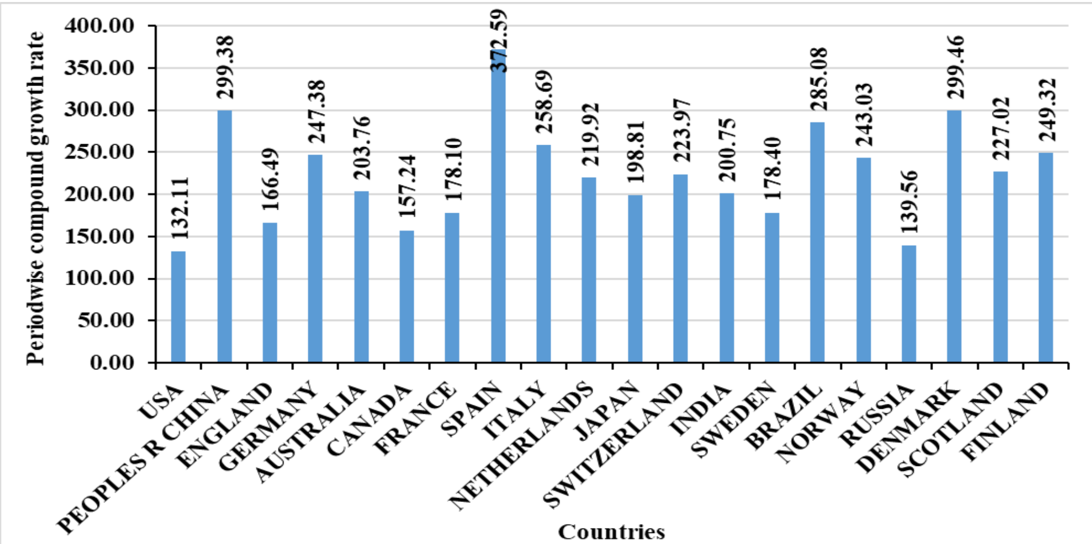


Figure 4.1.1.7: Compound period-wise growth rate (CPGR) of publication numbers of top 20 countries

4.1.1.2.2. Ten year's period-wise growth of the number of Publications of top 20 countries

Total global publications were increased from 33622 during 1990-1999 to 331755 during 2010-2019 with a growth rate of 214.12 % (Figure 4.1.1.8). Figure 4.1.1.9exhibits the period-wise publications by the top 20 countries. Average publications of the top 20 countries were increased from 1663.7 during the initial period (1990-1999) to 20905.1 during the last period (2010-2019) with a compound period-wise growth rate (CPGR) of 254.54 % (Table 4.1.1.2). The USA ranked the 1st throughout the periods. Seven countries have contributed more than the group average publications during the last periods and India secured 11th position (Table4.1.1.2) by contributing 12290 publications during the last period (Figure 4.1.1.10). Seven countries having more CPGR than the group's average CPGR and India's rank was 5th with a CPGR of 175.03% (Figure 4.1.1.11).

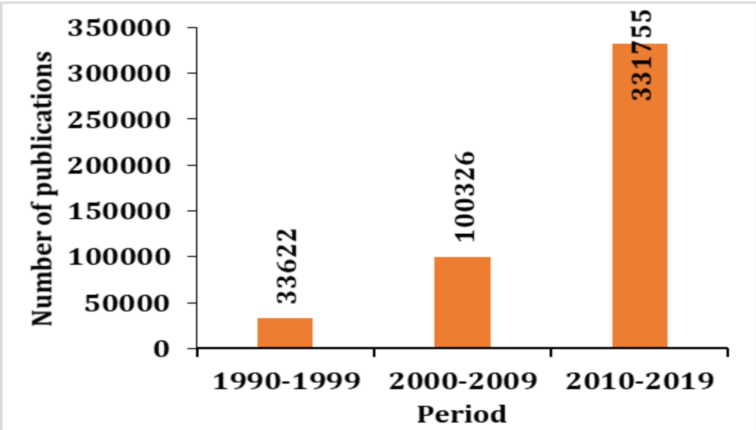


Figure 4.1.1.8: Number of total global publications during different ten-year periods.

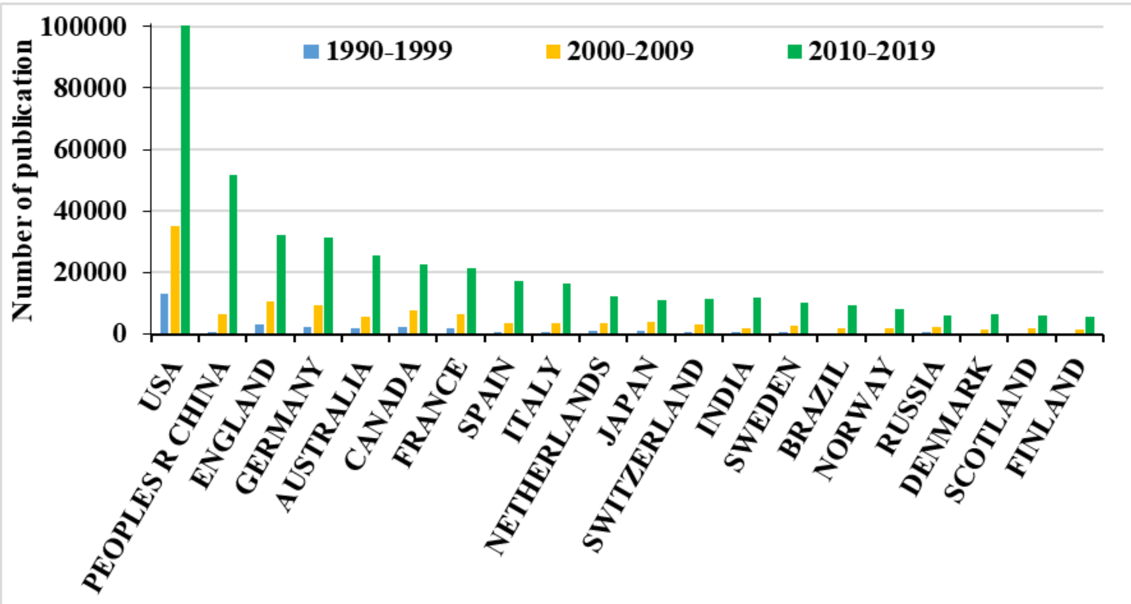


Figure 4.1.1.9: Number of publications during different ten year's periods by top 20 countries

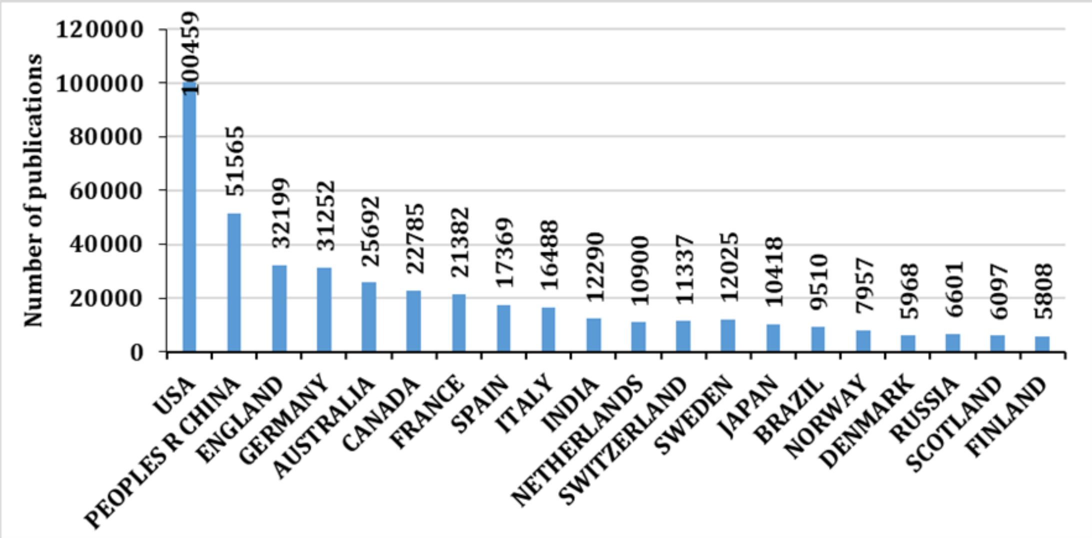


Figure 4.1.1.10: Publication numbers of top 20 countries during last period (2010-2019)

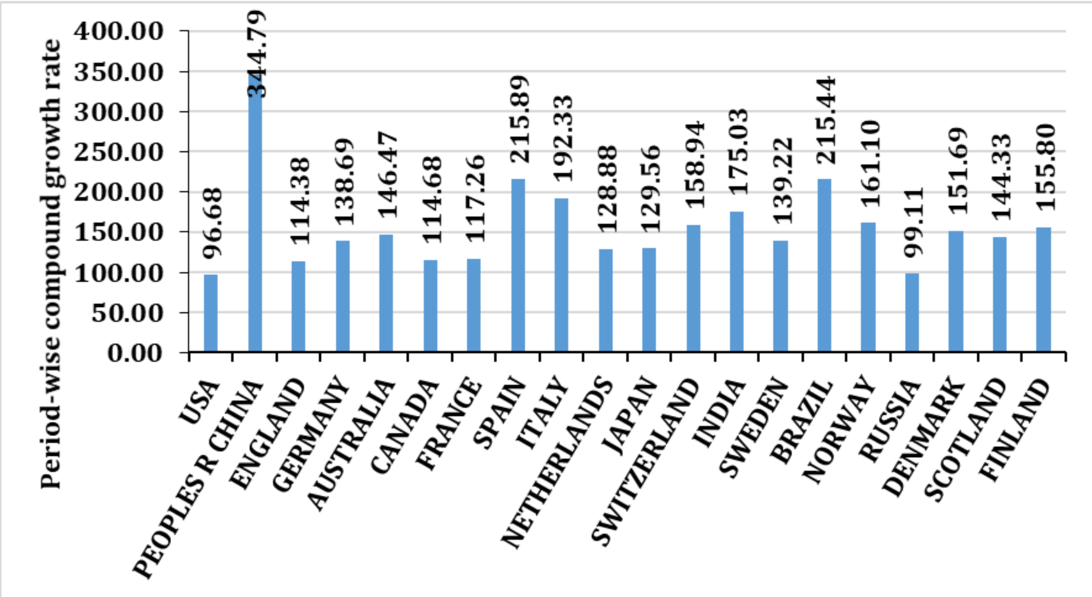


Figure 4.1.1.11: Compound ten year's period-wise growth rate (CPGR) of publication numbers of top 20 countries

Table 4.1.1.2: Average number of publications by the top 20 countries, number of countries having more publications than the group average number of publications among the top 20 countries, India's rank and name of the top countries during different ten year's periods.

	Periods		
	1990-1999	2000-2009	2010-2019
Group average number of publications of the top 20 countries	1663.7	5778.65	20905.1
Number of countries having more publications	6	7	7

than the group average			
India's Rank	14	16	11
Group Top	USA	USA	USA
Indian publications	578	1979	12290

4.1.1.3. Period-wise growth of organization numbers of top 20 countries

4.1.1.3.1. Five year's period-wise growth of organization numbers of top 20 countries

The total number of organizations involved in the climate change research was increased from 453 during the initial period (1985-1989) to 55637 during the last period (2015-2019) with a compound period-wise growth rate (CPGR) of 122.95 % (Figure 4.1.1.12). Figure 4.1.1.13 exhibits the period-wise number of organizations involved in climate change research by the top 20 countries. The average number of organizations from the top 20 countries were increased from 29.45 during the initial period (1985-1989) to 9245.35 during the last period (2015-2019) with a compound period-wise growth rate (CPGR) of 160.69 % (Table 4.1.1.3). The USA ranked the 1st throughout the periods. Organizations from nine countries have involved more than the group average publications during the last periods and India ranked 15th position (Table 4.1.1.3) by involving 6588 organizations during the last period (Figure 4.1.1.13).

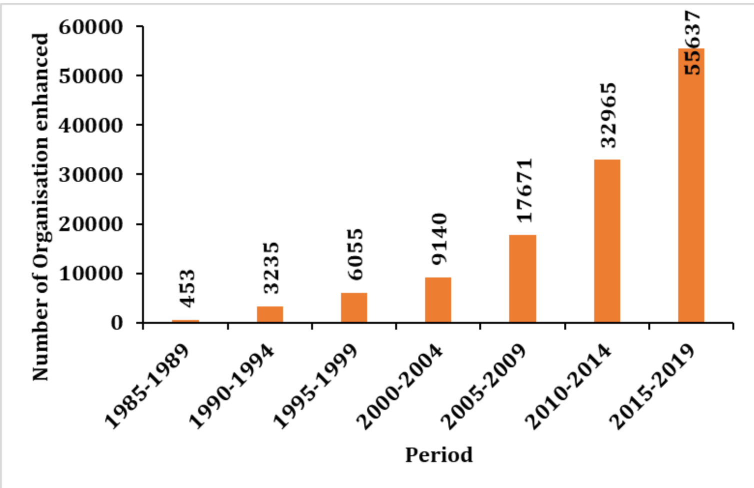


Figure 4.1.1.12: Global total number of organizations during different five year's periods

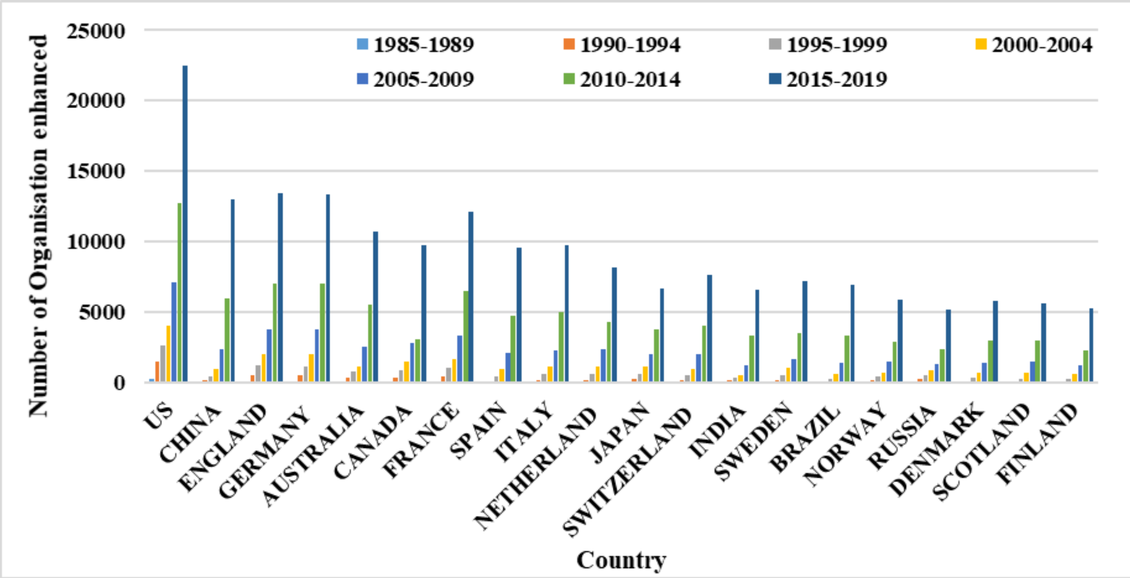


Figure 4.1.1.13: Number of organizations involved during different five year's periods from top 20 countries

Table 4.1.1.3: Average number of organizations involved from top 20 countries, number of countries having more organizations than the group average, India's rank based on the number of organizations and name of the top countries during different five year's periods.

	Periods						
	1985-1989	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014	2015-2019
Group average number of organizations of the top 20 countries	**29.45**	**287.2**	**701.9**	**1235.9**	**2382.8**	**4676.55**	**9254.35**
Number of countries having more organizations than the group average	**4**	**6**	**6**	**5**	**7**	**8**	**9**
India's Rank	**9**	**15**	**17**	**20**	**20**	**13**	**15**
Group Top	**USA**	**USA**	**USA**	**USA**	**USA**	**USA**	**USA**
Number of organizations from India	14	138	330	546	1226	3372	6588

4.1.1.3.2. 10 year's Period-wise growth of organization numbers of top 20 countries

The total number of organizations involved in the climate change research was increased from 7597 during the initial period (1990-1999) to 74053 during the last period (2010-2019) with a compound period-wise growth rate (CPGR) of 212.21 % (Figure 4.1.1.14). Figure 4.1.1.15exhibits the period-wise number of organizations involved in climate change research by the top 20 countries. The average number of organizations from the top 20 countries were increased from 833.7 during the initial period (1990-1999) to 11208.55 during the last period (2010-2019) with a CPGR of 266.66 % (Table 4.1.1.4). The number of organizations of Indian publication increased with a CPGR of 342.07 % which is quite higher than the CPGR of the total as well as top 20 countries. The maximum number of organizations were involved from the USA throughout the periods. Organizations from nine countries have involved more than the group average publications during the last periods and India ranked 15th position (Table 4.1.1.4) by involving 7915 organizations during the last period (Figure 4.1.1.15).

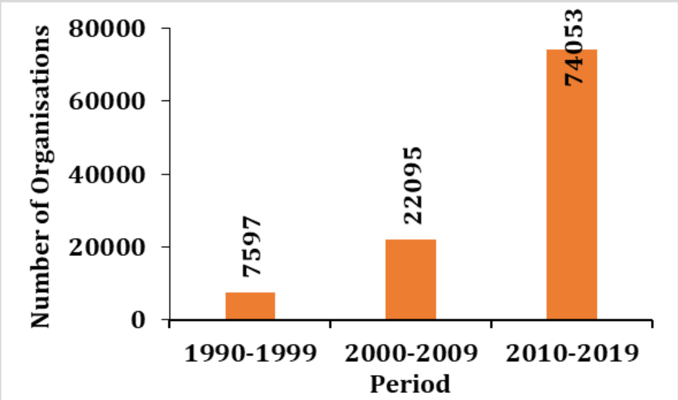


Figure 4.1.1.14: Global total number of organizations during different ten-year periods.

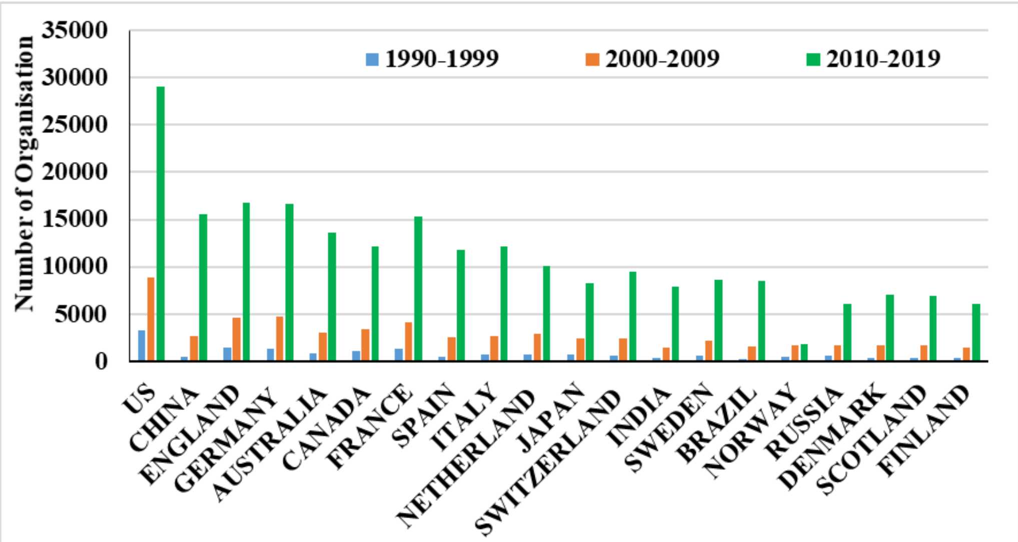


Figure 4.1.1.15: Number of organizations involved during different ten year's periods from top 20 countries

Table 4.1.1.4: Average number of organizations involved from top 20 countries, number of countries having more organizations than the group average, India's rank based on the number of organizations and name of the top countries during different periods.

	Periods		
	1990-1999	2000-2009	2010-2019
Group average number of organizations of the top 20 countries	833.7	2888.1	11208.55
Number of countries having more organizations than the group average	6	6	9
India's Rank	16	20	15
Group Top	USA	USA	USA
Number of organizations from India	405	1442	7915

4.1.1.4. Global and Indian top organizations

Among the total 89237 global organizations, the top 30 organizations contributed 15.44% of the total global publications. The top 100 organizations contributed 30.02 % of the total global publications. Among the global top 30 and top 100 organizations, there are no Indian organizations. Top 500 organizations contributed 60.31 % of the total global publications. Eleven countries have no organization in the top 30 (Figure 4.1.1.16) and 4 countries have no organization in the top 100 organization's list (Table 4.1.1.5).

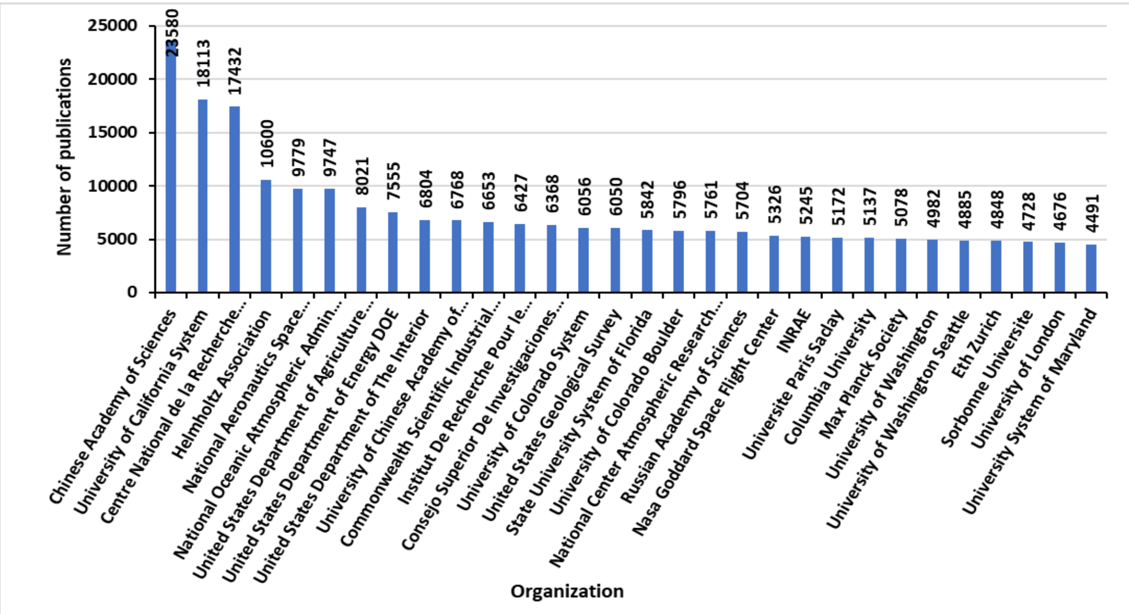


Figure 4.1.1.16: Number of publications by top 30 organizations of the total global publications

There are only nine organizations from India in the top 500 organization's list namely Indian Institute Of Technology System IIT System (Rank-109), Indian Council of Agricultural Research ICAR (Rank-169), Ministry of Earth Sciences MOES India (Rank-218), Department of Space DOS Government of India (Rank-258), Council of Scientific Industrial Research CSIR India (Rank-285), Department of Science Technology India (Rank-395), Indian Institute of Tropical Meteorology IITM (Rank-407), Indian Space Research Organisation ISRO (Rank-432), Indian Institute of Science IISC Bangalore (Rank-467). Figure 4.1.1.16 and 4.1.1.17representing the publications contributions by the top 30 global and top 30 Indian organizations respectively.

Table 4.1.1.5: Number of organizations from different countries in top 30 and top 100 organization's list of total global publications

Rank	Country	No. of Organizations among top 30 organizations	No. of Organizations among top 100 organizations
1	USA	15	48
2	CHINA	2	5
3	ENGLAND	2	10
4	GERMANY	2	3
5	AUSTRALIA	1	5
6	CANADA	0	4
7	FRANCE	5	10
8	SPAIN	1	1
9	ITALY	0	1
10	NETHERLAND	0	2
11	JAPAN	0	1
12	SWITZERLAND	1	2
13	SWEDEN	0	3
14	INDIA	0	0
15	BRAZIL	0	0
16	NORWAY	0	0
17	RUSSIA	1	1
18	DENMARK	0	2
19	SCOTLAND	0	0
20	FINLAND	0	1

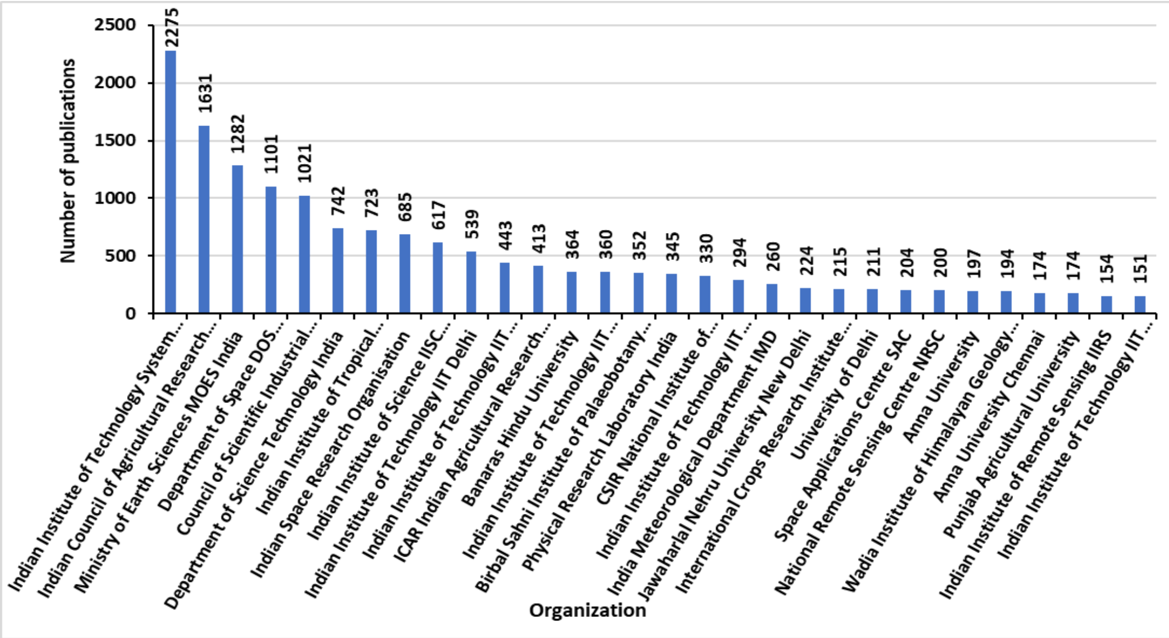


Figure 4.1.1.17: Number of publications by top 30 organizations of the total Indian publications

4.1.1.5. Period-wise growth of Number of Authors by top 20 countries

4.1.1.5.1. Five year's period-wise growth of the number of authors by top 20 countries

Figure 4.1.1.18shows the period-wise number of authors involved in the climate change research by the top 20 countries. The average number of authors from the top 20 countries were increased from 58.35 during the initial period (1985-1989) to 43760.9 during the last period (2015-2019) with a CPGR of 201.42 % (Table 4.1.1.6). The highest number of authors were performed their research from the USA throughout the periods. Author's numbers from nine countries were involved more than the group average author's numbers during last periods and India ranked 16th position (Table 4.1.1.6) by involving 24689 authors during the last period with a CPGR of 243.61 % (Figure 4.1.1.18). The period-wise average number of authors per publication from the top 20 countries was increased at successive periods. A similar trend was also observed in the case of India but the average author's numbers per publication were lower than that of the global average during different periods except during 1990-1994 (Table 4.1.1.6).

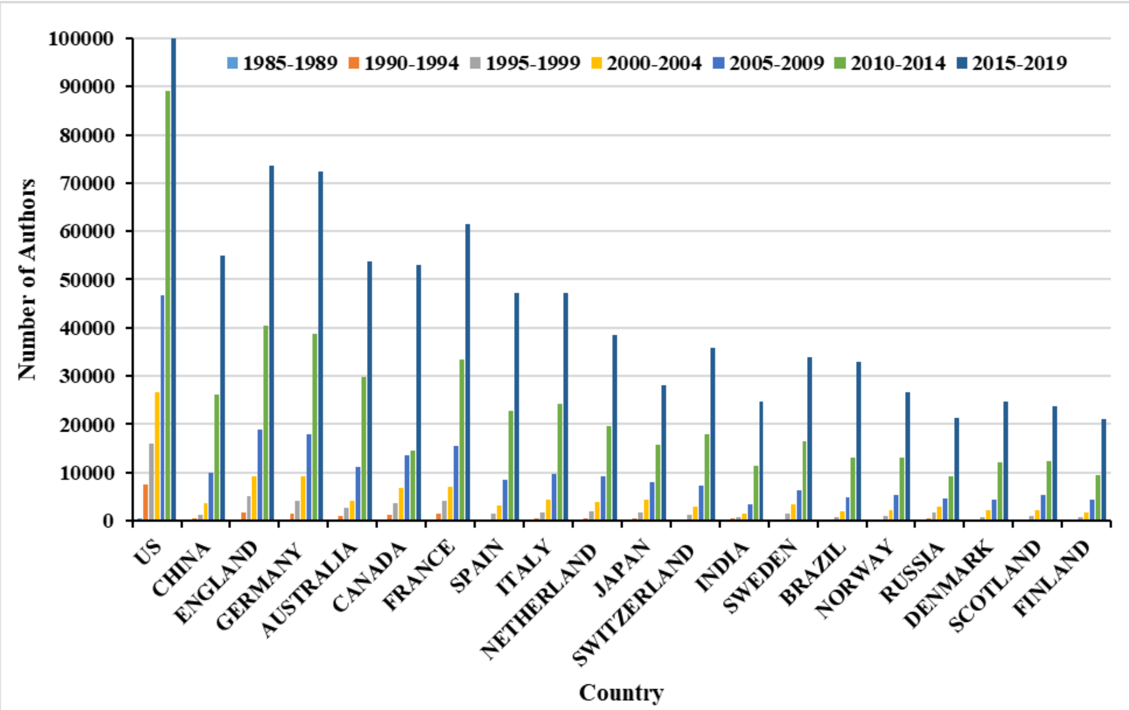


Figure 4.1.1.18: Number of authors involved during different periods from top 20 countries

Table 4.1.1.6: Average number of authors involved from top 20 countries, number of countries having more authors than the average number of authors involved among the top 20 countries, India's rank based on the participation of authors and name of the top countries during different five year's periods.

	Periods						
	1985-1989	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014	2015-2019
Group average number of Authors from the top 20 countries	58.35	969.4	2689.45	5176.6	10743.2	23480.2	43760.9
Number of countries having more authors than the group average	4	6	6	5	6	7	9
India's Rank	12	11	18	20	20	18	16
Number of authors from India	15	404	779	1399	3494	11449	24698
Group Top	USA	USA	USA	USA	USA	USA	USA
Average number of authors per publications from the top 20 countries	1.81	1.98	2.30	2.57	2.81	3.00	3.32
Average number of authors per publications from India	1.36	2.08	2.01	2.43	2.43	2.95	3.03

4.1.1.5.2. Ten year's period-wise growth of Number of Authors by top 20 countries

Figure 4.1.1.19shows the period-wise number of authors involved in the climate change research by the top 20 countries. The average number of authors from the top 20 countries were increased from 3369.5 during the initial period (1990-1999) to 55020.6 during the last period (2010-2019) with a CPGR of 304.09 % (Table **4.1.1.7**). The USA ranked the 1st throughout the periods. Author's numbers from nine countries have involved more than the group average author's numbers during last periods and India ranked 18th position (Table **4.1.1.7**) by involving 31671 authors during the last period with a CPGR of 432.71 % (Figure **4.1.1.19**).

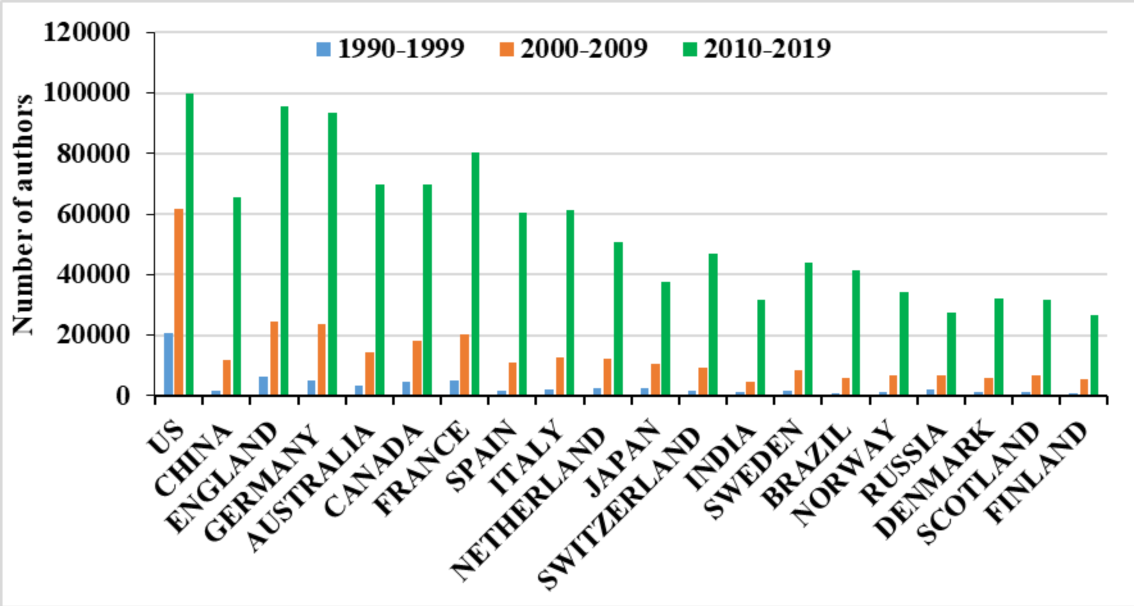


Figure 4.1.1.19: Number of authors involved during different periods from top 20 countries

Table 4.1.1.7: Average number of authors involved from top 20 countries, number of countries having more authors than the average number of authors involved among the top 20 countries, India's rank based on the participation of authors and name of the top countries during different ten year's periods.

	Periods		
	1990-1999	2000-2009	2010-2019
Group average number of Authors from the top 20 countries	3369.5	14016.75	55020.6
Number of countries having more authors than the group average	6	6	9
India's Rank	17	20	18
Group Top	USA	USA	USA
Number of authors from India	1116	4453	31671
The average number of authors per publications from India	1.93	2.25	2.58

4.1.1.6. Period-wise growth of Funded Research by top 20 countries

4.1.1.6.1. Five year's Period-wise growth of Funded Research by top 20 countries

Figure 4.1.1.20shows the period-wise number of the global total number of funded researches in climate change. It has been observed that the funding information was not available for most of the publications during 1985-2009 as this field was not mandatory to be provided during publication communications. During the last two periods number of funded research publications were increased from 223165 to 370060 with a growth rate of 65.82 %. For the same period, the growth rate of Indian-funded research was 336.82 %. Figure 4.1.1.21shows the period-wise number of funded researches the climate change research by the top 20 countries. The average number of funded researches by the top 20 countries were increased from 13.15 during the initial period (1985-1989) to 35495.55 during the last period (2015-2019) with a CPGR of 273.14 % (Table 4.1.1.8). The USA ranked the 1st throughout the periods. The number of funded researches from seven countries has involved more than the group average number of funded researches during last periods and India ranked 20th position (Table 4.1.1.8) by funding 9846 pieces of research during the last period (Figure 4.1.1.21).

Table 4.1.1.8: Average number of funded researches from top 20 countries, number of countries having more funded researches than the average number of funded researches among the top 20 countries, India's rank based on the number of funded researches and name of the top countries during different five year's periods.

	Periods						
	1985-1989	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014	2015-2019
Group average number of funded researches from the top 20 countries	13.15	12.65	8.1	44.05	2451.5	16247.9	35495.55
Number of countries having more funded researches than the group average	3	3	4	2	6	6	7
India's Rank	14(0)	17(0)	12(2)	17	20	19	20
Group Top	USA	USA	USA	USA	USA	USA	USA
Number of funded researches from India	0	0	2	10	433	2254	9846

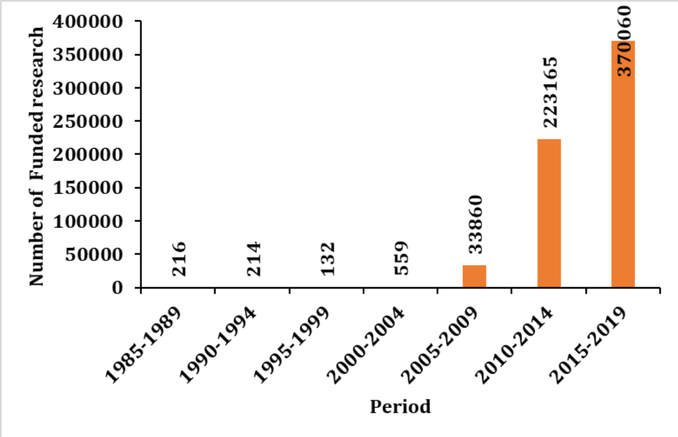


Figure 4.1.1.20: Global total number of funded researches during different five year's periods

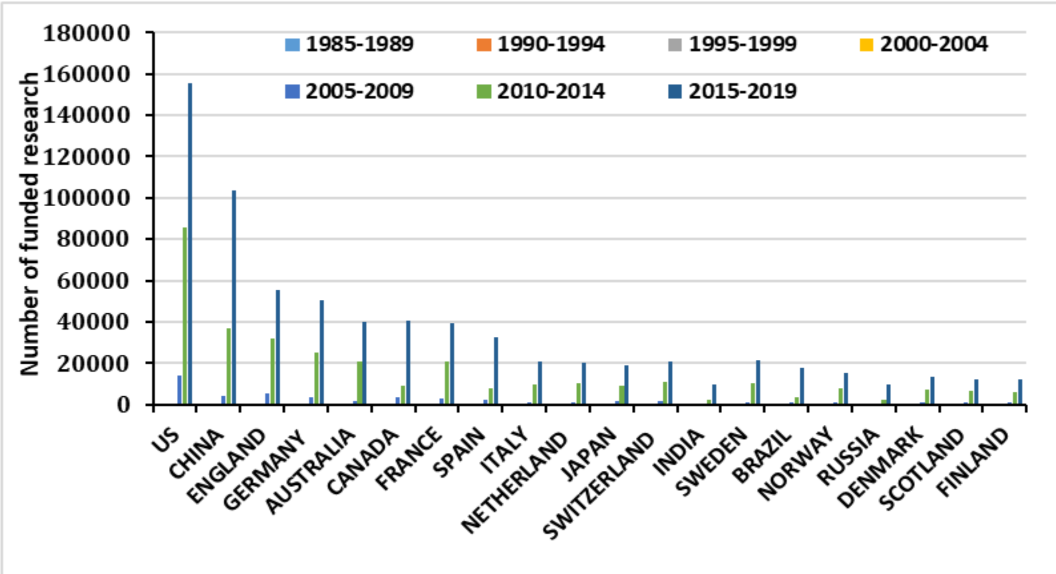


Figure 4.1.1.21: Number of funded researches during different five year's periods from top 20 countries

4.1.1.6.2. Ten year's period-wise growth of Funded Research by top 20 countries

Figure 4.1.1.22shows the period-wise number of the global total number of funded researches in climate change. It has been observed that the funding information was not available for most of the publications during 1990-2009 as this field was not mandatory to be provided during publication communications. During the last period, 534766 funded research publications were recorded. Figure 4.1.1.23shows the period-wise number of funded researches the climate change research by the top 20 countries. The average number of funded researches by the top 20 countries were increased from 27.35 during the initial period (1990-1999) to 52804.9 during the last period (2010-2019) (Table 4.1.1.9). The USA ranked the 1st throughout the periods. The number of funded researches from seven countries has involved more than the group average number of funded researches during last periods and India ranked 20th position (Table 4.1.1.9) by funding 13543 pieces of research during the last period (Figure 4.1.1.23).

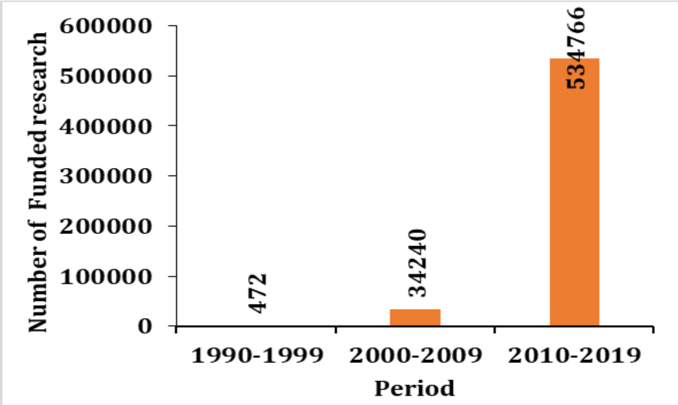


Figure 4.1.1.22: Global total number of funded researches during different ten year's periods

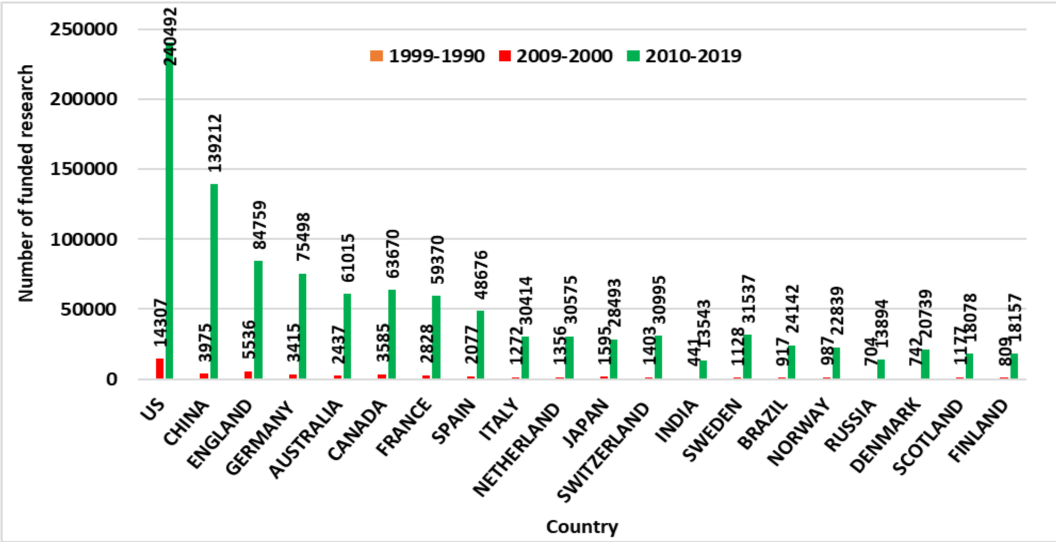


Figure 4.1.1.23: Number of funded researches during different ten year's periods from top 20 countries

Table 4.1.1.9: Average number of funded researches from top 20 countries, number of countries having more funded researches than the average number of funded researches among the top 20 countries, India's rank based on the number of funded researches and name of the top countries during different ten year's periods.

	Periods		
	1990-1999	2000-2009	2010-2019
Group average number of funded researches from the top 20 countries	27.35	2534.55	52804.9
Number of countries having more funded researches than the group average	2	6	7

India's Rank	18	20	20
Group Top	USA	USA	USA
Number of funded researches from India	2	441	13543

4.1.1.7. Period-wise growth of meeting abstract by top 20 countries

4.1.1.7.1. Five year's period-wise growth of meeting abstract by top 20 countries

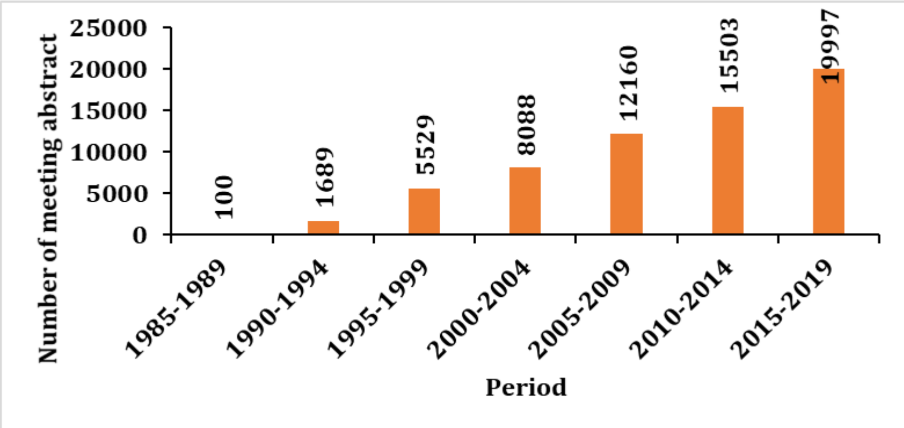


Figure 4.1.1.24: Global total number of meeting abstract during different five year's periods

Figure 4.1.1.24shows the period-wise number of the global total number of meeting titles in climate change. The number of meeting titles was increased from 100 during the initial period (1985-1989) to 19997 during the last period (2015-2019) with a CPGR of 254.95%. Figure 4.1.1.25shows the period-wise number of meeting titles in the climate change research were participated by the top 20 countries. The average number of meeting titles that were participated by the top 20 countries were increased from 1.5 during the initial period (1985-1989) to 827.3 during the last period (2015-2019) with a CPGR of 186.37 % (Table 4.1.1.10). The USA ranked the 1st throughout the periods. Nine countries have participated in the number of meeting titles more than the group average participation in meeting titles during the last periods and India ranked 6th position (Table 4.1.1.10) by participating in 1134 meeting titles during the last period with a CPGR of 139.56 % (Figure 4.1.1.25).

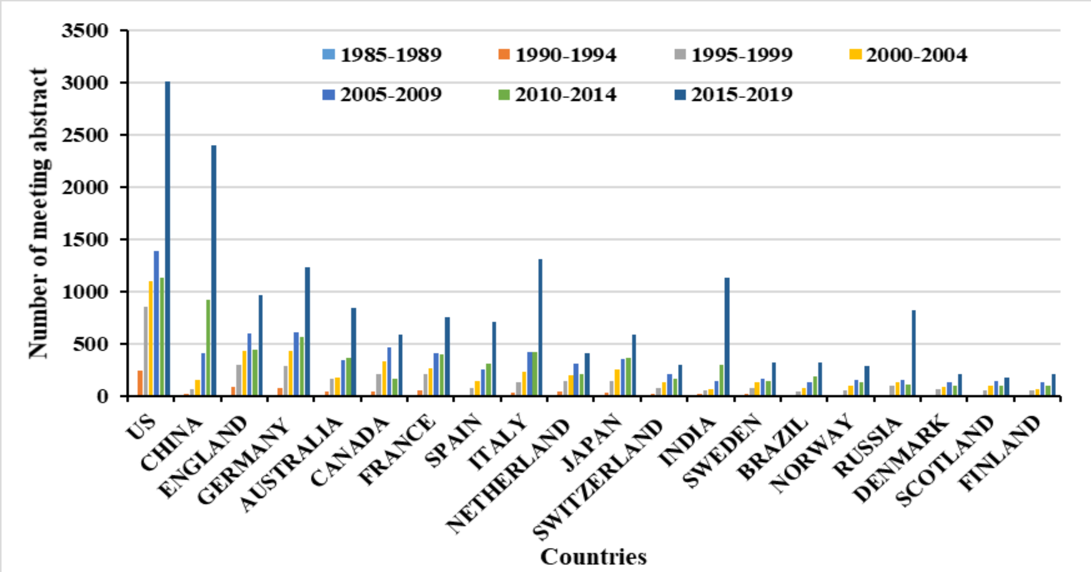


Figure 4.1.1.25: Number of meeting abstract during different five year's periods from top 20 countries

Table 4.1.1.10: Average number of meeting abstract from top 20 countries, number of countries having more meeting abstract than the average number of meeting abstract among the top 20 countries, India's rank based on the number of meeting abstract and name of the top countries during different periods.

	Periods						
	1985-1989	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014	2015-2019
Group average number of meeting titles (participations) from the top 20 countries	1.5	56.05	237.5	381.7	577.2	652.4	827.3
Number of countries having more meeting titles (participations) than the group average	5	6	6	7	8	9	9
India's Rank	2	12	19	20	17	10	6
Group Top	USA	USA	USA	USA	USA	USA	USA
Number of meeting titles participated by India	6	16	66	86	228	484	1134

4.1.1.7.2. 10 year's Period-wise growth of meeting abstract by top 20 countries

Figure **4.1.1.23** shows the period-wise global total number of meeting titles in climate change. The number of meeting titles was increased from 7329 during the initial period (1990-1999) to 35914 during the last period (2010-2019) with a CPGR of 121.37 %. Figure 4.1.1.26 shows a period-wise number of meeting titles in the climate change research that were participated by the top 20 countries. The average number of meeting titles that were participated by the top 20 countries were increased from 308.9 during the initial period (1990-1999) to 1516.6 during the last period (2010-2019) with a CPGR of 121.67 % (Table 4.1.1.11). The USA ranked the 1st throughout the periods. Seven countries have participated in the number of meeting titles more than the group average participation in meeting titles during the last periods and India ranked 6th position (Table 4.1.1.11) by contributing 1679 abstracts in meeting titles during the last period with a CPGR of 352.50 % (Figure 4.1.1.26).

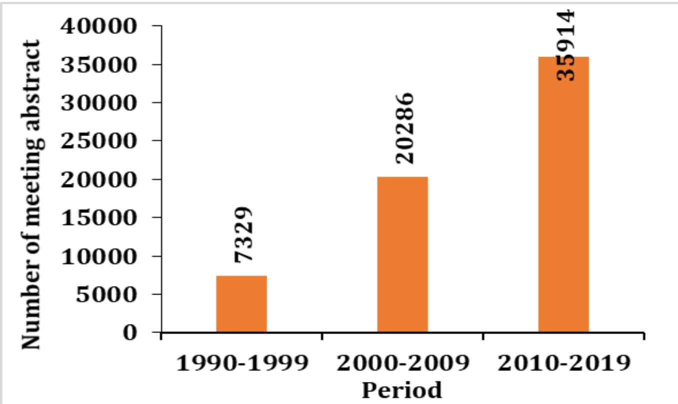


Figure 4.1.1.26: Global total number of meeting titles during different ten year's periods

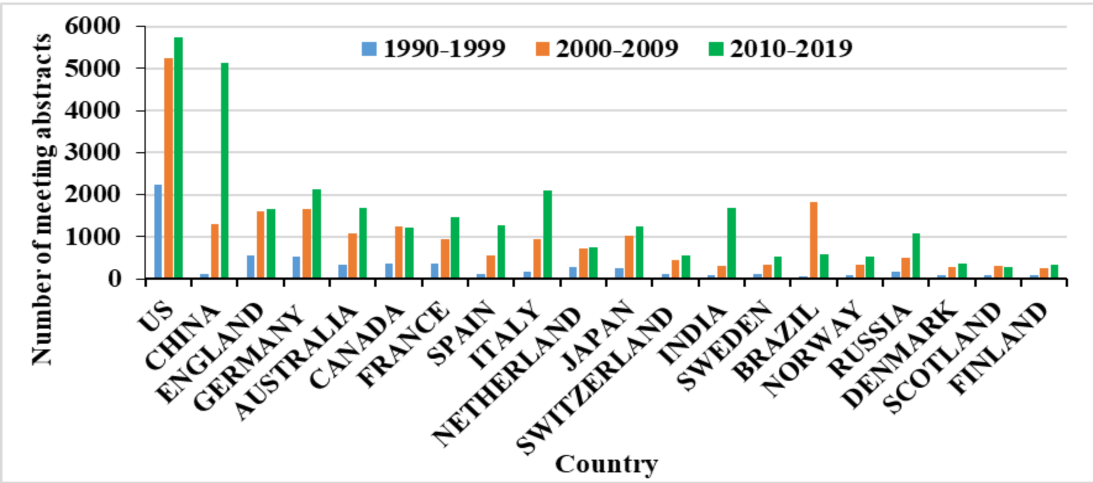


Figure 4.1.1.26: Number of meeting titles during different ten year's periods from top 20 countries

Table 4.1.1.11: Average number of meeting abstract from top 20 countries, number of countries having more meeting abstract than the average number of meeting abstract among the top 20 countries, India's

rank based on the number of meeting abstract and name of the top countries during different ten year's periods.

	Periods		
	1990-1999	2000-2009	2010-2019
Group average number of meeting titles (participations) from the top 20 countries	308.9	1045.9	1516.6
Number of countries having more meeting titles (participations) than the group average	6	7	7
India's Rank	17	19	6
Group Top	USA	USA	USA
Number of meeting titles participated by India	82	318	1679

4.1.1.8. Period-wise growth of Source Titles by top 20 countries

4.1.1.8.1. Five year's period-wise growth of Source Titles by top 20 countries

Figure 4.1.1.27 shows the period-wise global total number of source titles in the climate change for research communications. The number of source titles or journals were increased from 248 during the initial period (1985-1989) to 11255 during the last period (2015-2019) with a CPGR of 88.86 %. Figure 4.1.1.28 shows the period-wise number of source titles for climate change research communications by the top 20 countries. The average number of source titles or journals to communicate research publication by the top 20 countries were increased from 13.3 during the initial period (1985-1989) to 1805.05 during the last period (2015-2019) with a CPGR of 126.69 % (Table 4.1.1.12). The USA ranked the 1st throughout the periods. Ten countries have the number of source titles or journals to communicate research publication more than the group average number of source titles or journals during last periods and India ranked 9th position (Table 4.1.1.12) by publishing in 1978 source titles or journals during the last period with a CPGR of 162.83 % (Figure 4.1.1.28). The average number of publications per journal by India is much lower than the average number of publications per journal by the top 20 countries (Table 4.1.1.12) throughout the periods.

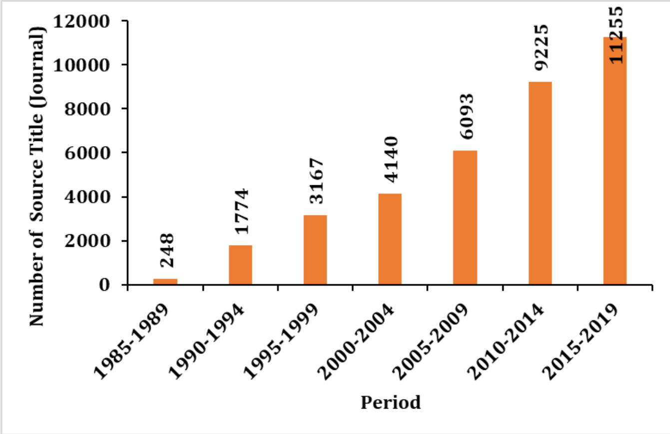


Figure 4.1.1.27: Global total number of journals during different five year's periods

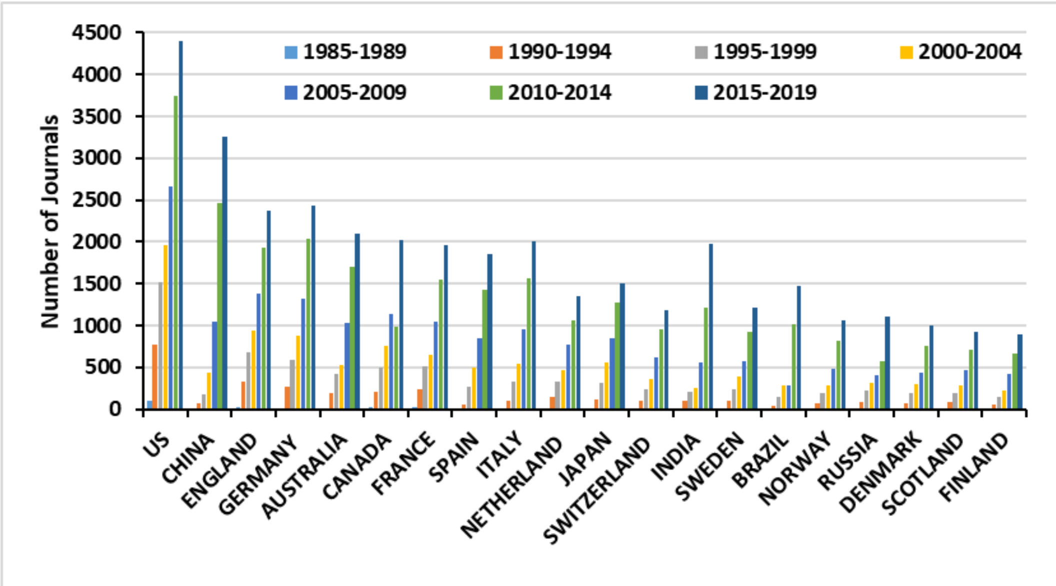


Figure 4.1.1.28: Number of source titles during different five year's periods from top 20 countries

Table 4.1.1.12: Average number of source titles by top 20 countries, number of countries having more source titles than the average number of source titles among the top 20 countries, India's rank based on the number of source titles and name of the top countries during different five year's periods.

	Periods						
	1985-1989	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014	2015-2019
Group average number of journals for publications communication by the top 20 countries	13.3	161	372.05	546.25	866.35	1369.7	1805.05
Number of countries having more journals for publications communication than the group average	5	4	6	7	8	8	10

India's Rank	12	11	14	19	14	12	9
Group Top	USA	USA	USA	USA	USA	USA	USA
Number of journals for publications communication by India	6	102	205	261	557	1219	1978
Average number of publications per journals by the top 20 countries	2.43	3.04	3.14	3.69	4.41	5.71	7.29
Average number of publications per journals by India	1.83	1.90	1.89	2.21	2.58	3.19	4.115

4.1.1.8.1. 10 year's period-wise growth of Source Titles by top 20 countries

Figure 4.1.1.29 shows the period-wise number of the global total number of source titles (journals) in climate change for research communications. The number of source titles or journals were increased from 4054 during the initial period (1990-1999) to 16561 during the last period (2010-2019) with a CPGR of 102.11 %.

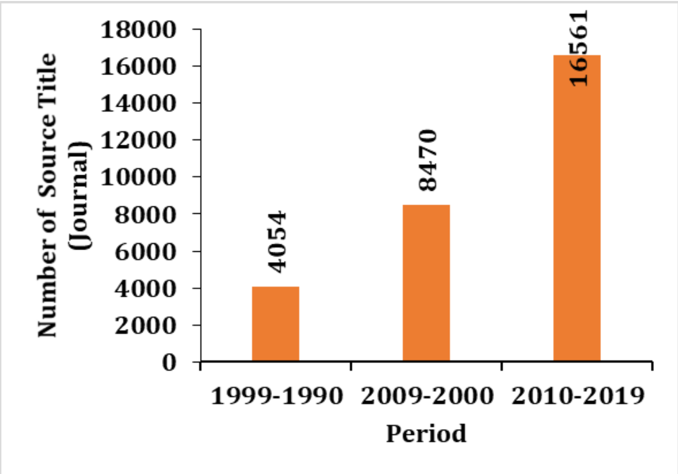


Figure 4.1.1.29: Global total number of journals during different ten year's periods

Figure 4.1.1.30 shows a period-wise number of source titles for climate change research communications by the top 20 countries. The average number of source titles or journals to communicate research publication by the top 20 countries were increased from 454.2 during the initial period (1990-1999) to 2499.9 during the last period (2010-2019) with a CPGR of 134.60 % (Table 4.1.1.13). The USA ranked the 1st throughout the periods. Ten countries have the number of source titles or journals to communicate research publication more than the group average number of source titles or journals during last periods and India ranked 9th position (Table 4.1.1.13) by publishing in 1612 source titles or journals during the last period with a CPGR of 131.41 % (Figure 1.2.16). The average number of publications per journal by India is much lower than the average number of publications per journal by the top 20 countries (Table 4.1.1.13) throughout the periods.

Table 4.1.1.13: Average number of Source Titles by top 20 countries, number of countries having more Source Titles than the average number of Source Titles among the top 20 countries, India's rank based on the number of Source Titles and name of the top countries during different ten year's periods.

	Periods		
	1990-1999	2000-2009	2010-2019
Group average number of Source Titles for publications communication by the top 20 countries	454.2	1165.4	2499.9
Number of countries having more Source Titles for publications communication than the group average	6	9	9
India's Rank	14	14	9
Group Top	USA	USA	USA
Number of Source Titles for publications communication by India	261	690	2649
Average number of publications per Source Titles by the top 20 countries	8.29	11.84	20.03
Average number of publications per Source Titles by India	2.21	2.87	4.64

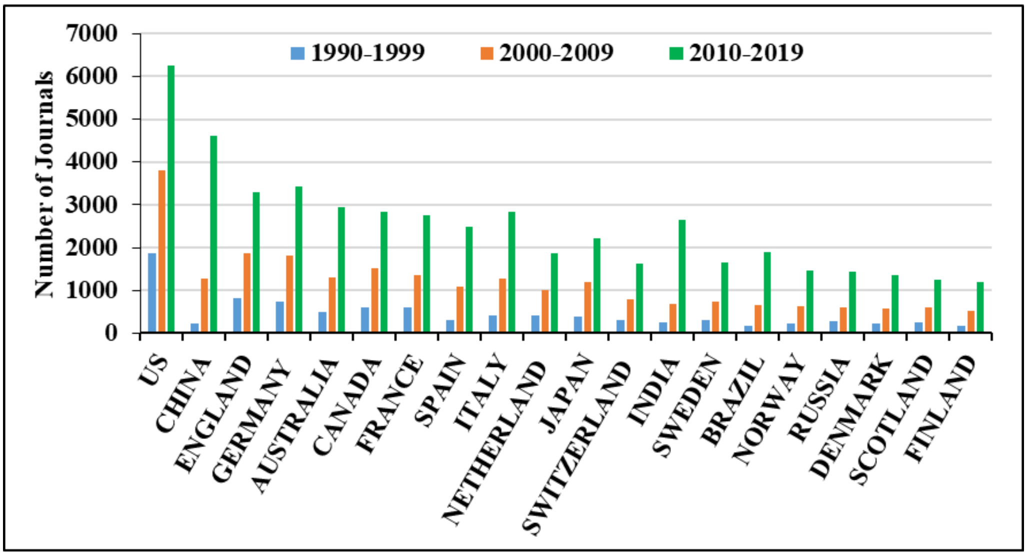


Figure 4.1.1.30: Number of journals for publications during different ten year's periods from top 20 countries

India’s contribution in Top 30 Source Titles (Journals)

Total global research on climate change has been published in 23688 source titles or journals. Top 30 source titles or journals have published 22.21 % of the total global research on climate change. Total Indian research on climate change has been published in 3006 source titles or journals. Top 30 source titles or journals have published 15.93 % of the total Indian research on climate change. India has contributed at a higher proportion than the global in some low-impact journals (IF range 2-5). India has contributed at a lower proportion than the global in some high-impact journals namely Nature, Science (Figure 4.1.1.31).

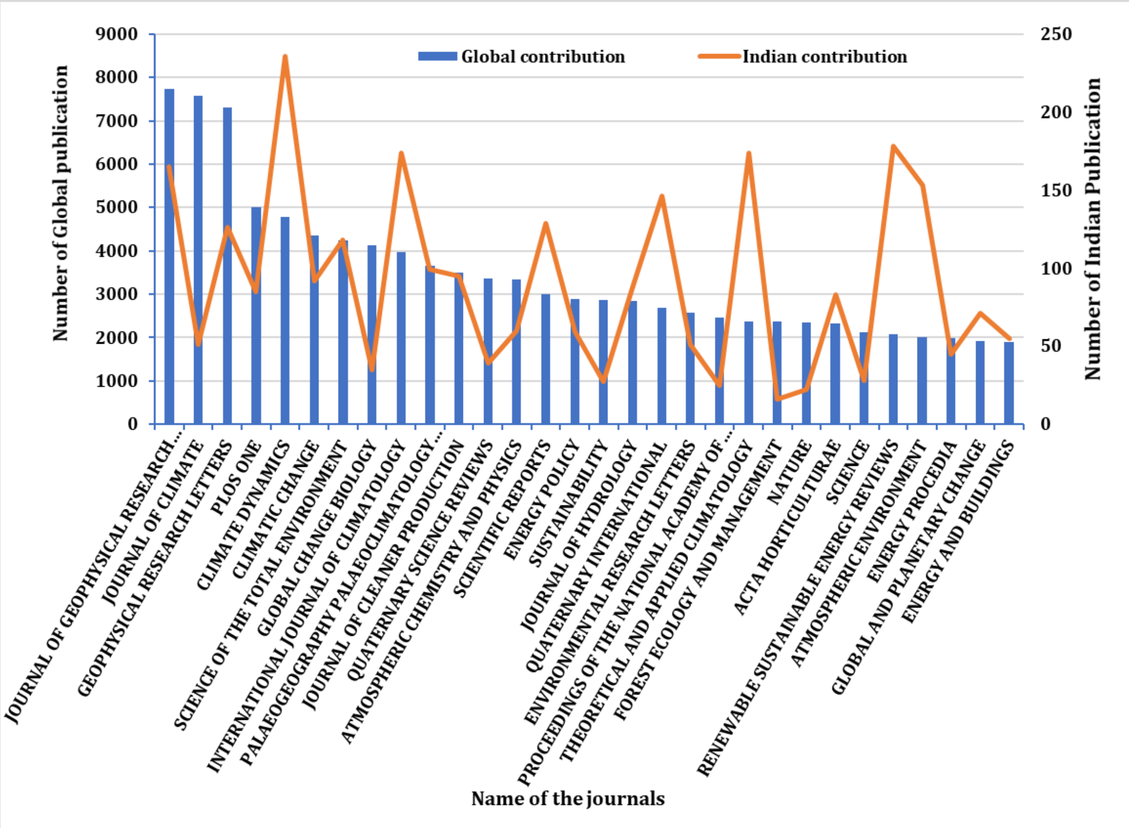


Figure 4.1.1.31: Number of global and Indian publications in top 30 most frequent journals during total periods.

4.1.2. Analysis from Scopus database

In the Scopus database, the information about various bibliometric parameters is limited to only the top 160 entities therefore the comparative quantitative evaluation of all the bibliometric parameters has not been performed.

4.1.2.1. Year-wise total global publications and publications by top 30 countries

Using the final search string a total of 649544 publications were retrieved globally from the Scopus database from 1985 to 2019. Figure 4.1.2.1 shows year-wise publication results from the Scopus database. The compound annual growth rate was 11.09 %. Publications that have been considered for analysis are in the form of various reviews, articles, and editorial materials, papers presented at meetings and conferences, etc. The top 30 countries contributed about 83.87 % (normalized) of the total global publications (Figure 4.1.2.2) and the top 20 countries contributed about 76.37 % (normalised) of the total global publications. Among the top 20 countries, 6 countries contributed more than the group average (35626.8 papers). India held 9th rank by contributing 24865 publications i.e., 2.66 % (normalised) of the total global publications. India has contributed to the total global publications at a higher proportion of publications in the Scopus database than that of the publications in the Web of Science database.

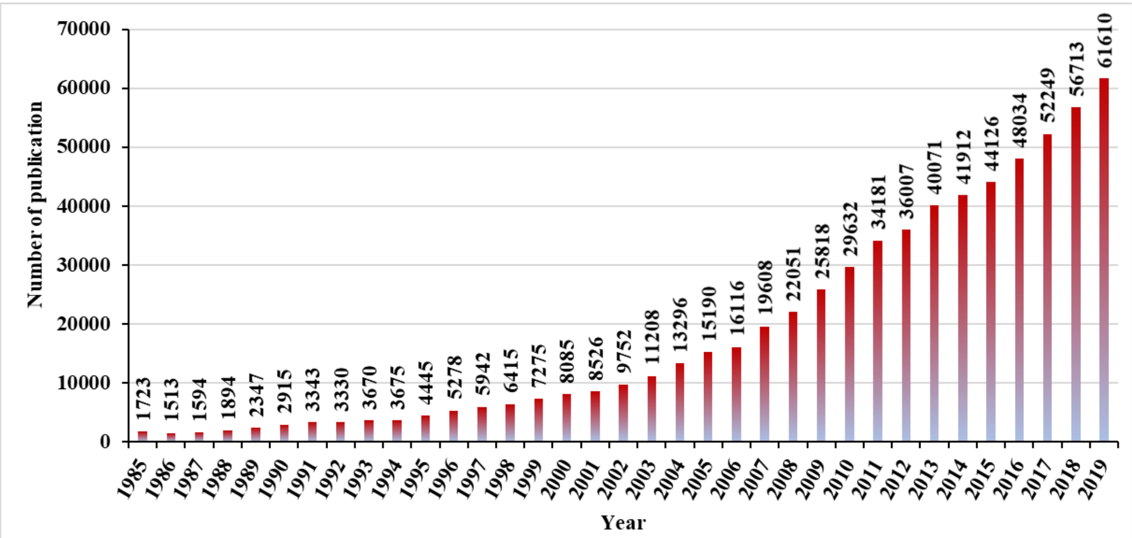


Figure 4.1.2.1: Year-wise total global publications from Scopus database

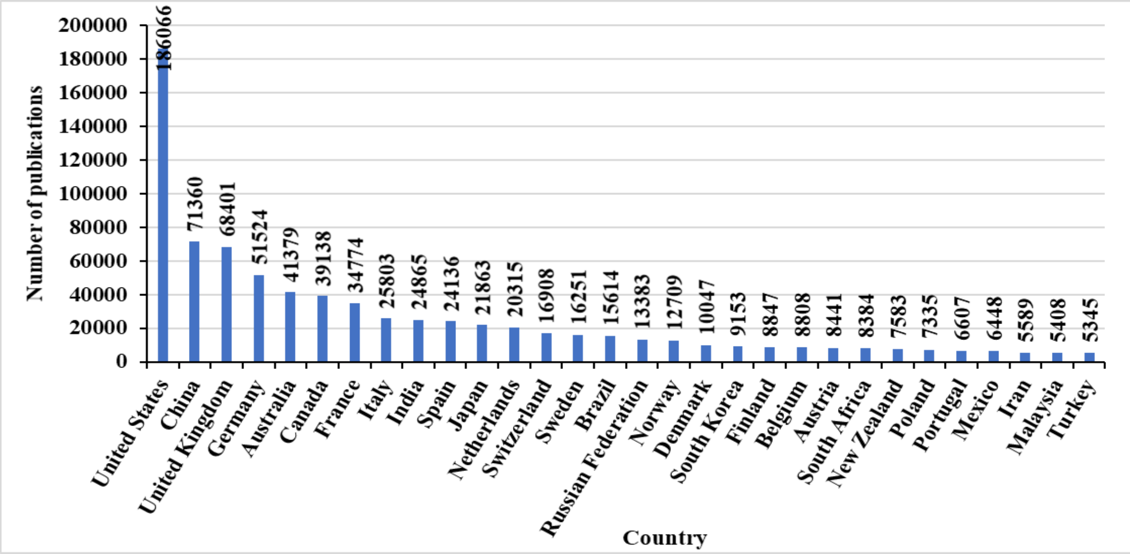


Figure 4.1.2.2: Number of total publications by top 30 countries

4.1.2.2. Period-wise growth of the number of Publications of top 20 countries

4.1.2.2.1. Five year's period-wise growth of the number of Publications of top 20 countries

Figure 4.1.2.3 exhibits the period-wise publications by the top 20 countries. Average publications of the top 20 countries were increased from 280.9 during the initial period (1985-1989) to 15071.1 during the last period (2015-2019) with a compound period-wise growth rate (CPGR) of 94.20 % (Table 4.1.2.1). The USA ranked the 1st throughout the periods. Six countries have contributed more than the group average publications and India achieved 8th position during the last period (2015-2019) by contributing 13717 publications (Figure 4.1.2.4). Seven countries having more CPGR than the group's average CPGR (114.89 %) and India's rank was 8th with a CPGR of 112.73% (Figure 4.1.2.5).

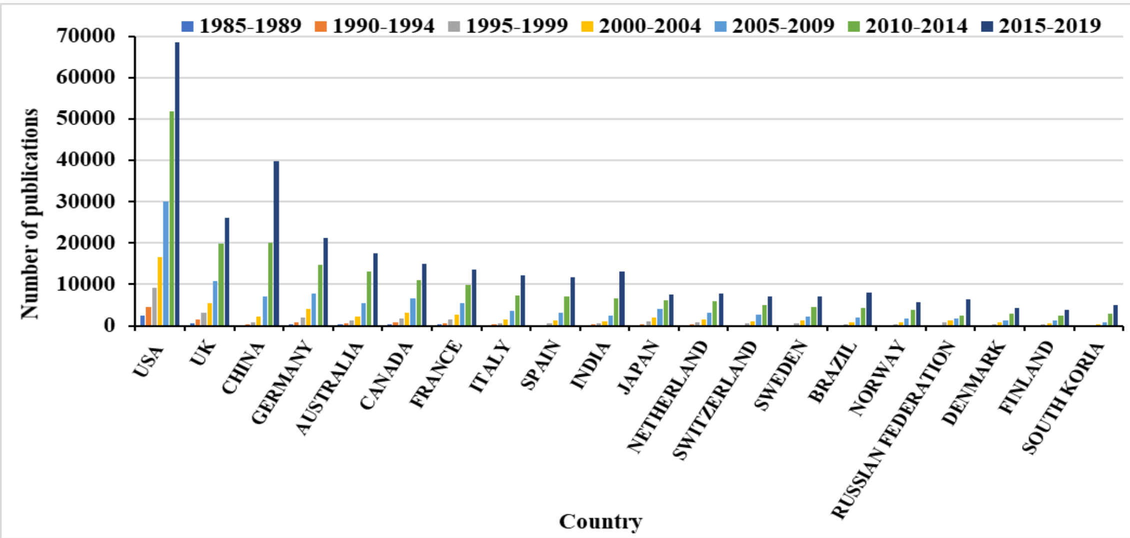


Figure 4.1.2.3: Number of publications during different five year's periods by top 20 countries

Table 4.1.2.1: Average number of publications by top 20 countries, number of countries having more publications than the average number of publications among the top 20 countries, India's rank based on the number of publications and name of the top countries during different five year's periods.

	Periods						
	1985-1989	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014	2015-2019
Group average number of publications of the top 20 countries	280.9	577	1323.2	2518.35	5154.6	10110.35	15071.1
Number of countries having more publications than the group average	6	6	5	5	7	6	5
India's Rank	9	10	15	15	13	10	8
Group Top	USA	USA	USA	USA	USA	USA	USA
Indian publications	148	266	500	952	2385	6677	13197

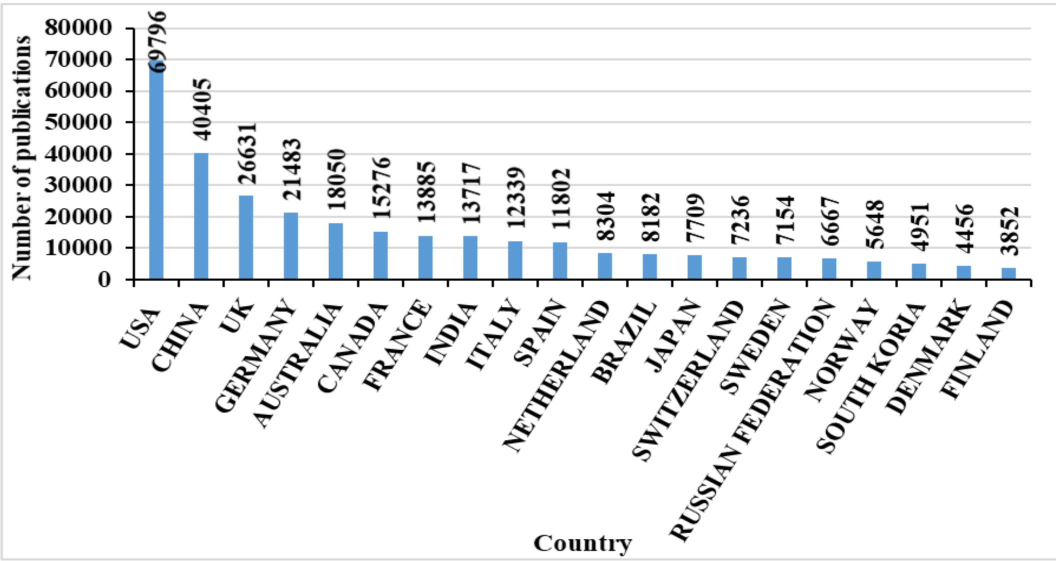


Figure 4.1.2.4: Publication numbers of top 20 countries during last period (2015-2019)

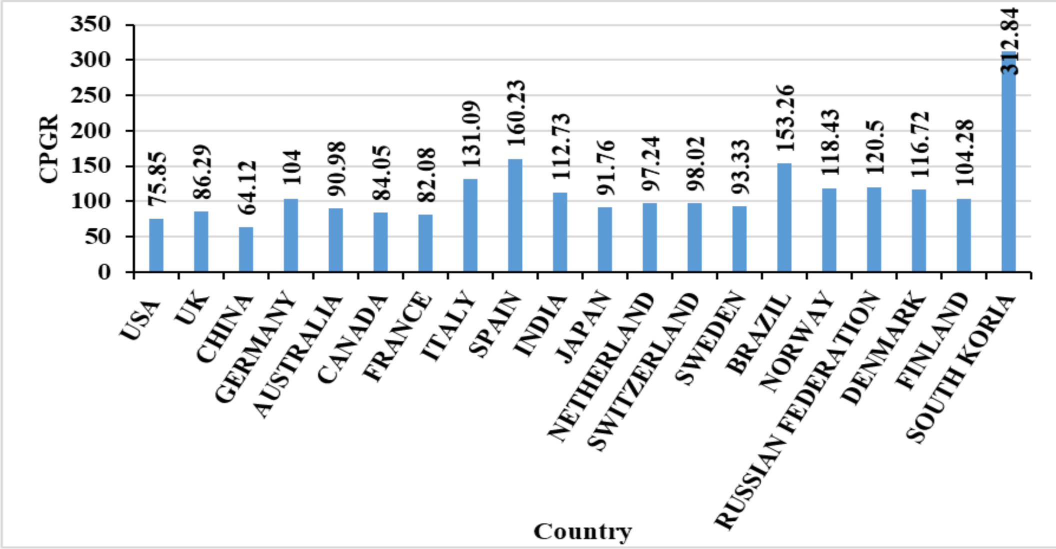


Figure 4.1.2.5: Compound period-wise growth rate (CPGR) of publication numbers of top 20 countries

4.1.2.2.2. Period-wise (10 years) growth of the number of Publications of top 20 countries

Figure 4.1.2.6 exhibits the period-wise publications by the top 20 countries. Average publications of the top 20 countries were increased from 1937.85 during the initial period (1990-1999) to 25617.55 during the last period (2015-2019) with a compound period-wise growth rate (CPGR) of 263.58 % (Table 4.1.2.2). The USA ranked the 1st throughout the periods. Five countries have contributed more than the group average publications and India achieved 8th position during the last period (2010-2019) by contributing 20511 publications (Figure 4.1.2.7). Six countries having more CPGR than the group's average CPGR (335.80 %) and India's rank was 5th with a CPGR of 412.80 % (Figure 4.1.2.8).

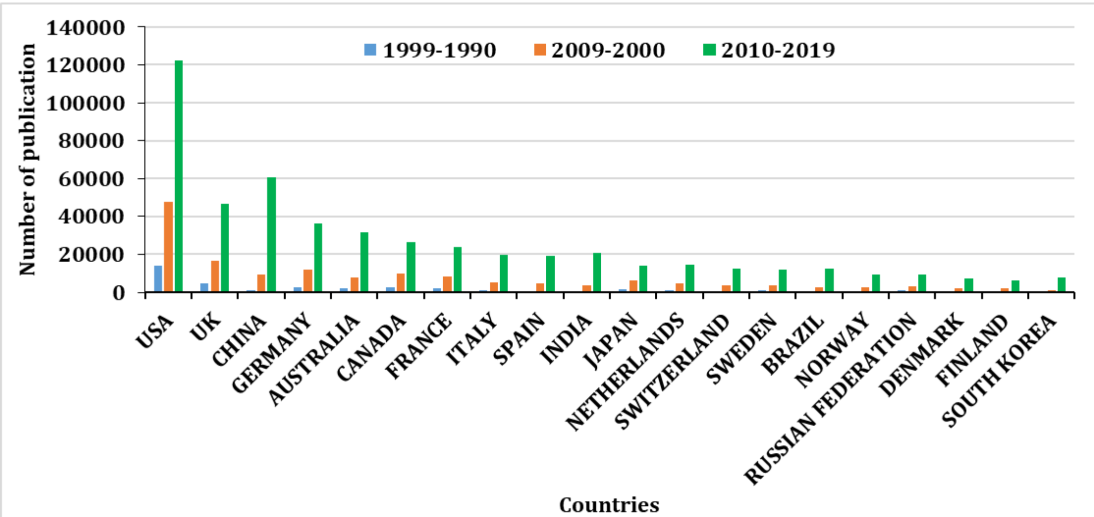


Figure 4.1.2.6: Number of publications during different ten year's periods by top 20 countries

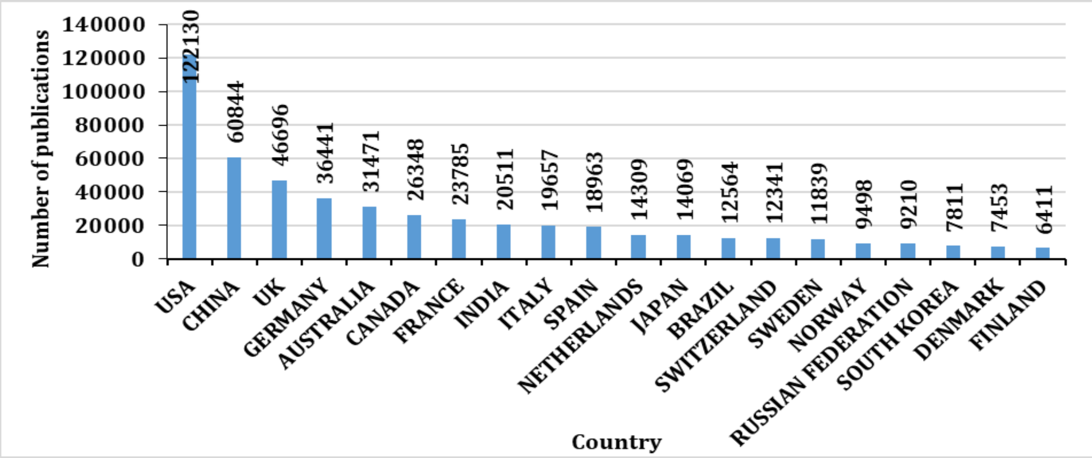


Figure 4.1.2.7: Publication numbers of top 20 countries during last period (2015-2019)

Table 4.1.2.2: Average number of publications by top 20 countries, number of countries having more publications than the average number of publications among the top 20 countries, India's rank based on the number of for publications and name of the top countries during different ten year's periods.

	Periods		
	1990-1999	2000-2009	2010-2019
Group average number of publications of the top 20 countries	1937.85	7795.6	25617.55
Number of countries having more publications than the group average	6	6	5
India's Rank	13	13	8
Group Top	USA	USA	USA
Indian publications	780	3433	20511

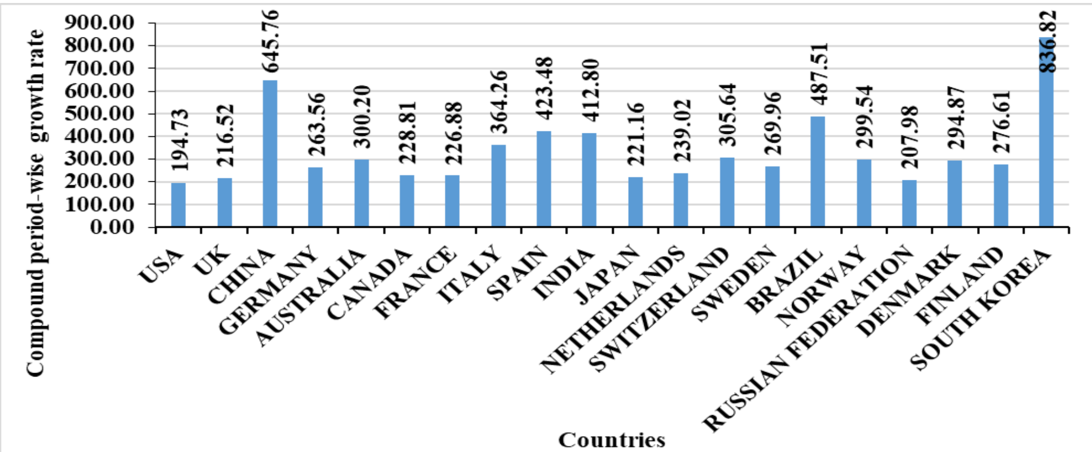


Figure 4.1.2.8: Compound period-wise growth rate (CPGR) of publication numbers of top 20 countries

4.1.2.3. Global and Indian top organizations

The top 30 organizations (Figure 4.1.2.8) contributed 24.78 % of the total global publications. The top 100 organizations contributed 54.10 % of the total global publications. Among the global top 30 and top 100 organizations, there are no Indian organizations (Figure 4.1.2.8). Eight countries have no organization in the top 30 and 2 countries have no organization in the top 100 organization’s list (Table 4.1.2.3). Figure 4.1.2.8 and 4.1.2.9 representing the publications contributions by the top 30 global and top 30 Indian organizations respectively.

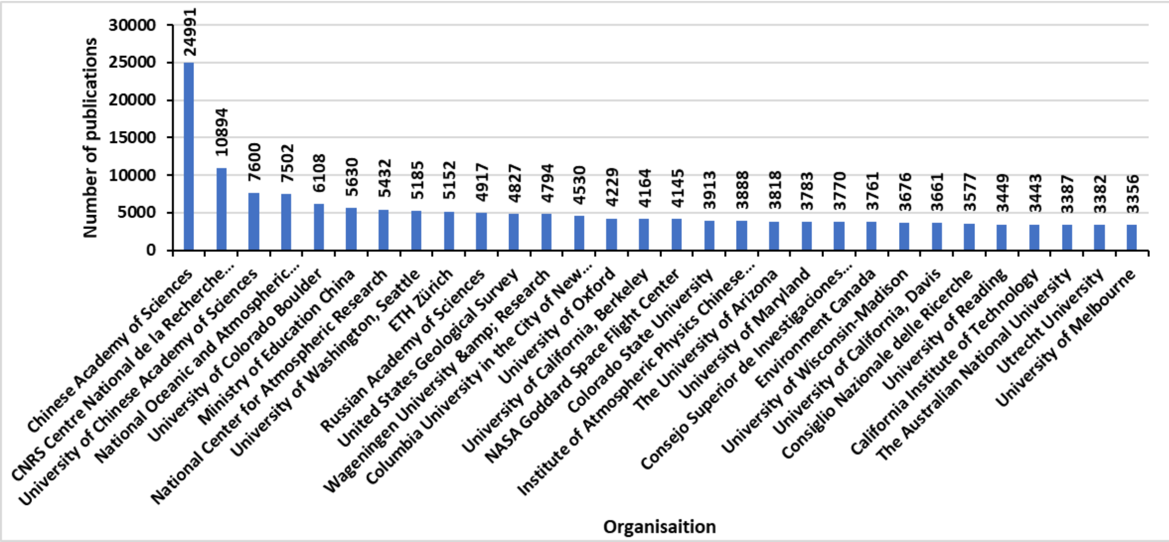


Figure 4.1.2.8: Number of publications by top 30 Global organizations

Table 4.1.2.3: Number of organizations from different countries in top 30 and top 100 organization’s list of total global publications

	No of organizations in top 30 organizations list	No of organizations in top 100 organizations list
USA	14	41
UK	2	12
China	8	12
Germany	0	2
Australia	1	4
Canada	1	4
France	1	4
Italy	1	1
Spain	1	1
India	0	0
Japan	0	2

Netherland	1	2
Switzerland	1	2
Sweden	0	3
Brazil	0	1
Norway	0	1
Russian Federation	1	1
Denmark	0	2
Finland	0	1
South Korea	0	0

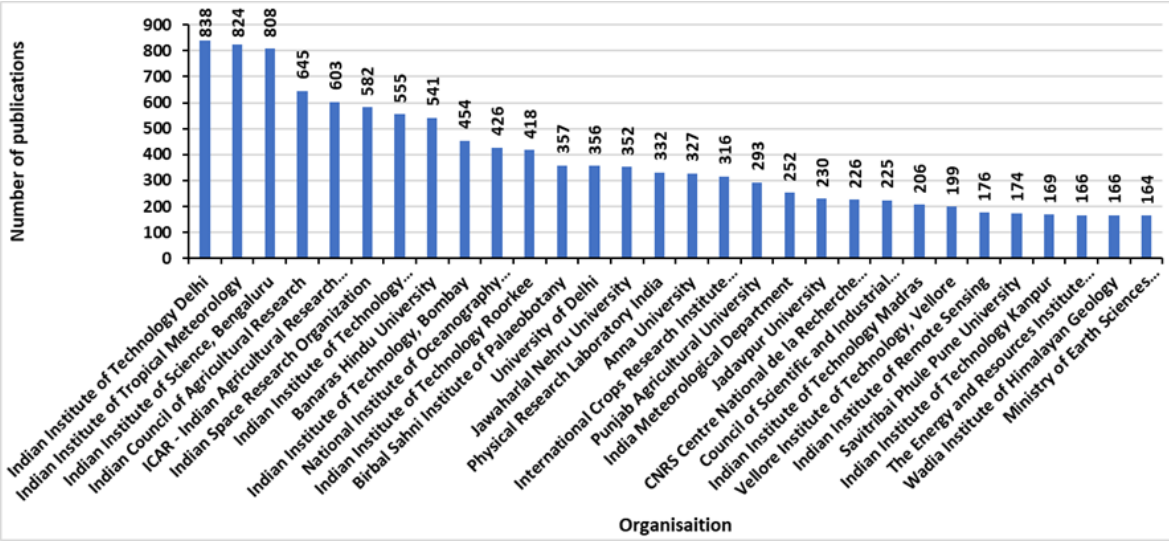


Figure 4.1.2.9: Number of publications by top 30 Indian organizations

4.1.2.4. India's contribution to the top 30 Source Titles (Journals)

Top 30 source titles or journals have published 16.95 % of the total global research on climate change. Top 30 source titles or journals have published 12.41 % of the total Indian research on climate change. India has contributed at a higher proportion than the global in some low-impact journals (IF range 2-5). India has contributed at a lower proportion than the global in some high-impact journals namely Nature, Science (Figure 4.1.2.10). A similar scenario was also observed in the case of the Web of Science database.

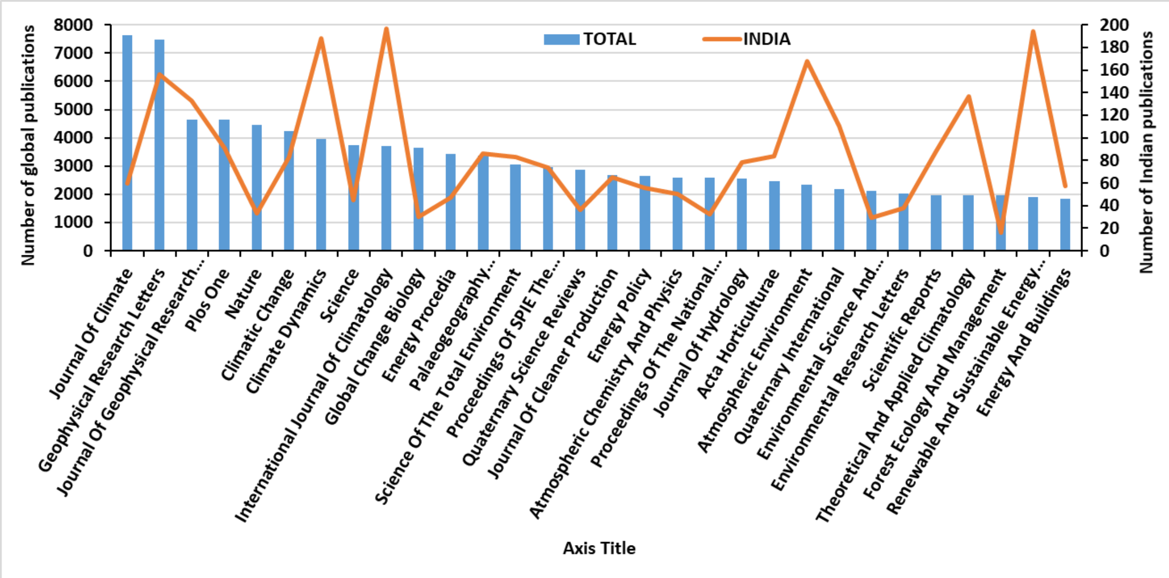


Figure 4.1.2.10: Number of global and Indian publications in top 30 most frequent journals during total periods.

4.1.3. Analysis from Indian Citation index database

4.1.3.1. Year-wise total global publications and Indian publications

Using the final search string a total of 9845 publications were retrieved globally from the Indian Citation Index database from 2005 to 2019. Figure 4.1.3.1 shows year-wise total global and Indian publications from the Indian Citation Index database. The global number of publications were increased from 182 in 2005 to 939 in 2019 with a CAGR of 12.43%. Alongside, the Indian publications were increased from 158 in 2005 to 658 in 2019 with a CAGR of 10.72 %. Publications that have been considered for analysis are in the form of various reviews, articles, and editorial materials, papers presented at meetings and conferences, etc.

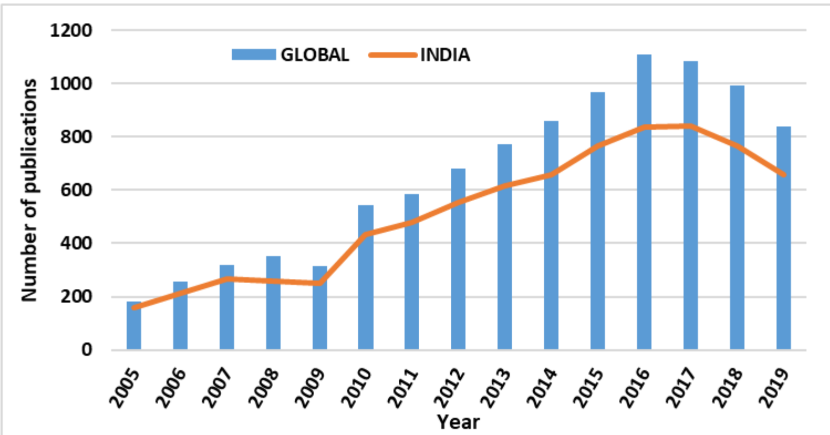


Figure 4.1.3.1: Year-wise total global publications from Indian Citation index database

4.1.3.2. Period-wise (5 years) growth of the number of Publications of top 20 countries

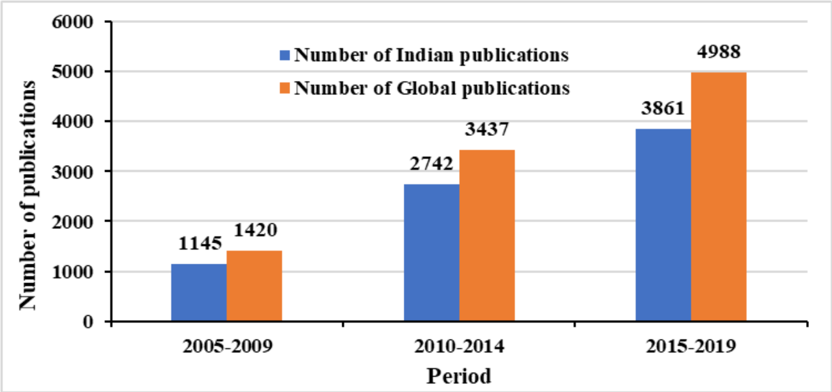
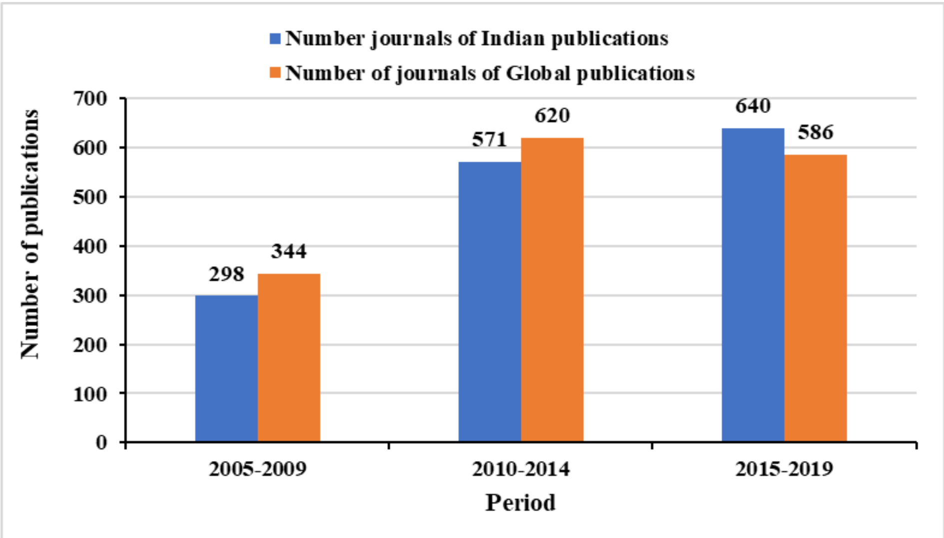


Figure 4.1.3.2: Number of total global publications during different five year's periods.

Figure 4.1.3.2 exhibits the period-wise publications by total global and Indian publications. Total global publications ere increased from 1420 during the initial period (2005-2009) to 4988 during the last period (2015-2019) with a compound period-wise growth rate (CPGR) of 87.42 % (Figure 4.1.3.2). Total Indian publications ere increased from 1145 during the initial period (2005-2009) to 3861 during the last period (2015-2019) with a compound period-wise growth rate (CPGR) of 83.63 % (Figure 4.1.3.2). India ranked the 1st throughout the periods.

4.1.3.3. India's contribution to Top 30 Source Titles (Journals)

Figure 4.1.3.3 shows the top 30 source titles in the Indian Citation Index on climate change research. The top 30 source titles or journals of the Indian Citation Index have published 34.57 % of the total global publications and 33.20 % of the total Indian publications on climate change.



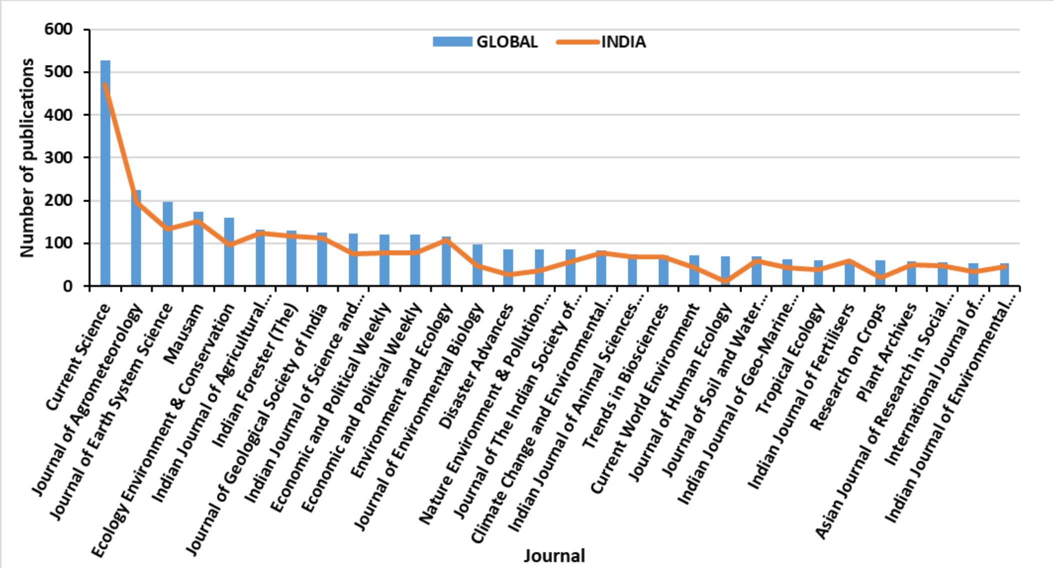


Figure 4.1.3.3: Number of publications by top 30 journals of the total global and Indian publications

4.2. Period-wise impact evaluation of the research publications through citation analysis

4.2.1. Analysis from Web of Science database

4.2.1.1. Period-wise Average Citation of top 20 and top 30 countries

Figure 4.2.1.1shows the period-wise average citations of the publications by the top 20 countries. The average citation of publications of the top 20 countries was 61.65 during the initial period (1985-1989) and it was decreased to 54.16 during the next period. Then the average citation was increased for consecutive two periods (57.09 & 67.20) and during subsequent periods it was decreased. This is because the publications need time lag to be cited (Table 4.2.1.1). Scotland ranked 1stduring the initial period, Denmark ranked 1st for consecutive two periods, then Switzerland ranked the 1st during next three periods and Scotland ranked the 1st during last period. Ten countries have average citations more than the group average citation during the last period (2015-2019) and India ranked the last position throughout the periods (Figure 4.2.1.1).

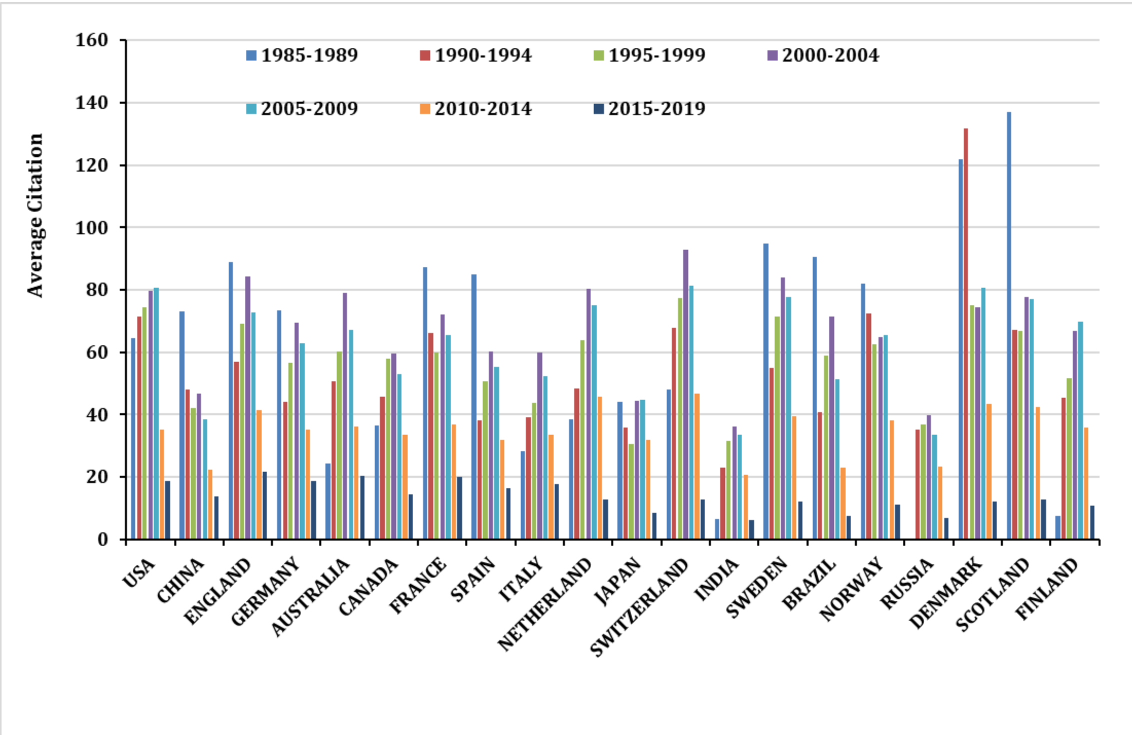


Figure 4.2.1.1: Average citations of the total publications during different periods of top 20 countries

Table 4.2.1.1: The average of average citations of top 20 countries, number of countries having more publications than the group's average citation of publications among the top 20 countries, India's rank based on the average citation and name of the top countries during different periods.

	Periods						
	1985-1989	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014	2015-2019
Group average of average citation of publications of the top 20 countries	61.65	54.16	57.09	67.20	61.93	34.87	13.82
Number of countries having more average citation than the group average	7	8	10	11	12	12	9
India's Rank	19	20	20	20	20	20	20
Group Top	Scotland	Denmark	Denmark	Switzerland	Switzerland	Switzerland	Denmark

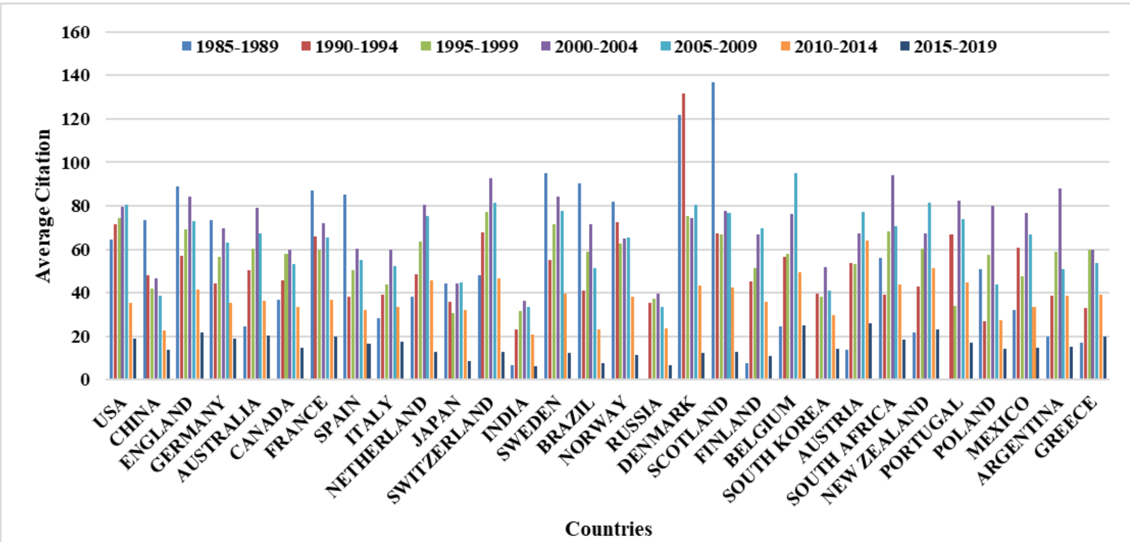


Figure 4.2.1.2: Average citations of the total publications during different periods of top 30 countries

Figure 4.2.1.2 shows the period-wise average citations of the publications by the top 30 countries. The average citation of publications of the top 30 countries was 48.96 during the initial period (1985-1989) and it was increased at successive periods until 2000-2004 and during subsequent periods it was decreased (Table 4.2.1.2). Scotland ranked 1stduring the initial period, Denmark ranked 1st for consecutive two periods, Switzerland ranked 1st during 2000-2004, Belgium ranked 1st during 2005-2009 and Austria ranked the 1st during last two periods. Eleven countries have average citations more than the group average citation during the last period (2015-2019) and India ranked the last position during the same period (Figure **4.2.1.1**).

Table 4.2.1.2: The average of average citations of top 30 countries, number of countries having more publications than the group's average citation of publications among the top 30 countries, India's rank based on the average citation and name of the top countries during different periods.

	Periods						
	1985-1989	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014	2015-2019
Group average of average citation of publications of the top 30 countries	48.96	51.38	55.89	69.56	63.08	37.33	15.47
Number of countries having more average citation than the group average	9	12	14	15	17	14	11
India's Rank	27	30	29	30	29	30	30
Group Top	SCOTLAND	DENMARK	DENMARK	SWITZERLAN D	BELGIUM	AUSTRIA	AUSTRIA

4.2.1.2. Calculated 5-year impact factor of top 20 countries

Figure 4.2.1.3. shows the period-wise calculated 5-year impact factor of the publications by top 20 countries. The calculated 5-year impact factor of the publications of the top 20 countries was increased from 1.42 during the initial period (1985-1989) to 7.073 during the last period 2015-201 (Table 4.2.1.3.). England ranked 1stduring the initial period, Denmark ranked 1st at successive three periods, Switzerland ranked the 1st during net three periods and Netherlands ranked the 1st during last period. Ten countries have a higher 5-year impact factor than the group average during the last period (2015-2019) and India ranked 19th during the last period (Figure 4.2.1.3).

Figure 4.2.1.4 shows the period-wise calculated 5-year impact factor of the publications by the top 30 countries. The calculated 5-year impact factor of the publications of the top 30 countries was increased from 1.20 during the initial period (1985-1989) to 6.97 during the last period 2015-201 (Table 4.2.1.4). Fourteen countries have a higher 5-year impact factor than the group average during the last period (2015-2019) and India ranked 29th during the last period (Figure 4.2.1.4).

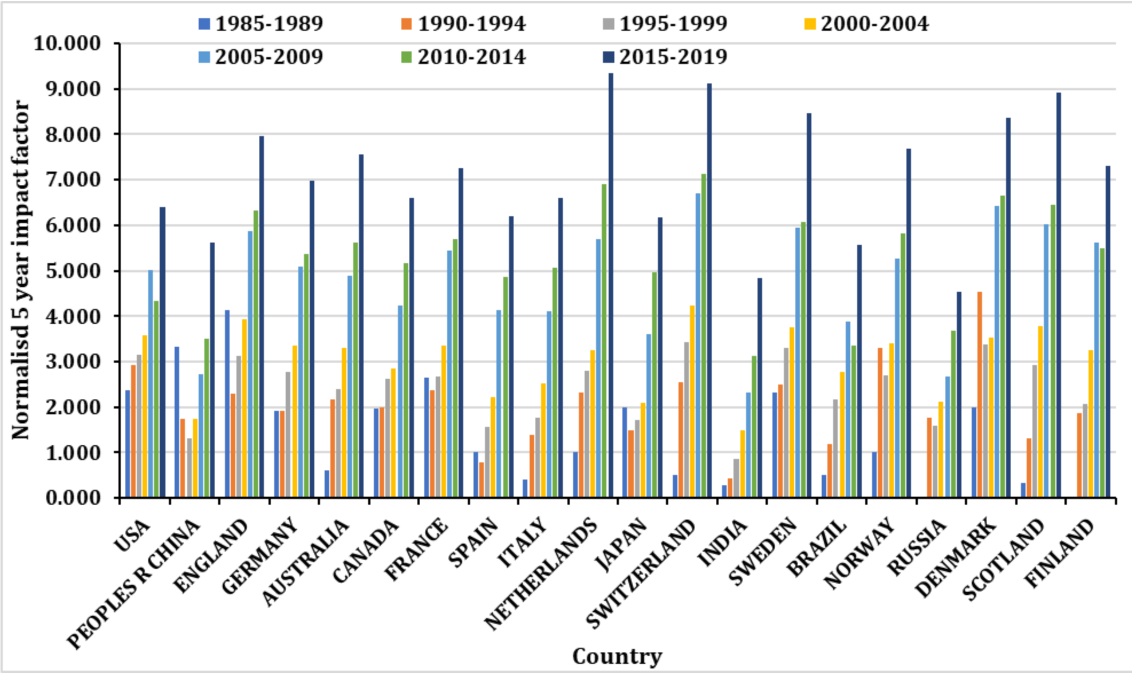


Figure 4.2.1.3: Calculated 5-year impact factor of top 20 countries during different periods

Table 4.2.1.3: Group average of calculated 5-year impact factor of top 20 countries, number of countries having more calculated 5-year impact factor than the group's average calculated 5-year impact factor among the top 20 countries, India's rank based on the calculated 5-year impact factor and name of the top countries during different periods.

	Periods						
	1985-1989	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014	2015-2019
Group Average of calculated 5-year impact factor of the top 20 countries	1.42	2.04	2.42	3.03	4.79	5.28	7.073
Number of countries having more calculated 5-year impact factor than the group average	10	11	9	8	8	7	10
India's Rank	18	20	20	20	20	20	19
Calculated 5-year impact factor of India	0.27	0.44	0.87	1.49	2.33	3.13	4.83
Group Top	England	Denmark	Denmark	Switzerland	Switzerland	Switzerland	Netherlands

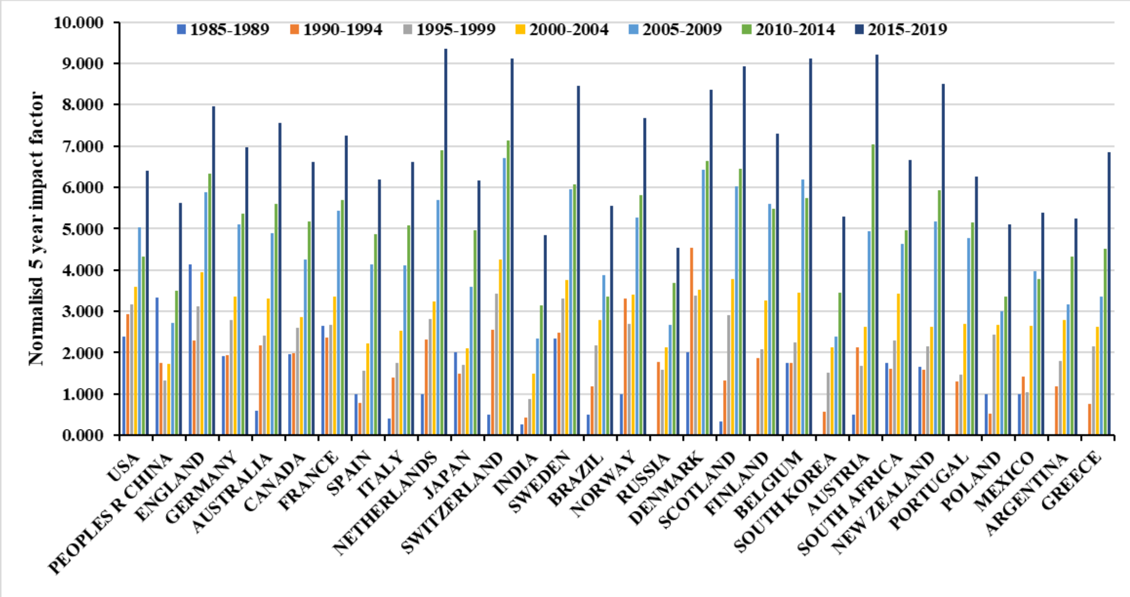


Figure 4.2.1.4: Calculated 5-year impact factor of top 30 countries during different periods

Table 4.2.2.4.: Group average of calculated 5-year impact factor of top 30 countries, number of countries having higher calculated 5-year impact factor than the group's average among the top 30 countries, India's rank based on the calculated 5-year impact factor and name of the top countries during different periods.

	Periods						
	1985-1989	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014	2015-2019
Group Average of calculated 5-year impact factor of the top 30 countries	1.200	1.791	2.237	2.943	4.577	5.128	6.970
Number of countries having more calculated 5-year impact factor than the group average	12	13	15	14	17	16	14
India's Rank	24	30	30	30	30	30	29
Group Top	England	Denmark	Denmark	Switzerland	Switzerland	Switzerland	Netherlands

4.2.1.3. h-index of total publication and Period-wise h-index of top 20 and top 30 countries

Figure 4.2.1.5 shows the h-index of the total publication of the top 20 countries. The Group average h-index of the total publication of the top 20 countries is 324.25. Eight countries have a higher h-index than the group average h-index and India ranked 19th (Figure 4.2.1.5). Figure 4.2.1.6 exhibits the period-wise h-index of the top 20 countries. The average h-index of the top 20 countries were increased from 10.8 during the initial period (1985-1989) to 178.1 during 2005-2009 (Table 2.2.3) and the h-index of the last two consecutive periods was decreased. The USA ranked the 1st throughout the periods. Nine countries have a higher h-index than the group average h-index during the last period (2015-2019) and India ranked the 18th position during the last three periods (Table 4.2.1.5).

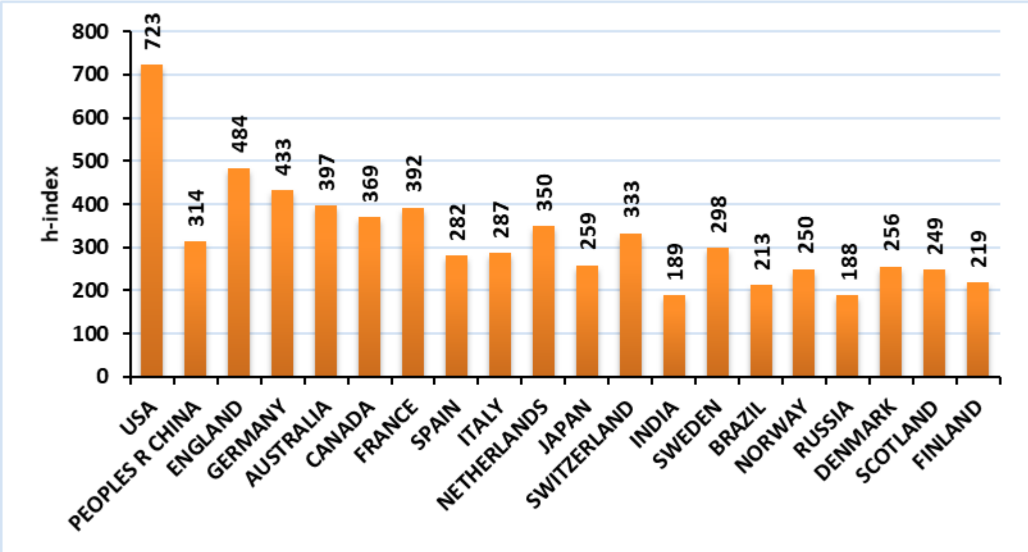


Figure 4.2.1.5: h-index of total publications of top 20 countries

Table 4.2.1.5: Group average of h-index of top 20 countries, number of countries having more h-index than the group's average h-index among the top 20 countries, India's rank based on the h-index and name of the top countries during different periods.

	Periods						
	1985-1989	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014	2015-2019
Group average h-index of the top 20 countries	10.8	62.75	107.4	144.85	178.1	165.05	127.3
Number of countries having more h-index than the group average	6	6	6	6	8	7	9
India's Rank	13	18	20	20	19	19	18
h-index of India	3	29	48	74	98	101	90
Group Top	USA	USA	USA	USA	USA	USA	USA

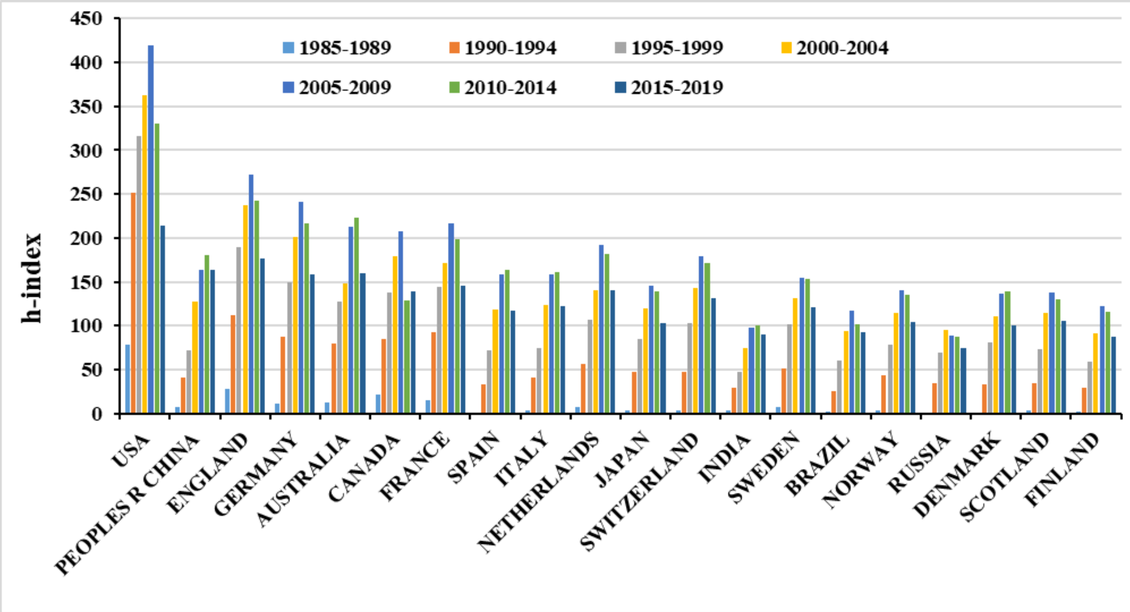


Figure 4.2.1.6: h-index of top 20 countries during different periods.

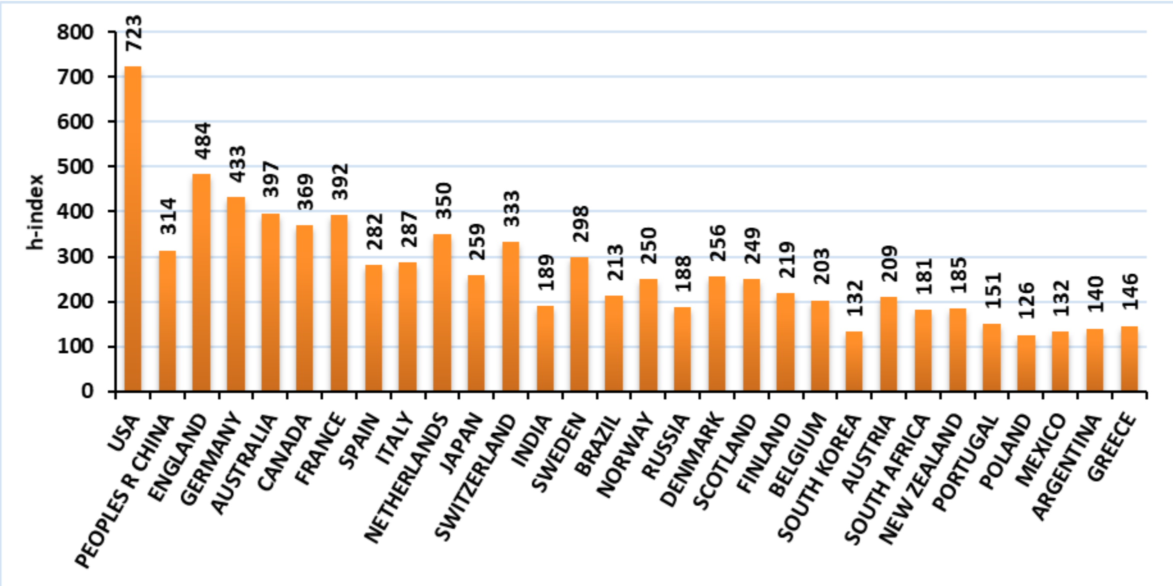


Figure 4.2.1.7: h-index of total publications of top 30 countries

Figure 4.2.1.7 shows the h-index of the total publication of the top 30 countries. The Group average h-index of the total publication of the top 30 countries is 269.67. Twelve countries have a higher h-index than the group average h-index and India ranked 21st (Figure 4.2.1.7). Figure 4.2.1.8 exhibits the period-wise h-index of the top 30 countries. The average h-index of the top 30 countries were increased from 7.93 during the initial period (1985-1989) to 150.50 during 2005-2009 (Table 4.2.1.6) and the h-index of the last two consecutive periods was decreased. The USA ranked the 1st throughout the periods. Fourteen countries have a higher h-index than the group average h-index during the last period (2015-2019) and India ranked 21st position during the last three periods (Table 4.2.1.6).

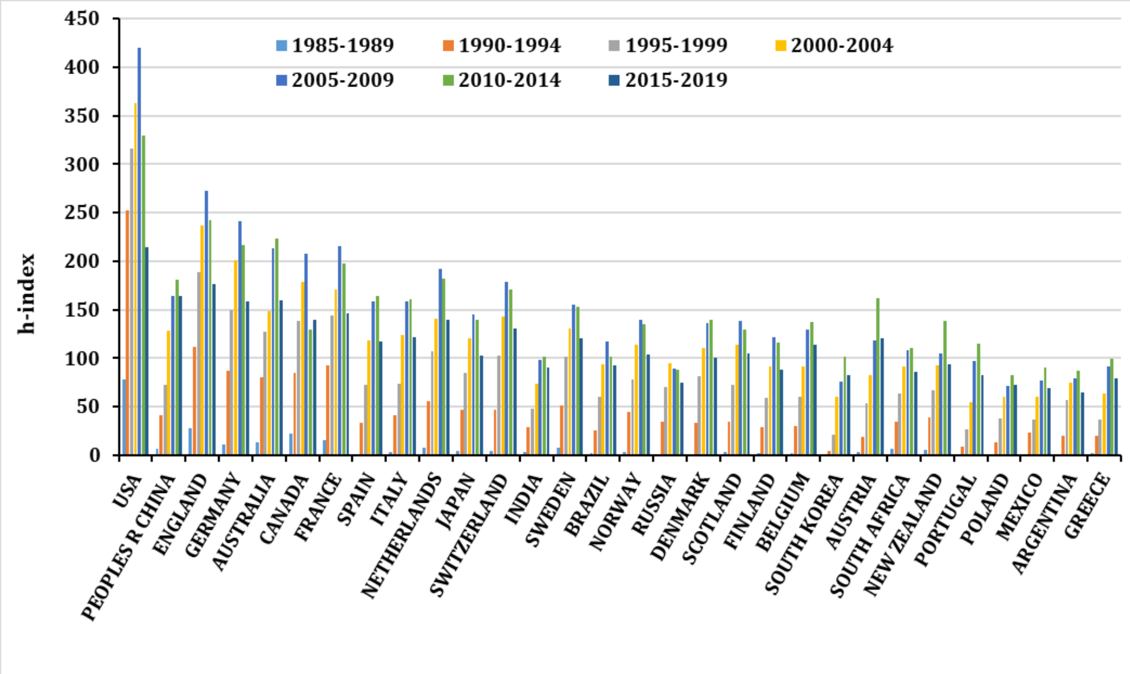


Figure 4.2.1.8: h-index of top 30 countries during different periods

Table 4.2.1.6: Group average of h-index of top 30 countries, number of countries having higher h-index than the group's average h-index among the top 30 countries, India's rank based on the h-index and name of the top countries during different periods.

	Periods						
	1985-1989	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014	2015-2019
Group average h-index of the top 30 countries	7.93	48.90	86.93	120.97	150.50	147.43	113.73
Number of countries having more h-index than the group average	8	8	9	11	12	11	14
India's Rank	15	21	25	25	23	24	21
Group Top	USA	USA	USA	USA	USA	USA	USA

4.2.1.4. Publication's % in country-specific top 100 journals of top 20 countries

It has been observed that the top 100 journals published 41.07 % of total global publications. Figure 4.2.1.9 shows the % of publications in country-specific top 100 journals based on the number of publications of the top 20 countries. The average % of total publications of top 20 countries in country-specific top 100 journals is 53.39%. Ten countries have published more publications in country-specific top 100 journals and India ranked 14th by publishing 51.77% of total Indian publications.

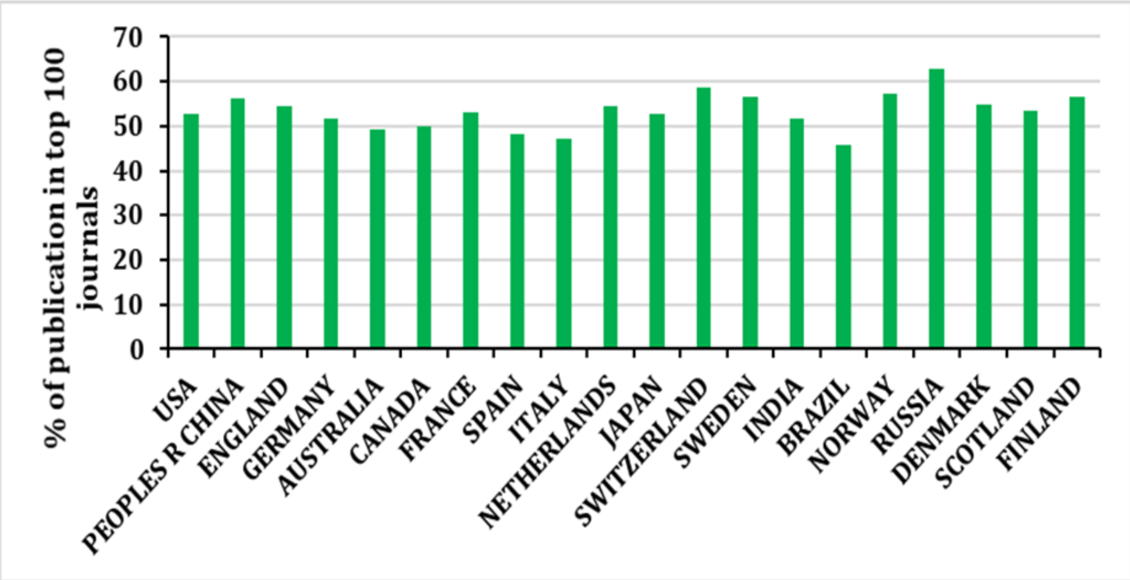


Figure 4.2.1.9: Distribution of publication % in top 100 journals of top 20 countries

4.2.1.5. Average impact factor of country-specific top 100 journals of top 20 countries

The average impact factor of country-specific top 100 journals of top 20 countries is 4.43. Figure 4.2.1.10 shows the average impact factor of country-specific top 100 journals of top 20 countries. Fifteen countries have more average impact factors than the average impact factor of country-specific top 100 journals of top 20 countries. India ranked last with having an average impact factor of 2.97. The average impact factor of individual publications in country-specific top 100 journals of top 20 countries is 4.63. Figure 4.2.1.10 also shows the average impact factor of individual publications in country-specific top 100 journals of top 20 countries. Twelve countries have more average impact factors than the average impact factor of individual publications in country-specific top 100 journals of top 20 countries. India ranked last with having an average impact factor of 2.386.

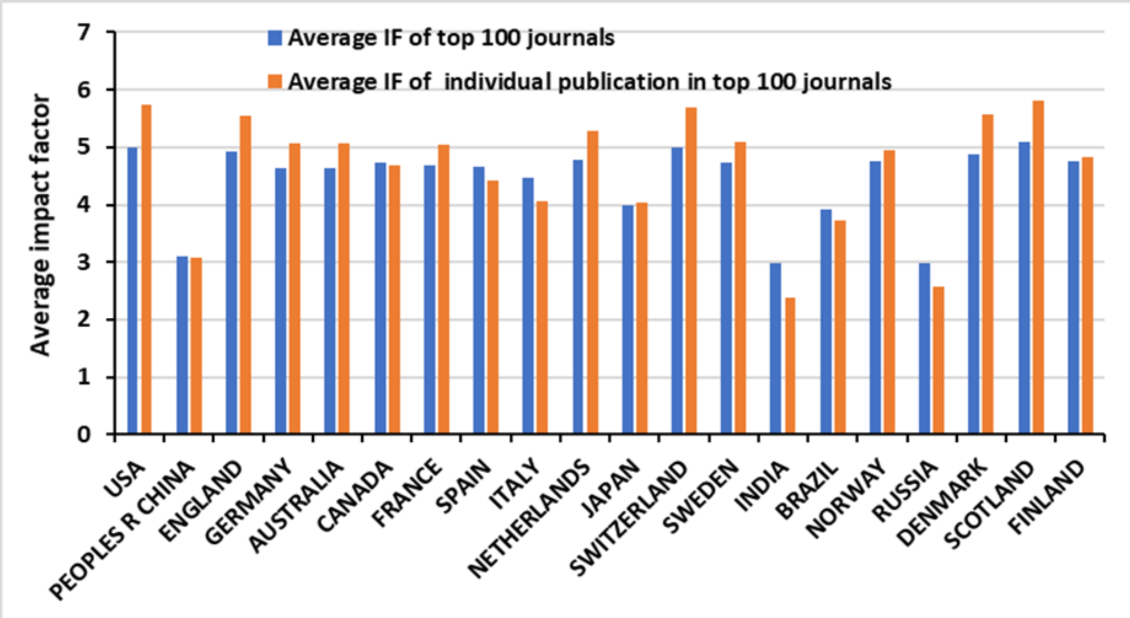


Figure 4.2.1.10: Average Impact Factor of top 100 journals and individual publications in top 100 journals of top 20 countries

4.2.1.6. Publication frequency distribution among different IF categories of country-specific top 100 journal's publication of top 20 countries

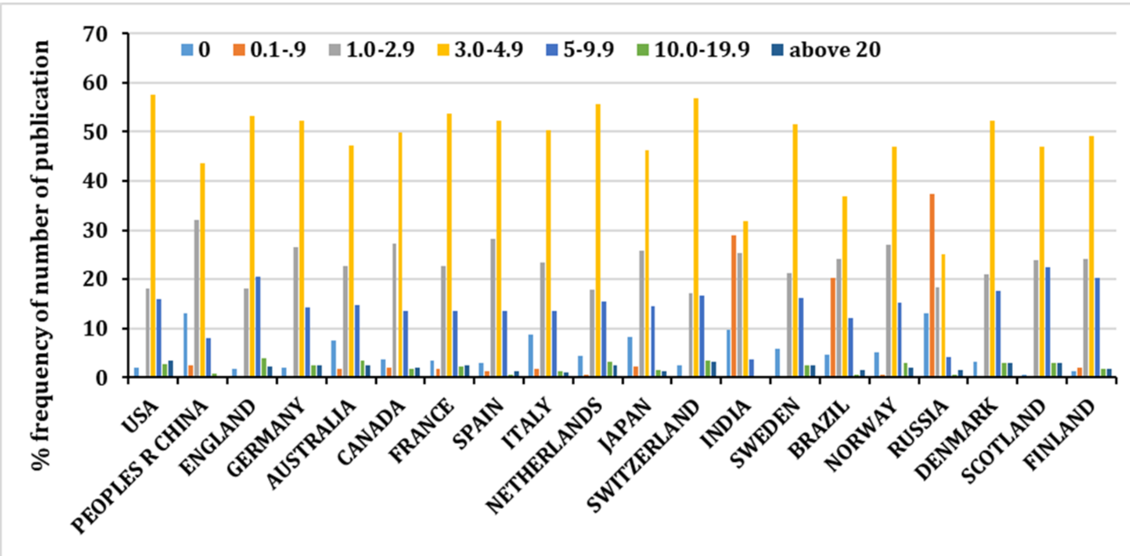


Figure 4.2.1.11: Publication frequency distribution among different IF categories of country-specific top 100 journal's publication of top 20 countries.

Figure 4.2.1.11 shows the publication frequency distribution among different IF categories of country-specific the top 100 journal's publications of top 20 countries. The most frequent publications of the top 20 countries were published in the 3 to 4.99 IF category followed by 1 to 2.99 and 5to 9.99 IF categories.

Above 20 IF was the lowest frequent IF category followed by 10 to 19.99 IF category. Eleven to twelve countries have more frequency than that of the average frequency of the top 20 countries among different IF categories of above IF 1 Table 4.2.1.7. India ranked better in below one and no IF categories. The top in various IF categories are represented in Table 4.2.1.7.

Table 4.2.1.7: Group average of the frequency of top 100 journals among different IF categories of top 20 countries, number of countries having higher frequency distribution than the group's average frequency distribution of top 100 journals among different IF categories of the top 20 countries, India's rank based on the frequency distribution of top 100 journals among different IF categories and name of the top countries during different periods.

Impact Factor	0	0.1-.9	1.0-2.9	3.0-4.9	5-9.9	10.0-19.9	above 20
Group average Frequency distribution	**5.20**	**5.15**	**23.26**	**47.96**	**14.33**	**2.08**	**2.02**
Number of countries having frequency distribution than the group average	**7**	**3**	**11**	**12**	**11**	**11**	**12**
India's Rank	**3**	**2**	**7**	**19**	**20**	**20**	**19**
Group Top	**China**	**Russia**	**China**	**USA**	**Scotland**	**England**	**USA**
Frequency distribution of Indian publications	9.83	28.96	25.24	31.93	3.70	0	0.34

4.2.2. Impact analysis from Scopus database

4.2.2.1. h-index of total publication and Period-wise h-index of top 20 countries

Figure 4.2.2.1 shows the h-index of the total publications of the top 20 countries. The Group average h-index of the total publication of the top 20 countries is 331.55. Eight countries have more h-index than the group average h-index and India ranked 18th (Figure 4.2.2.1). Figure 4.2.2.2 represents the period-wise h-index of the top 20 countries. The average h-index of the top 20 countries were increased from 37.25 during the initial period (1985-1989) to 193.45 during 2005-2009 (Table 2.3.1) and the h-index of the last two consecutive periods was decreased. The USA ranked the 1st throughout the periods. Nine countries have h-index more than the group average h-index during the last period (2015-2019) and India ranked the 17th position for the last two periods (Figure 4.2.2.2).

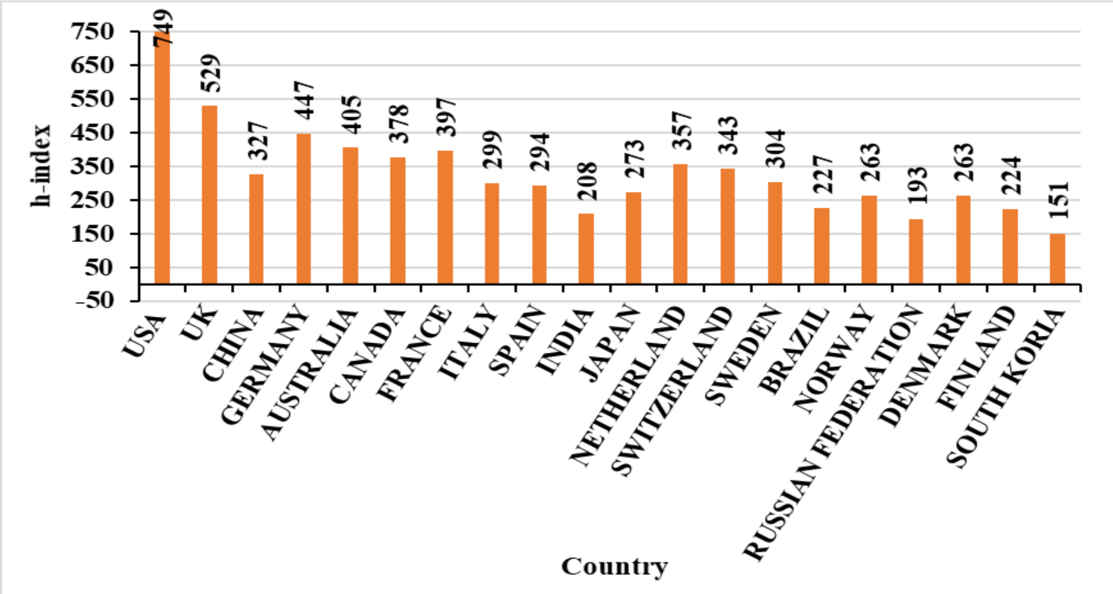


Figure 4.2.2.1: h-index of total publications of top 20 countries

Table 4.2.2.1.: Group average of h-index of top 20 countries, number of countries having more h-index than the group's average h-index among the top 20 countries, India's rank based on the h-index and name of the top countries during different periods.

	Periods						
	1985-1989	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014	2015-2019
Group average h-index of the top 20 countries	37.25	59.9	109.4	155.55	193.45	187.75	141.85
Number of countries having more h-index than the group average	6	6	7	6	7	8	9
India's Rank	10	16	19	19	18	17	17
Group Top	USA	USA	USA	USA	USA	USA	USA

It has been observed that the top 100 journals have published 30.75 % of total global publications. Figure 4.2.3.3 shows the % of publications in country-specific top 100 journals based on the number of publications of the top 20 countries. The average % of total publications of top 20 countries in country-specific top 100 journals is 43.92 %. Ten countries have published more publications in the country-specific top 100 journals and India ranked the last by publishing 36.66 % of total Indian publications.

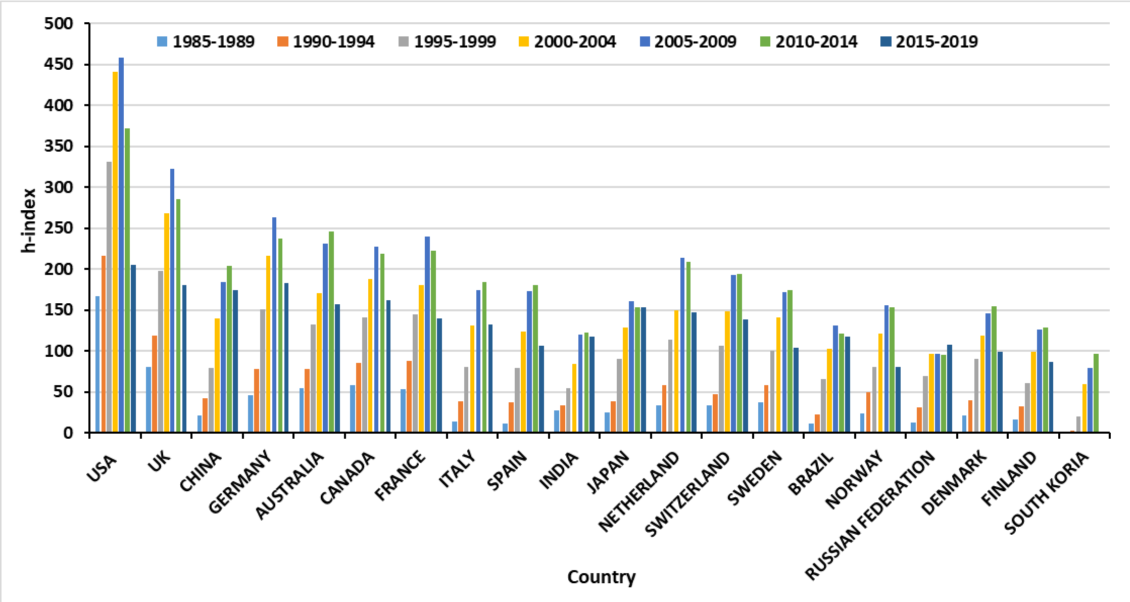


Figure 4.2.2.2.: h-index of top 20 countries during different periods

4.2.2.2. % of publication in country-specific top 100 journals of top 20 countries

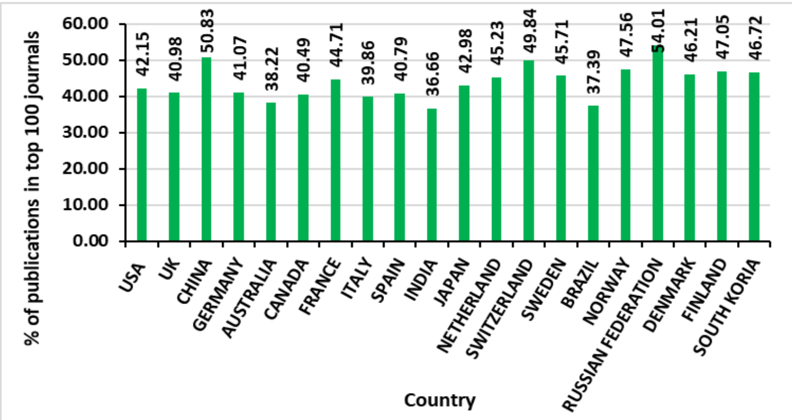


Figure 4.2.2.3.: Distribution of publication % in top 100 journals of top 20 countries

4.2.2.3. Average impact factor of country-specific top 100 journals of top 20 countries

Figure 4.2.2.4 shows the average impact factor of country-specific top 100 journals of top 20 countries. The average impact factor of country-specific top 100 journals of top 20 countries is 4.15. Thirteen countries have more average impact factors than the average impact factor of country-specific top 100 journals of top 20 countries. India ranked 19th with having an average impact factor of 2.88. The average impact factor of individual publications in country-specific top 100 journals of top 20 countries is 4.617.

Figure 4.2.2.4 shows the average impact factor of individual publications in country-specific top 100 journals of top 20 countries. Twelve countries have more average impact factors than the average impact factor of individual publications in country-specific top 100 journals of top 20 countries. India ranked 19th with having an average impact factor of 2.54 per publication.

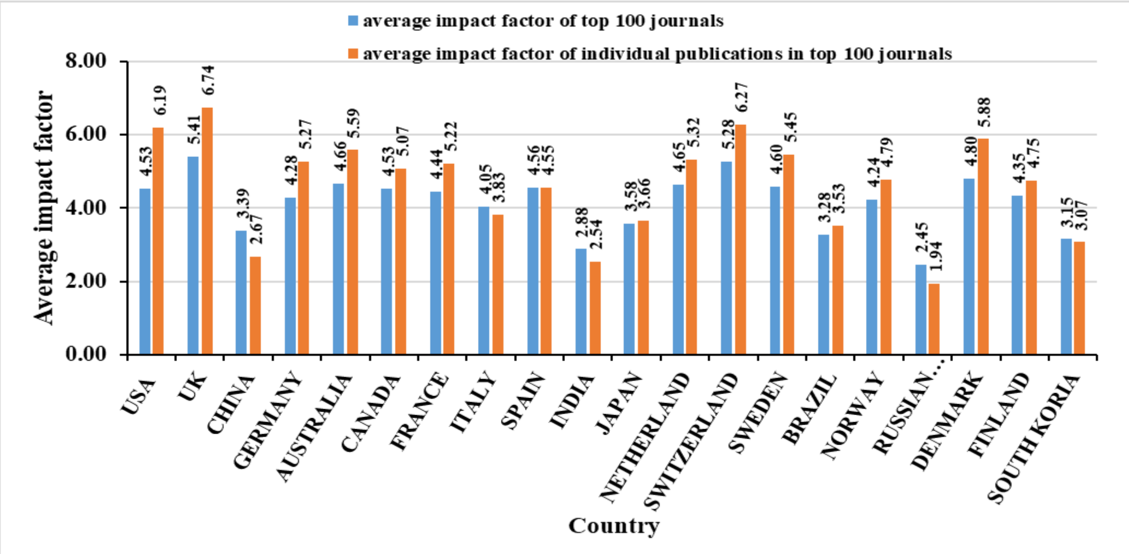


Figure 4.2.2.4: Average Impact Factor of top 100 journals and individual publications in top 100 journals of top 20 countries

4.2.3.4. Publication frequency distribution among different IF categories of country-specific top 100 journal's publication of top 20 countries

Figure 4.2.2.5 shows the publication frequency distribution among different IF categories of country-specific top 100 journal's publications of the top 20 countries. The most frequent publications of the top 20 countries were published in the 3 to 4.99 IF category followed by 1 to 2.99 and 5 to 9.99 IF categories. Above 20 IF was the lowest frequent IF category followed by 10 to 19.99 IF category. Ten to thirteen countries have more frequency than that of the average frequency of the top 20 countries among different IF categories of above IF 1 (Table 4.2.2.3). India ranked better in the below one and no IF categories. The top in various IF categories are represented in Table 4.2.2.3.

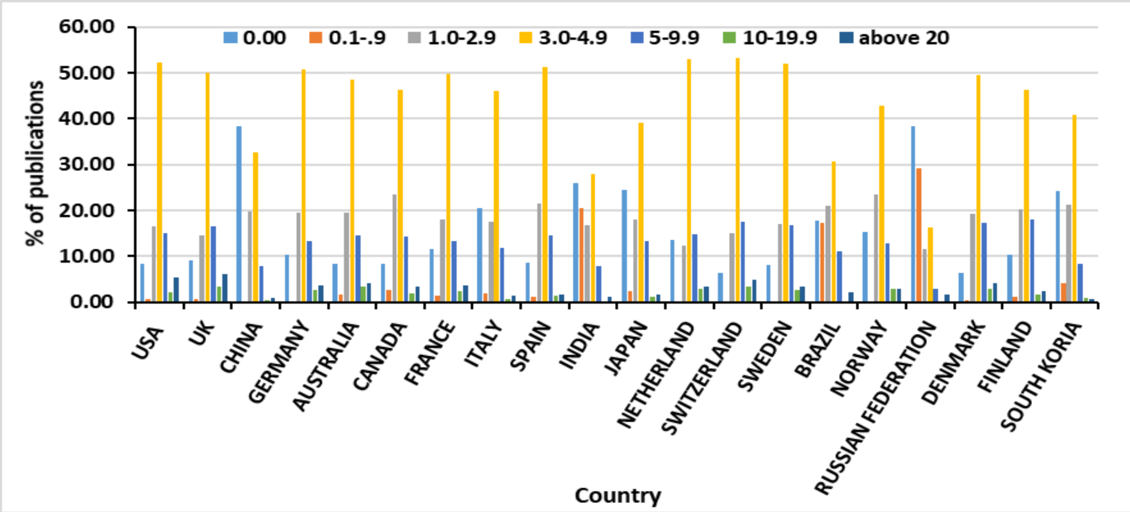


Figure 4.2.2.5: % of publications among different IF categories of country-specific top 100 journal's publication of top 20 countries.

Table 4.2.2.3: Group average of frequency distribution, number of countries having more frequency distribution than the group's average frequency distribution of top 100 journals among different IF categories among the top 20 countries, India's rank and name of the top countries among different IF categories of top 20 countries.

Impact Factor	0	0.1-.9	1-2.9	3 -4.9	5-9.9	10- 19.9	> 20
Group average Frequency distribution	15.70	4.24	18.31	43.95	13.07	1.83	2.89
Number of countries having frequency distribution more than the group average	7	3	10	13	13	10	10
India's Rank	3	2	15	19	19	20	18
Group Top	China	Russian Federation	Norway	Switzerland	Finland	Australia	UK
Frequency distribution of Indian publications	26.07	20.47	16.68	27.99	7.76	0.00	1.03

4.2.3. Indian Citation Index

4.2.3.1. Period-wise total and average citation of global and Indian publication

Figure 4.2.3.1 shows the period-wise total citations of the total global and Indian publications. The total citations of total global and Indian publications were increased slightly during the 2nd period then decreased abruptly during the last period. Whereas, the number of not cited publications of both global and Indian publications were increased at successive periods (Figure 4.2.3.2). The average citation of total global and Indian publications was also decreased at successive periods. It is quite interesting to see the average citation of Indian publications was quite higher than the average citation of total global publications (Figure 4.2.3.3).

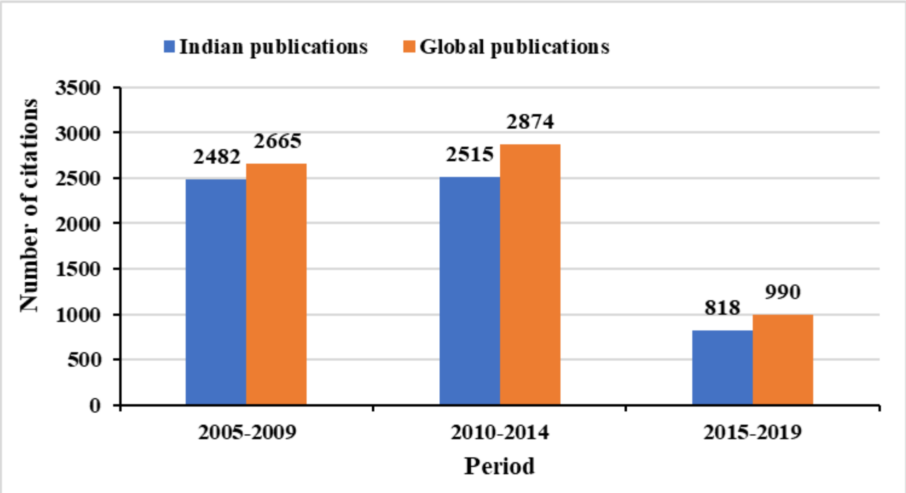


Figure 4.2.3.1: Period-wise total citation of total global and Indian publications

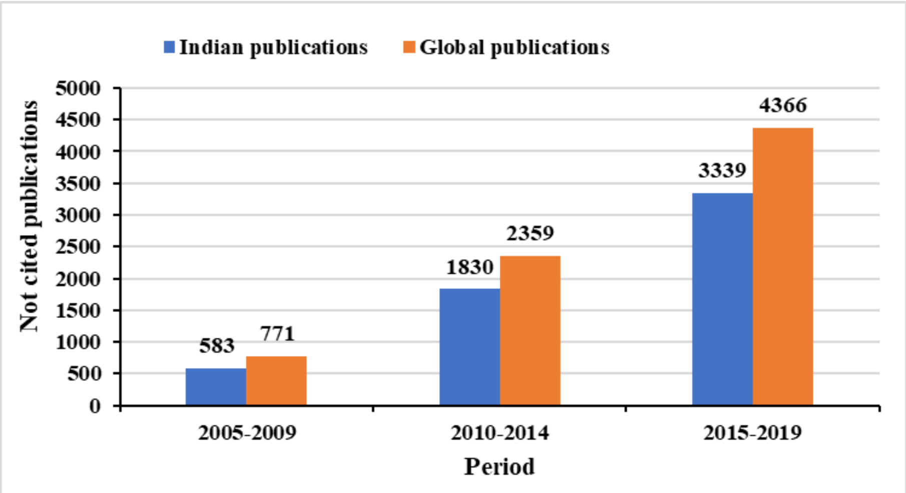


Figure 4.2.3.2: Period-wise number of not cited publications of total global and Indian publications

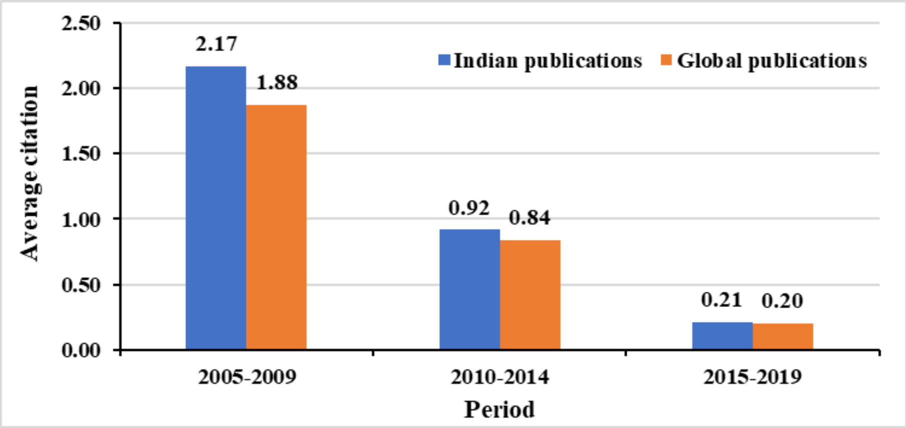


Figure 4.2.3.3: Period-wise average citation of total global and Indian publications

4.2.3.2. Period-wise h-index of global and Indian publication

Figure 4.2.3.4 shows the period-wise h-index of the total global and Indian publications. The h-index of total global publications and Indian publications were decreased at successive periods. The h-indices of both of the global and Indian publications were the same during the 1st (20) and 2nd (14) periods. During the last period, the h-index of global publication (7) was higher as compared to the h-index of Indian publications (6).

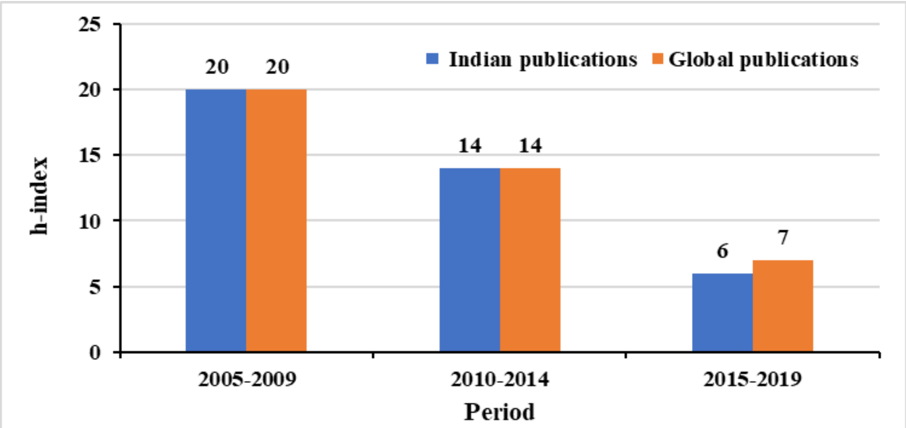


Figure 4.2.3.4: Period-wise h-index of total global and Indian publications

4.3. Research collaboration of India with different countries

4.3.1. Analysis from Web of Science database

4.3.1.1. Period-wise growth of Number of Collaborating countries of top 20 countries

Figure 4.3.1.1 represents the period-wise growth of the number of collaborating countries of the top 20 countries. The average number of collaborating countries of the top 20 countries were increased from 5.1 during the initial period (1985-1989) to 180.1 during 2015-2019 (Table 4.3.1.1). In the case of India, it was increased from 2 to 172. The USA was the most collaborating country throughout the period. Eight countries have collaborated with more countries than the group average during the last period (2015-2019) and India ranked the 15th position during the last period.

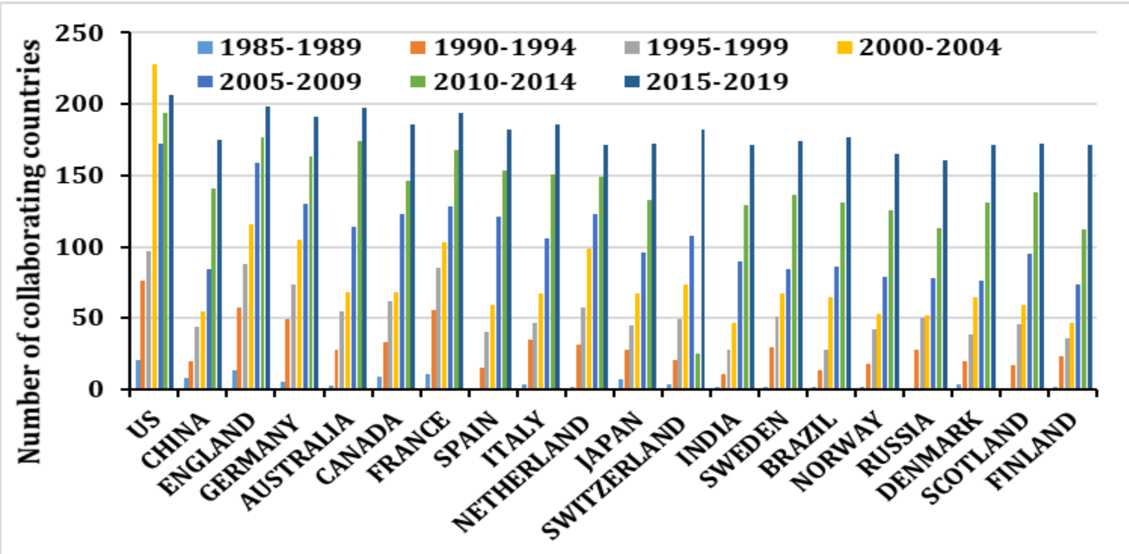


Figure 4.3.1.1: Number of collaborating countries of top 20 countries during different periods

Table 4.3.1.1: Group average of the number of collaborating countries of top 20 countries, number of countries having more collaborating countries than the group's average collaborating countries among the top 20 countries, India's rank based on the collaborating countries and name of the top countries during different periods.

	Periods						
	1985-1989	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014	2015-2019
Average number of collaborating countries of the top 20 countries	5.1	30.45	53.15	78.2	106.3	139.5	180.1

Number of countries having more collaborating countries than the average	6	7	7	5	9	10	8
India's Rank	11	20	19	19	13	15	15
Group Top	USA	USA	USA	USA	USA	USA	USA
Number of collaborating countries of India	2	11	28	47	90	129	172

Figure 4.3.1.2 represents the research collaboration among the top 20 countries of the total global climate change research. The size of the nodes proportional to the number of publications by each country; the size of the edges proportional to the number of collaborative publications with different countries. Colour of nodes indicating the different clusters based on the quantum of publications. The USA was the most collaborating country followed by China. All developed countries have strong collaboration linkages among them. The strength of Indian collaboration linkages with top countries is very weak even these are lower than the collaboration linkages of the same or lower publication's group.

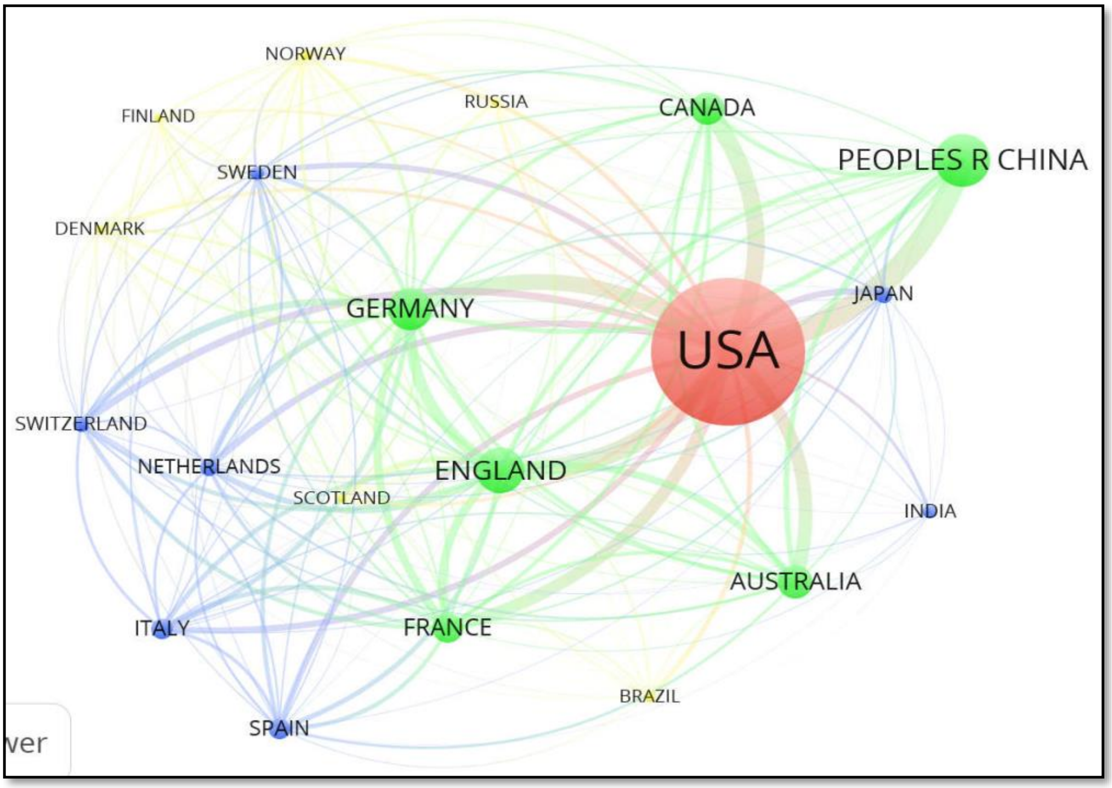


Figure 4.3.1.2: Collaboration network map among top 20 countries. The size of the nodes proportional to the number of publications by each country; the size of the edges proportional to the number of collaborative publications with different countries. Colour of nodes indicating the different clusters based

on the quantum of publications (red colour for more than 100000 publications, Green colour for more than 20000 publications, blue colour for more than 10000 publications, yellow colour for less than 10000 publications.

4.3.1.2. Indian research collaboration

Figure 4.3.1.3 represents the research collaboration network with the top 50 collaborating countries of Indian research on climate change. India has published the maximum collaborative research publications with the USA followed by England, Germany and France (Figure 4.3.1.4).

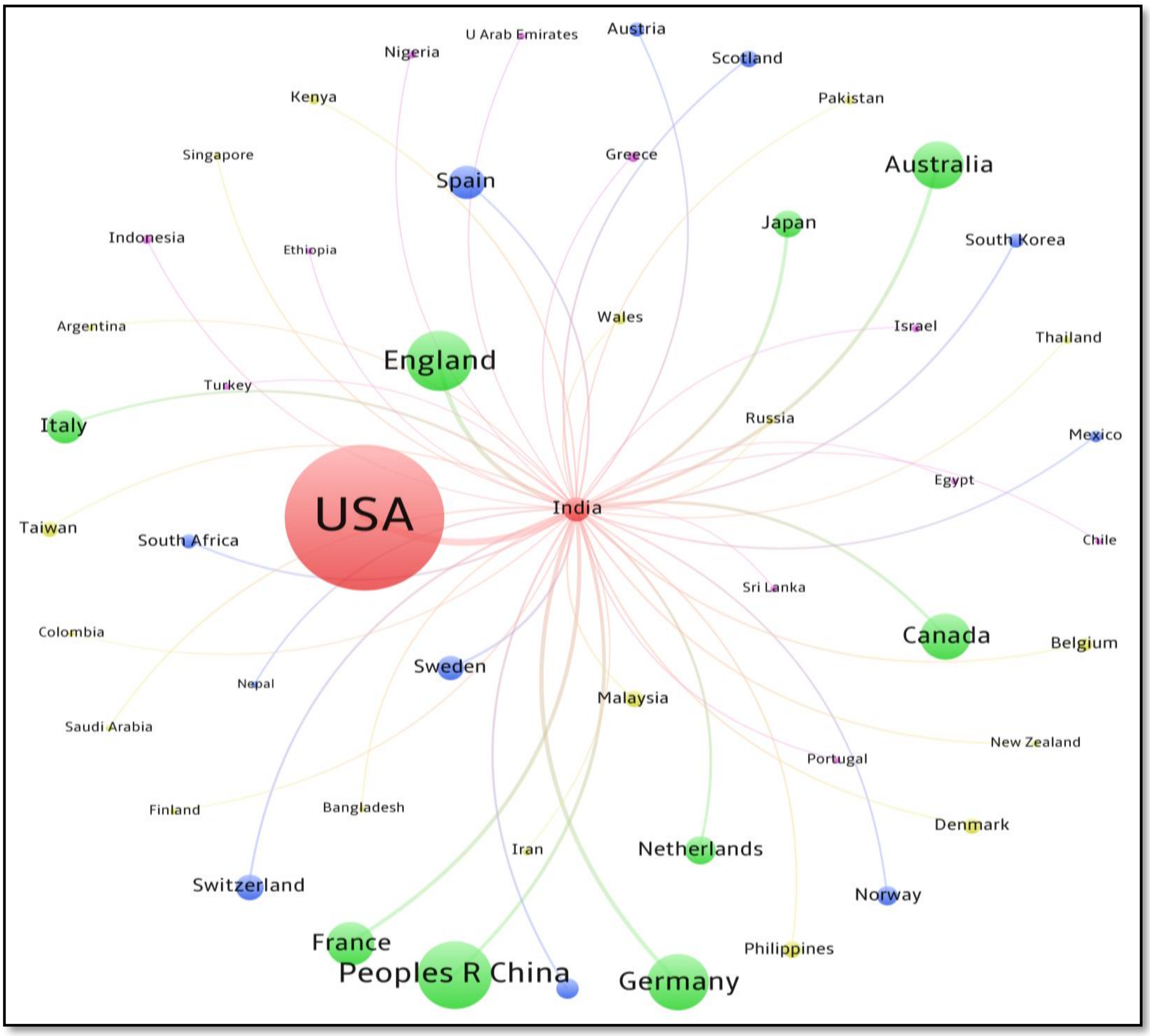


Figure 4.3.1.3: India's international collaboration network map with top 50 countries. The size of the nodes proportional to the number of total publications by each country; the size of the edges proportional to the number of India's collaborative publications with each country. Colour of nodes indicating the different clusters based on the quantum of collaborative publications (red colour for more than 1500

collaborative publications, green colour for more than 200 collaborative publications, blue colour for more than 100 collaborative publications, yellow colour for more than 500 collaborative publications, violet colour for less than 50 collaborative publications.

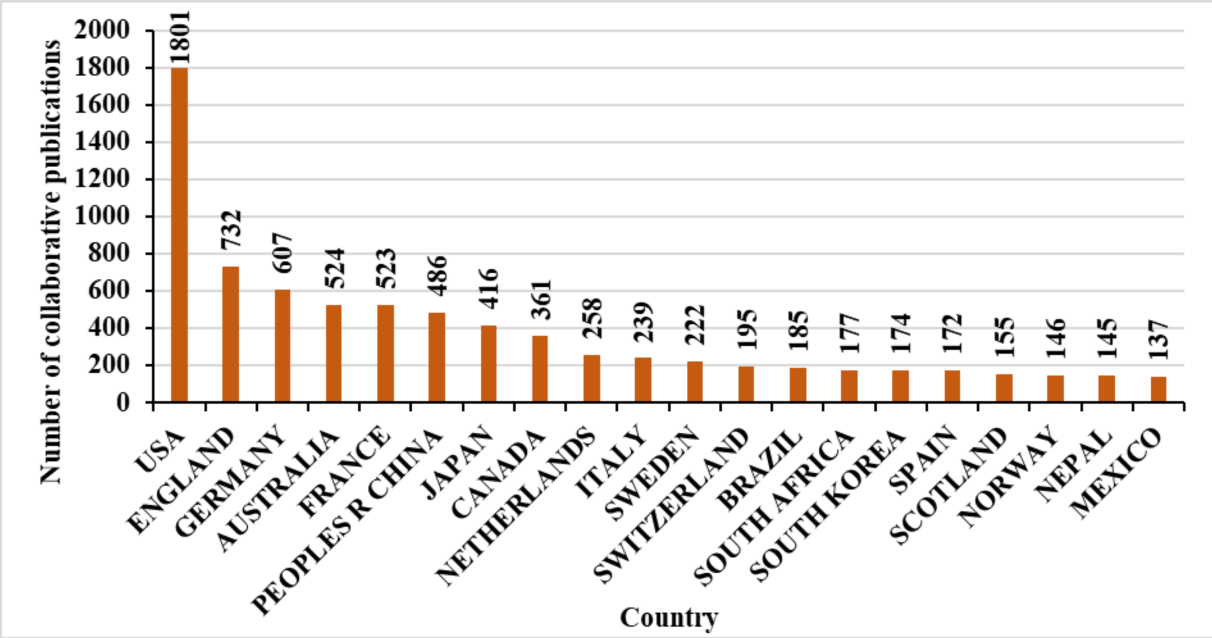


Figure 4.3.1.4: Number of collaborative publications of India with India's top 20 collaborating countries.

4.3.1.3. Impact of Indian Collaborative research

It has been observed that 31.97 % of total Indian publications were collaborative in nature. Among the total of 14663 Indian publications, 4022 (27.43 %) publications were published from the collaboration with the top 20 India's collaborating countries. Only 639 (4.36 %) publications were published in collaboration with the rest of the collaborating countries of India (Figure 4.3.1.5). Total Indian publications received 321021 citations. The 27.43% of total Indian publications with the top 20 Indian collaborating countries received 50.89 % (163396 citations) of the total Indian citations (Figure 4.3.1.6). Therefore, the average citations of the collaborative publications with the top 20 India's collaborating countries were about two times greater than that of the average citations of total Indian publications (Figure 4.3.1.7). The average citations of the collaborative publications with the rest of the collaborating countries of India were slightly lower than that of the total Indian publications.

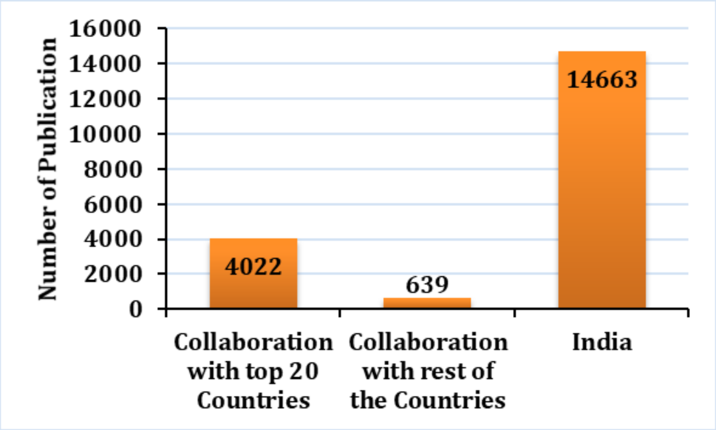


Figure 4.3.1.5: India's number of total publications, publications with top 20 collaborating countries and publications with the rest of the collaborating countries

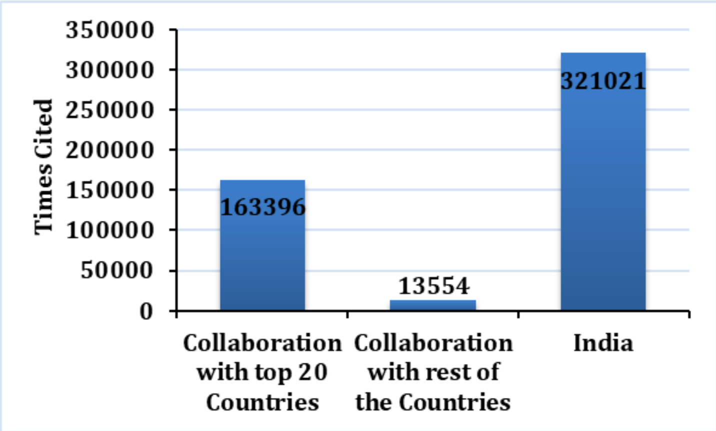


Figure 4.3.1.6: India's total citation of total publications, total citation of publications with top 20 collaborating countries and total citation of collaborating publications with the rest of the countries

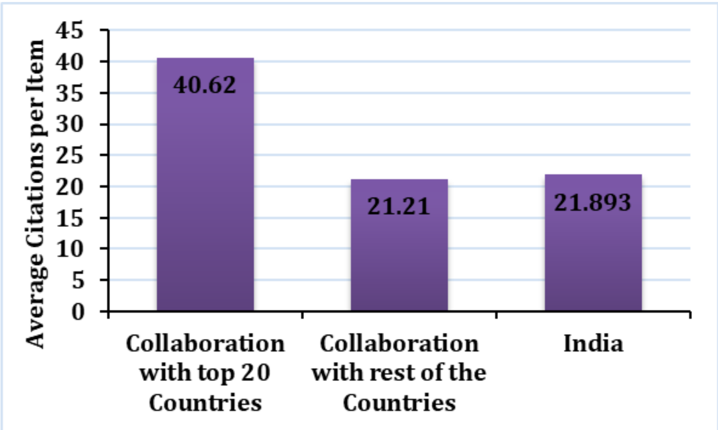


Figure 4.3.1.7: India's average citation of total publications, average citation of publications with top 20 collaborating countries and average citation of collaborating publications with the rest of the countries

Figure 4.3.1.8 representing the h-index of the total Indian publications, collaborative publications with the top 20 India's collaborating countries and the collaborative publications with rest of the India's collaborating countries. There is very less difference between the h-index of total Indian publications and collaborated publications with top 20 countries as compared to the number of publications. About 13.45 % of the total Indian publications have no citation. The percentage of publications without any citation is very lower (5.20%) for the top 20 India's collaborating countries as compared to the total Indian publications. About 9.86 % of the collaborative publications with rest of the India's collaborating countries were without any citations that are also lower than that of total Indian publications (Figure 4.3.1.9).

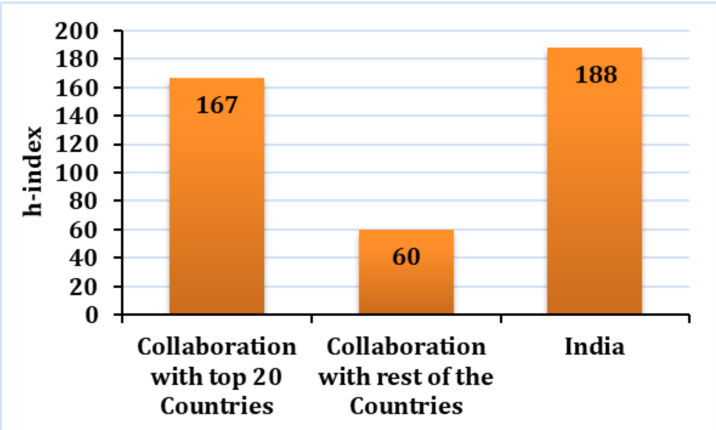


Figure 4.3.1.8: India's h-index of total publications, h-index of publications with top 20 collaborating countries and h-index of collaborating publications with the rest of the countries

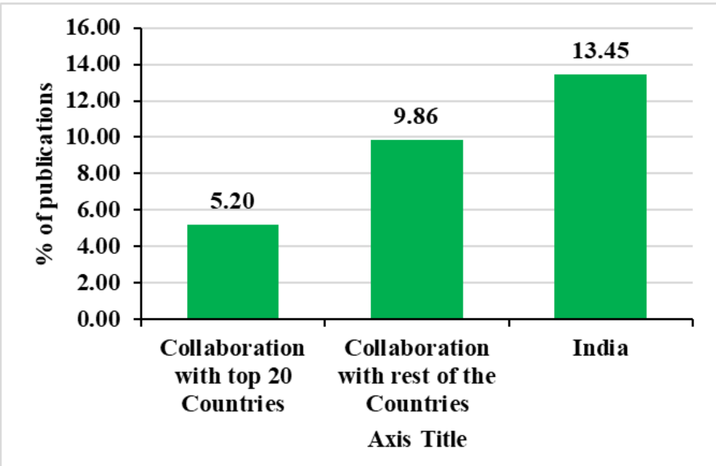


Figure 4.3.1.9: India's % of publications without any citation of total publications, collaborative publications with top 20 countries and collaborative publications with the rest of the countries

4.3.1.4. Collaborative national and International Organizations:

Figure 4.3.1.10 shows the number of publications by the top 20 Indian Collaborative Institute and Figure 4.3.1.11 shows the top 20 international collaborative institutes. Indian Institute of Technology system is the most collaborative organization from India followed by the Ministry of Earth Sciences, Council of Scientific & Industrial research. Centre National De La Recherche Scientifique CNRS is the most collaborative international organization in Indian collaborative research.

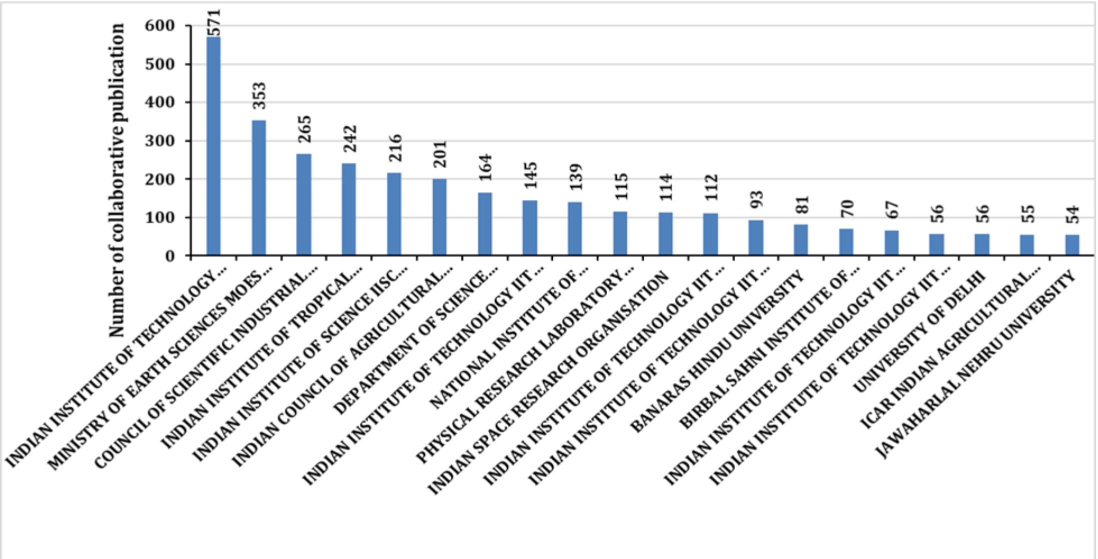


Figure 4.3.1.10: Top 20 Indian Collaborative Institute and their number of collaborative publications with India

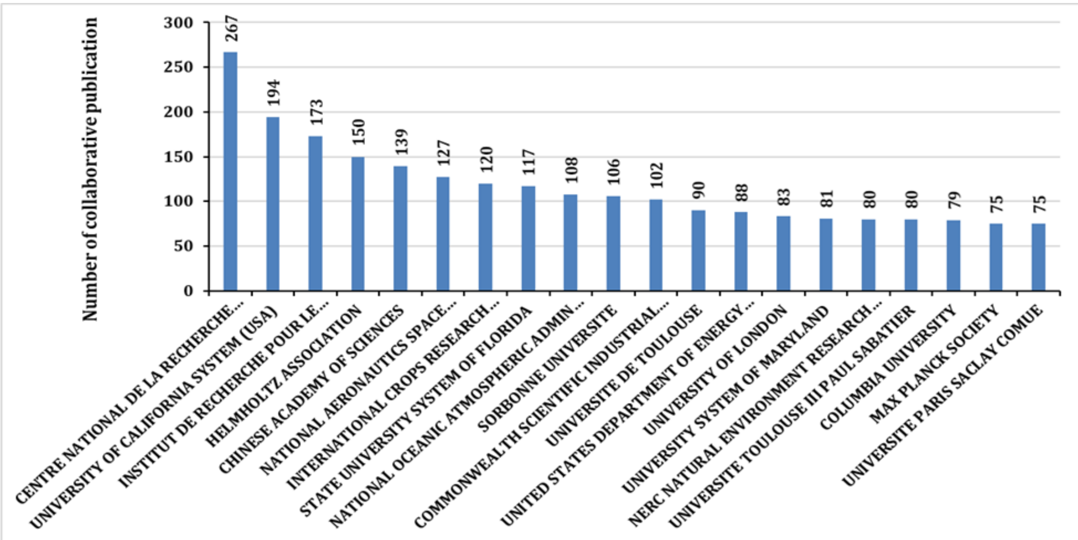


Figure 4.3.1.11: Top 20 International Collaborative Institute and their number of collaborative publications with India

4.3.1.5. Collaboration network among the top 100 organisations of Indian publications

Figure 4.3.1.11 shows the collaboration network of the top 100 Indian organization of total Indian climate change research. Table 4.3.1.2 represents the name of the top 100 collaborative organisations of Indian publications and their number of collaboration links, total link strength, number of documents, total citations, and average citations. Interestingly, the Indian publication is not in the leading position among the top 100 organizations of Indian climate change collaboration research. Indian Institution Tropical Meteorology registered with 10th rank and this the only organization based on total Link strength within the top 20 organization. Chinese Academy of Sciences registered the highest collaboration link strength in Indian climate change research collaboration followed by Columbia University, University of Washington, University of California San Diego, The University of Maryland, The University of Tokyo.

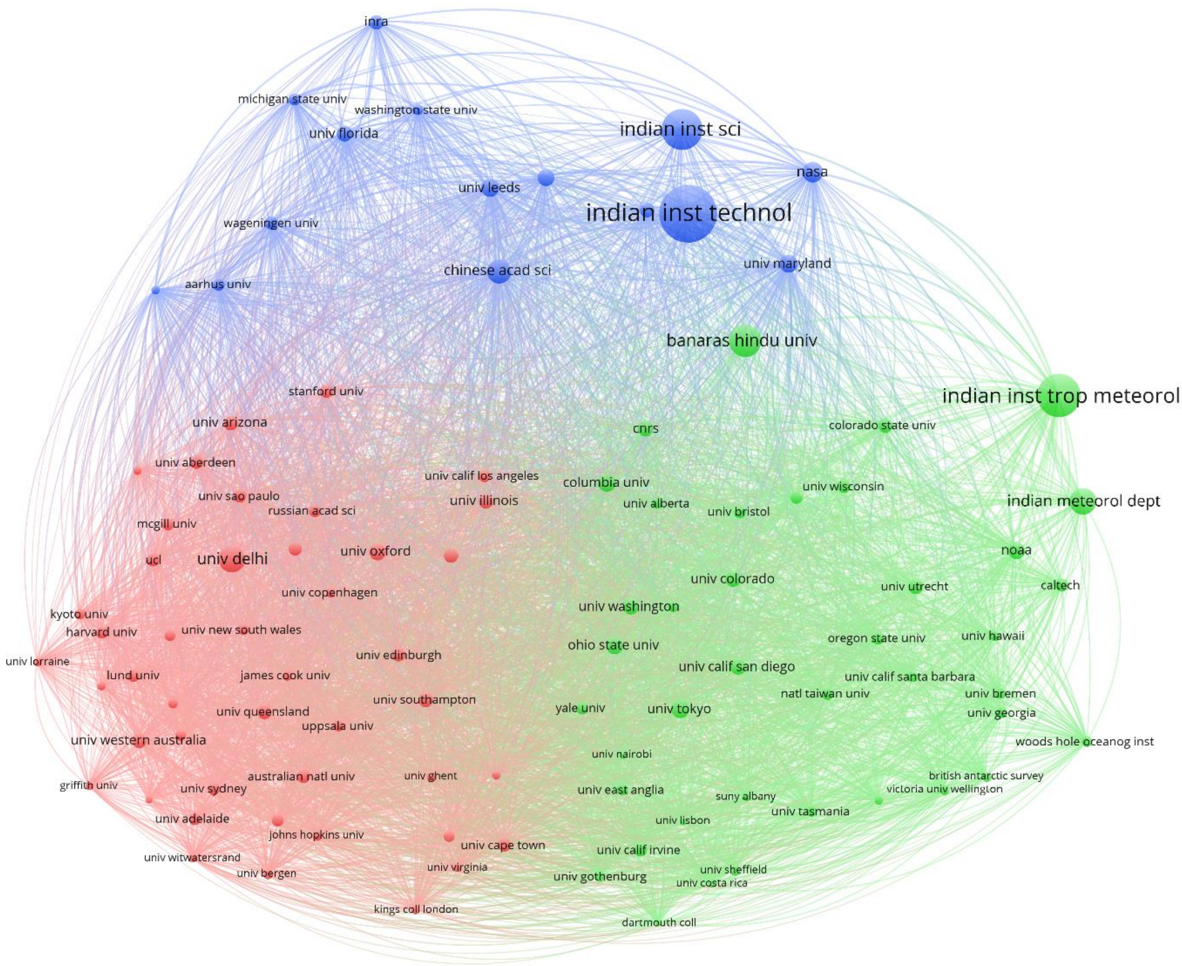


Figure 4.3.1.11: Collaboration network among top 100 organisations of Indian publications.

Table 4.3.1.2: Name of the top 100 collaborative organisations of Indian publications and their Number of collaboration links, total link strength, number of documents, total citations, and average citations.

Rank	Label	Links	Total Link Strength	Number of documents	Total Citations	Average Citations
1	Chinese Acad Sci	99	648	160	10486	65.5375
2	Columbia Univ	99	643	90	9957	110.6333
3	Univ Washington	99	631	59	10214	173.1186
4	Univ Calif San Diego	98	586	60	11193	186.55
5	Univ Maryland	97	523	94	5088	54.1277
6	Univ Tokyo	98	496	85	11872	139.6706
7	Univ Colorado	98	491	66	9876	149.6364
8	Yale Univ	98	466	32	7831	244.7188
9	Univ Oxford	98	462	72	12326	171.1944
10	Indian Inst Trop Meteorol	73	461	651	18774	28.8387
11	Univ Calif Irvine	97	460	43	8740	203.2558
12	NASA	80	456	110	8113	73.7545
13	Ohio State Univ	98	454	70	7075	101.0714
14	Univ Leeds	98	444	86	6291	73.1512
15	Univ Melbourne	99	443	52	6871	132.1346
16	Univ Gothenburg	96	422	30	5240	174.6667
17	Univ Alberta	98	418	30	6198	206.6
18	Univ Cape Town	97	416	45	6720	149.3333
19	Australian Natl Univ	98	403	41	8666	211.3659
20	Aarhus Univ	92	396	32	6614	206.6875
21	Univ Tasmania	96	394	27	4553	168.6296
22	NOAA	83	391	81	10258	126.642
23	Univ Sao Paulo	94	377	45	6139	136.4222
24	Univ Ghent	98	369	21	5204	247.8095
25	Wageningen Univ	89	364	48	8628	179.75
26	Texas A&M Univ	87	363	73	7182	98.3836
27	Univ Queensland	92	361	50	7758	155.16
28	Russian Acad Sci	92	360	35	7543	215.5143
29	Univ Arizona	93	358	54	9727	180.1296
30	Univ Copenhagen	97	352	22	7979	362.6818
31	Univ Southampton	98	343	49	6701	136.7551

32	Oregon State Univ	90	341	36	2448	68
33	Univ Lisbon	95	338	12	2629	219.0833
34	Univ Florida	91	334	69	6346	91.971
35	Natl Taiwan Univ	96	331	35	2619	74.8286
36	Stanford Univ	93	330	40	8506	212.65
37	Univ Oslo	98	327	26	9163	352.4231
38	Univ Utrecht	87	326	53	3666	69.1698
39	Univ Edinburgh	96	324	45	5809	129.0889
40	Suny Albany	96	324	14	3822	273
41	Univ Sheffield	96	322	19	3652	192.2105
42	Univ Costa Rica	95	322	13	4263	327.9231
43	Monash Univ	90	321	43	6660	154.8837
44	Univ Western Australia	90	318	56	6742	120.3929
45	UCL	91	318	48	7721	160.8542
46	Univ Toronto	89	317	27	5208	192.8889
47	Uppsala Univ	98	313	25	6955	278.2
48	Univ Zurich	98	311	31	4747	153.129
49	Univ Hohenheim	83	310	18	5745	319.1667
50	Indian Inst Technol	73	307	1261	32599	25.8517
51	Colorado State Univ	86	305	53	3904	73.6604
52	Univ Aberdeen	89	302	48	7815	162.8125
53	Univ Helsinki	91	302	25	5730	229.2
54	Univ New South Wales	93	302	25	4553	182.12
55	Univ Adelaide	89	301	35	6533	186.6571
56	Univ Virginia	98	298	16	7715	482.1875
57	Univ Bergen	89	296	19	5359	282.0526
58	Kings Coll London	94	294	17	7319	430.5294
59	Univ Bristol	99	289	32	3071	95.9688
60	Univ Calif Los Angeles	95	288	37	5544	149.8378
61	Univ Sydney	88	287	34	6709	197.3235
62	Univ British Columbia	90	287	32	7606	237.6875
63	Johns Hopkins Univ	96	287	19	5288	278.3158
64	Univ Witwatersrand	89	287	15	6955	463.6667
65	Victoria Univ Wellington	85	285	21	2031	96.7143
66	Univ Nairobi	95	284	11	2704	245.8182
67	Univ S Florida	97	283	18	2934	163

68	Harvard Univ	86	282	35	7161	204.6
69	Univ Delhi	87	277	200	8361	41.805
70	Washington State Univ	94	275	27	3120	115.5556
71	Lund Univ	91	274	34	6681	196.5
72	Univ Bremen	72	274	28	1144	40.8571
73	Univ Hawaii	86	273	24	3571	148.7917
74	Imperial Coll London	88	273	20	4702	235.1
75	Univ Calif Santa Barbara	87	268	27	1835	67.963
76	Michigan State Univ	81	266	36	3861	107.25
77	Kyoto Univ	87	266	27	4889	181.0741
78	British Antarctic Survey	82	266	21	1741	82.9048
79	Caltech	74	265	48	1835	38.2292
80	Woods Hole Oceanog Inst	73	264	30	1747	58.2333
81	INRA	62	260	56	3235	57.7679
82	Queensland UnivTechnol	86	260	15	4817	321.1333
83	Dartmouth Coll	92	258	8	3352	419
84	Sun Yat Sen Univ	82	257	18	4625	256.9444
85	James Cook Univ	91	255	23	5774	251.0435
86	Univ Fed Minas Gerais	86	255	13	5447	419
87	Univ Illinois	96	254	55	6745	122.6364
88	Univ Wisconsin	87	253	40	3922	98.05
89	Indian Meteorol Dept	67	251	210	6116	29.1238
90	Griffith Univ	85	249	17	5608	329.8824
91	Univ East Anglia	95	248	26	2554	98.2308
92	CNRS	87	247	64	3490	54.5312
93	Univ Lorraine	81	247	15	4478	298.5333
94	Stockholm Univ	82	246	39	4950	126.9231
95	Univ Saskatchewan	96	245	17	2734	160.8235
96	McgillUniv	90	242	36	6596	183.2222
97	Univ Georgia	76	238	30	1592	53.0667
98	Univ Reading	81	224	51	5403	105.9412
99	Indian Inst Sci	72	210	568	20775	36.5757
100	Banaras Hindu Univ	83	190	337	8224	24.4036

4.3.1.6. Collaboration network among top 500 authors of Indian publications

Figure 4.3.1.12 represents the Indian author's collaboration networks map among the top 500 authors of the total Indian climate change research. The size of the nodes proportional to the number of total publications by each author; the size of the edges proportional to the total strength of the total collaborative publications with each author. Different colour of nodes indicating the different clusters based on the quantum of collaboration of authors. Table 4.3.1.3 represents the name of the top 50authors among the top 500 collaborative authors of Indian publications and their number of collaboration links, total link strength, number of documents, total citations, and average citations of Indian collaborative research on climate change. KUMAR, A registered with the highest number of collaborations with 247 authors in 287 publications, and with 973 collaboration strength followed by SINGH, AK and SINGH, R number of collaboration of authors of 163 and 149 with link strength of 644.

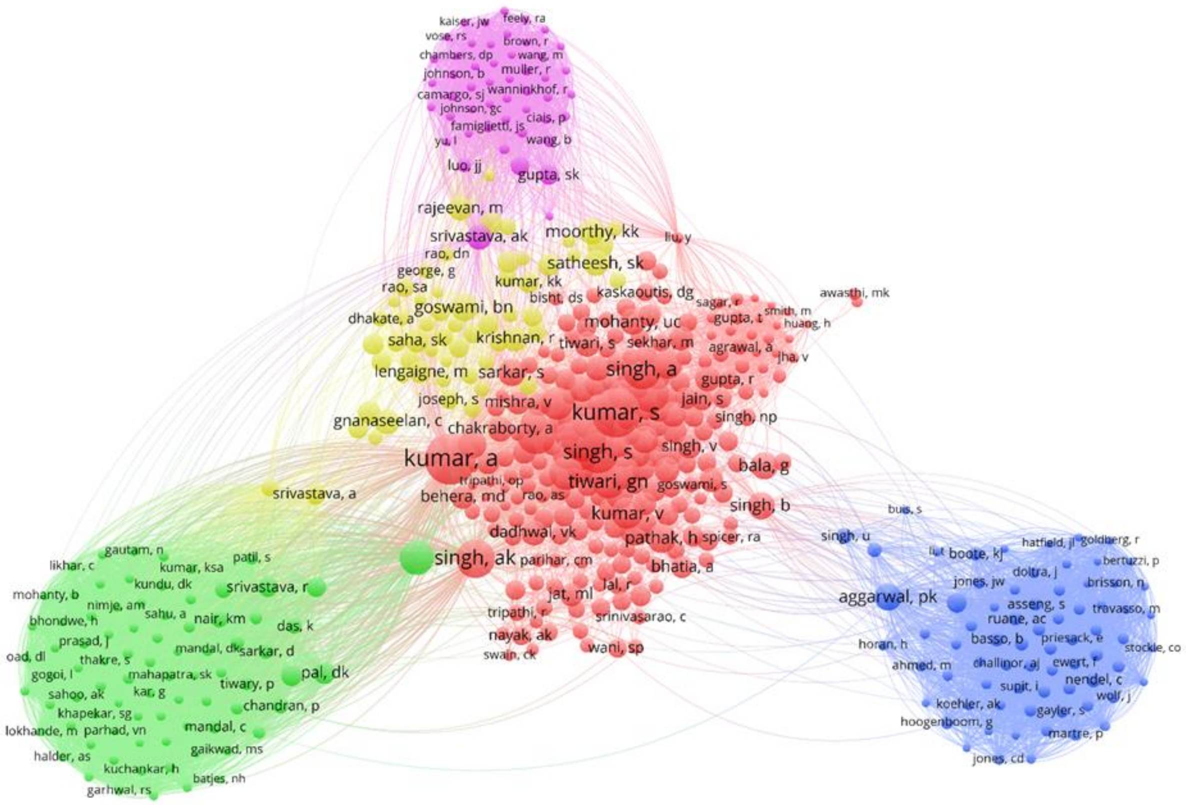


Figure 4.3.1.12: Collaboration network among top 500 authors of Indian publications

Table 4.3.1.3: Name of the top 50authors among top 500 collaborative authors of Indian publications and their Number of collaboration links, total link strength, number of documents, total citations and average citations.

Rank	Name of authors	Links	Total Link Strength	Number of documents	Total Citations	Average Citations
1	KUMAR, A	247	973	287	3226	11.2404
2	SINGH, AK	163	664	148	1882	12.7162
3	SINGH, R	149	644	114	1747	15.3246
4	PAL, DK	90	603	40	899	22.475
5	BHATTACHARYYA, T	91	598	36	719	19.9722
6	MAHAPATRA, S	121	576	22	525	23.8636
7	CHANDRAN, P	90	565	20	236	11.8
8	AGGARWAL, PK	97	564	68	3539	52.0441
9	RAY, SK	90	564	21	319	15.1905
10	SINGH, RS	101	555	32	394	12.3125
11	TIWARY, P	89	531	13	63	4.8462
12	MANDAL, C	86	530	14	140	10
13	SARKAR, D	93	527	19	274	14.4211
14	KUMAR, SN	79	526	34	1769	52.0294
15	VENUGOPALAN, MV	91	523	12	89	7.4167
16	NAIR, KM	88	520	21	363	17.2857
17	NENDEL, C	72	520	15	1802	120.1333
18	PRASAD, J	86	514	12	241	20.0833
19	SAHU, A	86	513	10	72	7.2
20	VELMOUROUGANE, K	86	513	9	95	10.5556
21	KERSEBAUM, KC	72	510	14	1773	126.6429
22	DURGE, SL	87	509	10	160	16
23	SRIVASTAVA, R	99	508	34	519	15.2647
24	BASSO, B	74	507	15	1805	120.3333
25	NIMKAR, AM	86	507	8	57	7.125
26	DAS, K	95	506	18	167	9.2778
27	MAJUMDAR, S	98	506	11	77	7
28	BIERNATH, C	72	503	12	1751	145.9167

29	GAYLER, S	72	503	12	1751	145.9167
30	PRIESACK, E	72	503	12	1751	145.9167
31	ASSENG, S	73	502	14	1579	112.7857
32	KUCHANKAR, H	86	502	7	46	6.5714
33	SHEIKH, S	86	502	7	46	6.5714
34	TELPANDE, BA	86	502	7	46	6.5714
35	KUMAR, KSA	87	500	9	43	4.7778
36	SRINIVAS, S	89	500	12	63	5.25
37	KOYAL, A	87	499	8	39	4.875
38	NIMJE, AM	86	498	7	48	6.8571
39	SUPIT, I	72	498	12	1512	126
40	KUNDU, DK	87	496	10	59	5.9
41	MANDAL, DK	87	496	11	45	4.0909
42	SIDHU, GS	87	496	8	76	9.5
43	WALLACH, D	72	495	12	1494	124.5
44	ANANTWAR, SG	86	494	7	46	6.5714
45	BOBADE, SV	86	494	7	46	6.5714
46	EWERT, F	72	494	12	1503	125.25
47	GAIKWAD, MS	86	494	7	46	6.5714
48	MAHAPATRA, SK	87	494	9	46	5.1111
49	PALOSUO, T	72	494	12	1503	125.25
50	GAUTAM, N	87	493	7	41	5.8571

4.3.1.7. Bibliographic coupling among the top 100 organisations of Indian publications

Figure 4.3.1.13 presents the bibliographic coupling network of the top 100 organization of Indian climate change research. Table 4.3.1.4 represents the name of the top 100 co-cited organisations of Indian publications and their number of co-citation links, total link strength, number of documents, total citations, and average citations. Indian Institution of Tropical Meteorology registered with the highest number of co-citation among the top 100 organisations of bibliographic coupling of organizations followed by another Indian organisation India Meteorological Department.

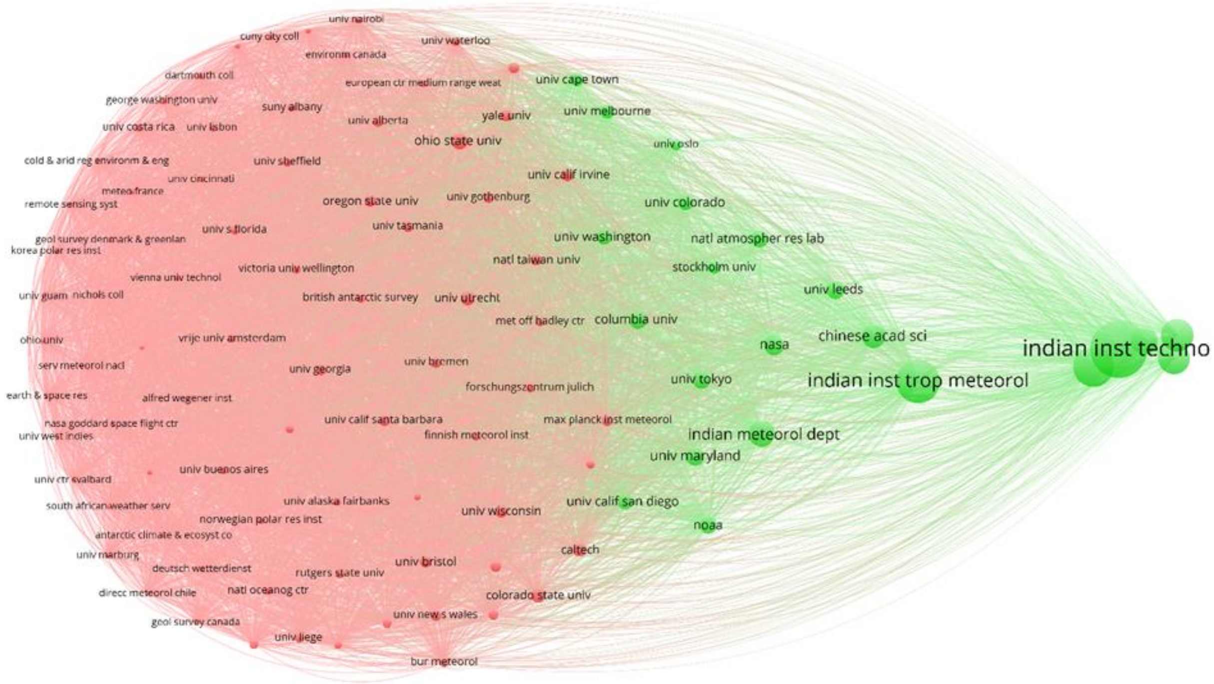


Figure 4.3.1.13: Bibliographic coupling network map of the top 100 organisations of Indian climate change research publications

Table 4.3.1.4: Name of the top 100 organisations of bibliographic coupling network of Indian publications and their Number of co-citation links, total link strength, number of documents, total citations and average citations.

Rank	Name of organizations	Links	Total Link Strength	Number of documents	Total Citations	Average Citations
1	Indian Inst Trop Meteorol	99	1133114	651	18774	28.8387
2	Indian Meteorol Dept	99	548806	210	6116	29.1238
3	Univ Maryland	99	531820	94	5088	54.1277
4	Univ Washington	99	501343	59	10214	173.1186
5	Columbia Univ	99	498082	90	9957	110.6333
6	Univ Calif San Diego	99	497667	60	11193	186.55
7	Caltech	99	478679	48	1835	38.2292
8	Univ Calif Irvine	99	478495	43	8740	203.2558
9	Woods Hole Oceanog Inst	99	465864	30	1747	58.2333
10	Univ Tasmania	99	458416	27	4553	168.6296
11	NOAA	99	457882	81	10258	126.642
12	Univ New S Wales	99	453610	28	2063	73.6786

13	Forschungszentrum Julich	99	453515	20	2855	142.75
14	Univ Hawaii	99	452947	24	3571	148.7917
15	Met Off Hadley Ctr	99	452752	20	3592	179.6
16	Japan MeteorolAgcy	99	452496	19	792	41.6842
17	Univ Gothenburg	99	452412	30	5240	174.6667
18	Yale Univ	99	451317	32	7831	244.7188
19	Natl Taiwan Univ	99	448569	35	2619	74.8286
20	Univ Utrecht	99	446006	53	3666	69.1698
21	Ohio State Univ	99	445581	70	7075	101.0714
22	European Ctr Medium Range Weather Forecasts	99	444154	11	2487	226.0909
23	British Antarctic Survey	99	443585	21	1741	82.9048
24	Oregon State Univ	99	443383	36	2448	68
25	Finnish Meteorol Inst	99	441445	21	802	38.1905
26	Indian Inst Technol	99	440698	1261	32599	25.8517
27	Univ Alberta	99	440455	30	6198	206.6
28	Korea MeteorolAdm	99	440326	11	974	88.5455
29	Victoria Univ Wellington	99	439981	21	2031	96.7143
30	Natl OceanogCtr	99	438544	15	967	64.4667
31	Univ Bremen	99	436201	28	1144	40.8571
32	Norwegian Polar Res Inst	99	435964	13	1603	123.3077
33	Suny Albany	99	435159	14	3822	273
34	Univ S Florida	99	433758	18	2934	163
35	Rutgers State Univ	99	433328	20	1276	63.8
36	Univ Buenos Aires	99	433046	15	3416	227.7333
37	Univ Calif Santa Barbara	99	432826	27	1835	67.963
38	Univ Alaska Fairbanks	99	432779	14	1804	128.8571
39	Univ Georgia	99	430296	30	1592	53.0667
40	NASA	99	429729	110	8113	73.7545
41	Vrije Univ Amsterdam	99	429029	16	497	31.0625
42	Univ Sheffield	99	428969	19	3652	192.2105
43	Univ Lisbon	99	428435	12	2629	219.0833
44	European Commiss	99	428356	16	2678	167.375
45	Univ Costa Rica	99	428251	13	4263	327.9231
46	George Washington Univ	99	427396	11	2410	219.0909
47	South African Weather Serv	99	426924	7	793	113.2857

48	Univ Cincinnati	99	426763	8	2357	294.625
49	Vienna UnivTechnol	99	426049	9	727	80.7778
50	Meteo France	99	425755	8	334	41.75
51	Alfred Wegener Inst	99	425540	6	298	49.6667
52	Korea Polar Res Inst	99	425261	6	311	51.8333
53	Geol Survey Denmark & Greenland	99	425009	6	462	77
54	Remote Sensing Syst	99	424938	5	317	63.4
55	Cold & Arid Reg Environm&Engn Res Inst	99	424650	5	462	92.4
56	Nichols Coll	99	424650	5	462	92.4
57	Danish Meteorol Inst	99	424382	6	298	49.6667
58	Nasa Goddard Space Flight Ctr	99	424070	5	244	48.8
59	Earth & Space Res	99	423797	5	242	48.4
60	ServMeteorolNacl	99	423558	5	282	56.4
61	Egyptian Meteorol Author	99	423066	5	238	47.6
62	Ohio Univ	99	422727	6	604	100.6667
63	Univ Guam	99	422672	5	240	48
64	Univ West Indies	99	422348	5	242	48.4
65	Univ Tokyo	99	419911	85	11872	139.6706
66	Univ Colorado	99	417053	66	9876	149.6364
67	Colorado State Univ	99	363914	53	3904	73.6604
68	Norwegian Meteorol Inst	99	357715	16	2861	178.8125
69	Bur Meteorol	99	346736	19	3113	163.8421
70	Max Planck Inst Meteorol	99	343400	26	1481	56.9615
71	Univ Zurich	99	341872	31	4747	153.129
72	Louisiana State Univ	99	336588	17	1146	67.4118
73	Univ Wisconsin	99	335880	40	3922	98.05
74	Univ Liege	99	334429	20	965	48.25
75	Univ Waterloo	99	331969	19	1055	55.5263
76	Univ Bristol	99	331280	32	3071	95.9688
77	Geol Survey Canada	99	330900	6	625	104.1667
78	Univ Marburg	99	328642	8	758	94.75
79	Univ Nairobi	99	324613	11	2704	245.8182
80	Natl Inst Space Res	99	323499	7	215	30.7143
81	Environm Canada	99	323435	8	974	121.75

82	Univ Cantabria	99	321956	7	232	33.1429
83	Indian Inst Sci	99	321951	568	20775	36.5757
84	Cuny City Coll	99	321632	8	248	31
85	DireccMeteorol Chile	99	316806	5	838	167.6
86	Dartmouth Coll	99	316219	8	3352	419
87	Sci Syst&Applicat Inc	99	315789	8	430	53.75
88	Antarctic Climate &EcosystCooperat Res Ctr	99	310424	5	337	67.4
89	UnivCtr Svalbard	99	308824	5	193	38.6
90	Deutsch Wetterdienst	99	308216	6	275	45.8333
91	Natl Atmospher Res Lab	99	266081	81	1345	16.6049
92	Stockholm Univ	99	252969	39	4950	126.9231
93	Univ Oslo	99	248435	26	9163	352.4231
94	Univ Cape Town	99	246548	45	6720	149.3333
95	Univ Melbourne	99	236025	52	6871	132.1346
96	Chinese Acad Sci	99	220101	160	10486	65.5375
97	Univ Leeds	99	190384	86	6291	73.1512
98	Phys Res Lab	99	144888	317	9389	29.6183
99	Banaras Hindu Univ	99	139586	337	8224	24.4036
100	Jawaharlal Nehru Univ	99	129417	216	3909	18.0972

4.3.1.8. Bibliographic coupling among the top 500 authors of Indian publications

Figure 4.3.1.14 presents the bibliographic coupling network of the top 500 authors of Indian climate change research. Table 4.3.1.5 represents the name of the top 50 co-cited authors of Indian publications and their number of co-citation links, total link strength, number of documents, total citations, and average citations. The top three authors namely KUMAR, A, RAJEEVAN, M, and SRIVASTAVA, AK were the most co-cited authors of Indian publications in this field. KUMAR, A registered with the highest number of authors of 499 with whom he was co-cited in 287 documents followed by RAJEEVAN, M co-cited with 438 authors in 50documents.

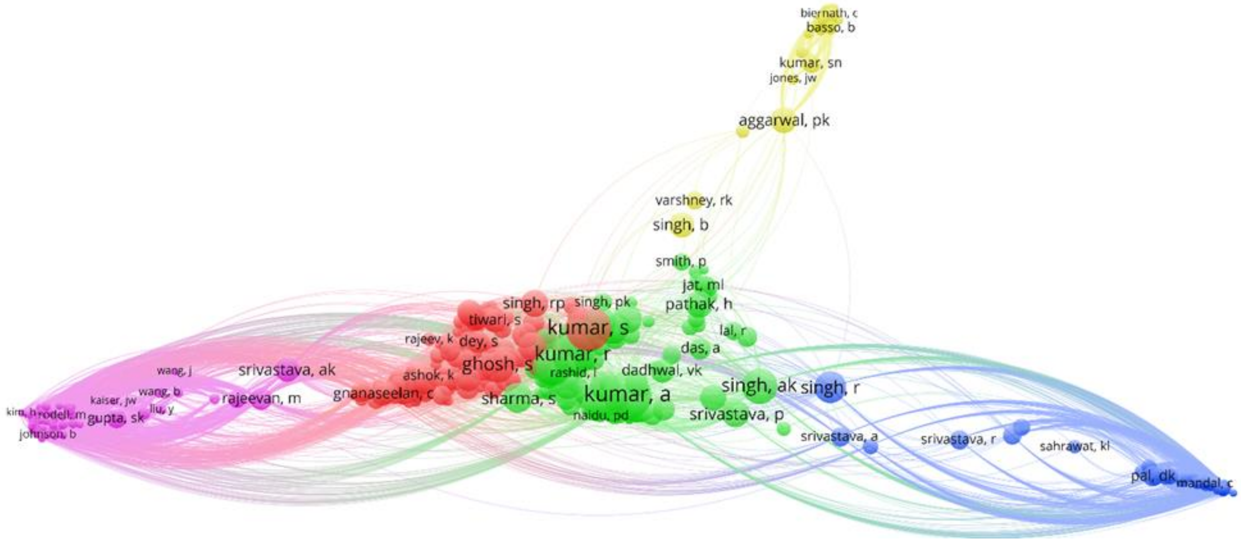


Figure 4.3.1.14: Bibliographic coupling network map of the top 500 authors of Indian climate change research publications

Table 4.3.1.5: Name of the top 50 authors among the top500 authors of bibliographic coupling network of Indian climate change research publications and their Number of co-citation links, total link strength, number of documents, total citations and average citations.

Rank	Name of the authors	Links	Total Link Strength	Number of documents	Total Citations	Average Citations
1	KUMAR, A	499	399209	287	3226	11.2404
2	RAJEEVAN, M	438	363858	50	2225	44.5
3	SRIVASTAVA, AK	499	329198	57	3048	53.4737
4	LUO, JJ	434	290129	13	468	36
5	KAISER, JW	430	265341	5	2422	484.4
6	CAMARGO, SJ	428	260985	7	408	58.2857
7	GUPTA, SK	440	260434	34	606	17.8235
8	WANNINKHOF, R	430	259777	7	422	60.2857
9	RODELL, M	428	258583	8	664	83
10	LUMPKIN, R	427	258115	5	242	48.4
11	WANG, SH	427	257740	5	318	63.6
12	MULLER, R	428	257408	8	247	30.875
13	WANG, L	428	256465	6	242	40.3333
14	LOEB, NG	427	256419	5	316	63.2
15	CHAMBERS, DP	427	255939	5	317	63.4

16	WILLIS, JK	427	255939	5	317	63.4
17	MOTE, T	427	255923	5	312	62.4
18	FEELY, RA	429	255874	5	340	68
19	MATHIS, JT	429	255874	5	340	68
20	BOYER, T	427	255806	6	245	40.8333
21	DUNN, RJH	430	255587	6	791	131.8333
22	DOMINGUES, CM	427	255452	5	240	48
23	KNAFF, JA	427	255353	5	240	48
24	JOHNSON, B	427	255330	6	240	40
25	LIN, II	427	255229	5	249	49.8
26	LORREY, AM	432	255221	6	782	130.3333
27	JOHNSON, GC	428	255174	5	250	50
28	SCHMID, C	428	255174	5	250	50
29	KRUGER, A	430	255077	6	239	39.8333
30	WILLETT, KM	427	255010	5	776	155.2
31	CHRISTY, JR	488	254838	5	269	53.8
32	LAZZARA, MA	488	254838	5	269	53.8
33	VOSE, RS	488	254838	5	269	53.8
34	RAHIMZADEH, F	427	254778	5	2195	439
35	ROMANOVSKY, VE	428	254211	5	330	66
36	WANG, M	427	254102	5	237	47.4
37	VAN DE WAL, RSW	427	254054	5	321	64.2
38	NIETO, JJ	427	253923	5	277	55.4
39	BROWN, R	427	253889	5	598	119.6
40	REVADEKAR, JV	438	247104	30	1243	41.4333
41	GOSWAMI, BN	434	226729	63	6036	95.8095
42	WANG, B	438	220005	11	1366	124.1818
43	SAHA, SK	497	214170	50	826	16.52
44	YU, L	427	208529	5	462	92.4
45	GHOSH, S	499	208222	144	2615	18.1597
46	FAMIGLIETTI, JS	432	206847	10	787	78.7
47	CHAUDHARI, HS	427	203155	37	919	24.8378
48	KOHLER, J	426	201769	5	581	116.2
49	COOPER, OR	427	200290	6	248	41.3333
50	CIAIS, P	424	194059	8	309	38.625

4.3.2. Analysis from Scopus database

4.3.2.1. Indian research collaboration

Figure 4.3.2.1 represents the research collaboration network with the top 50 collaborating countries of Indian research on climate change. Similar observations were noticed in the Scopus database like that of the Web of Science database. India has published the maximum collaborative research publications with the USA followed by England, Germany and Australia (Figure 4.3.2.2).

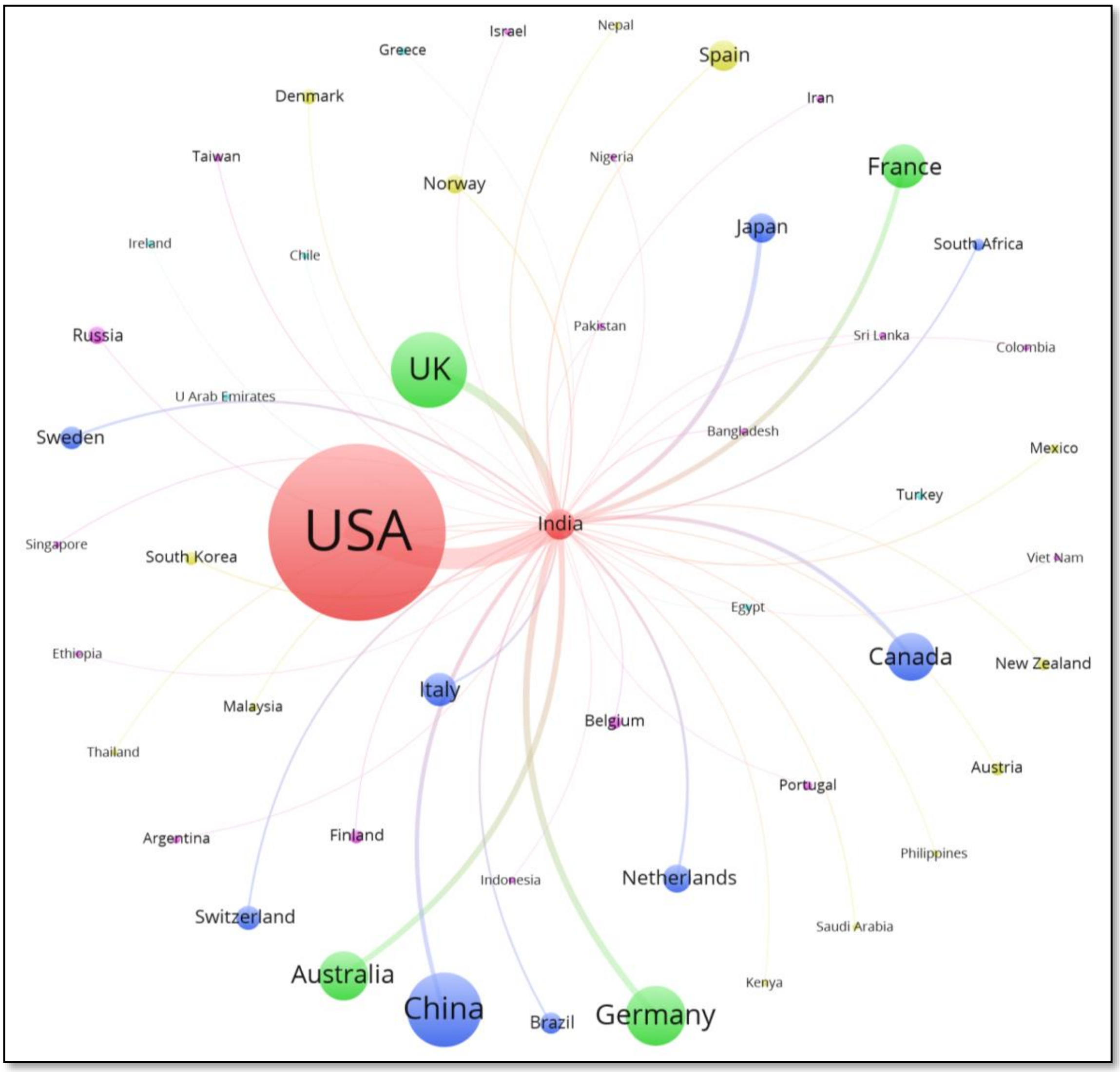


Figure 4.3.2.1: India's international collaboration network map with top 50 countries. The size of the nodes proportional to the number of total publications by each country; the size of the edges proportional to the number of India's collaborative publications with each country. Colour of nodes indicating the different clusters based on quantum of collaborative publications (red colour for more than 2000 collaborative publications, Green colour for more than 500 collaborative publications, blue colour for

more than 200 collaborative publications, yellow colour for more than 100 collaborative publications, violet colour for less than 100 collaborative publications.

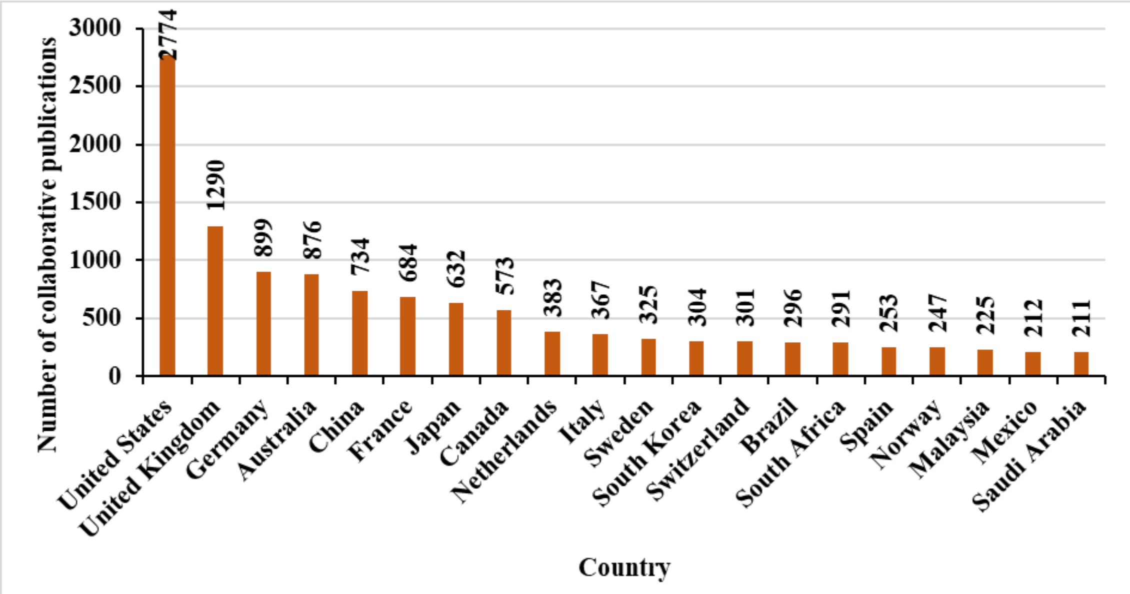


Figure 4.3.2.2: Number of collaborative publications with India's top 20 collaborating countries

4.3.2.2. Impact of Indian Collaborative research

It has been observed that 30.63 % of total Indian publications were collaborative. Among the total of 24865 collaborative Indian publications, 6555 (26.36 %) publications were published with the collaboration with the top 20 India's collaborating countries. Only 1062 (4.27 %) publications were published in collaboration with the rest of the collaborating countries of India (Figure 4.3.2.3). Total Indian publications received 439132 citations. The 23.13 % of total Indian publications with the top 20 Indian collaborating countries received 47.31 % (207746 citations) of the total Indian citations (Figure 4.3.2.4). Therefore, the average citations of the collaborative publications with the top 20 India's collaborating countries were about two times greater than that of the average citations of total Indian publications (Figure 3.2.5). The average citations of the collaborative publications with the rest of the collaborating countries of India were less than that of the total Indian publications. The h-index of the total Indian publications is higher than the h-index of collaborative publications with the top 20 India's collaborating countries and with rest of the India's collaborating countries (Figure 4.3.2.6). About 36.37 % of the total Indian publications have no citation (Figure 4.3.2.7). The percentage of publications without any citation is very lower for the publications with the top 20 India's collaborating countries

(12.68 %) and the rest of India's collaborating countries (17.89 %) as compared to the total Indian publications.

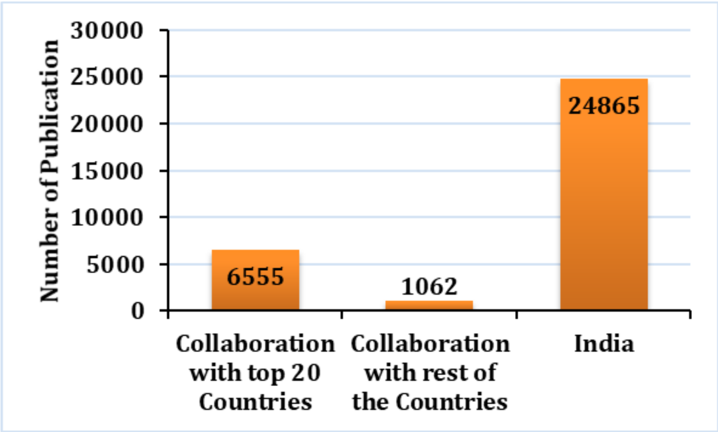


Figure 4.3.2.3: India's total publications, publications with top 20 collaborating countries and publications with the rest of the collaborating countries.

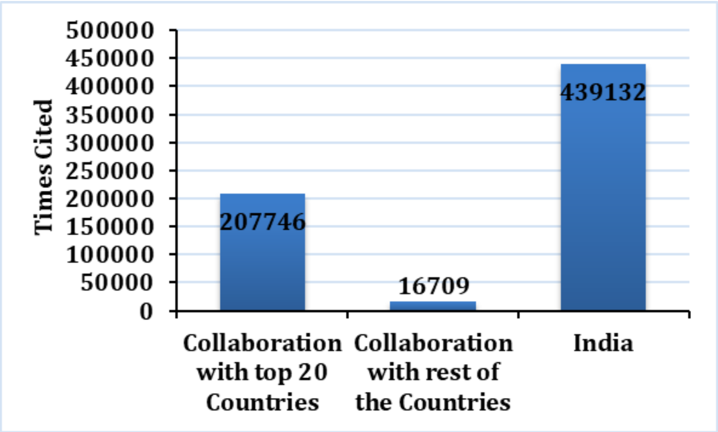


Figure 4.3.2.4: India's total citation of total publications, total citation of publications with top 20 collaborating countries and total citation of collaborative publications with the rest of the countries.

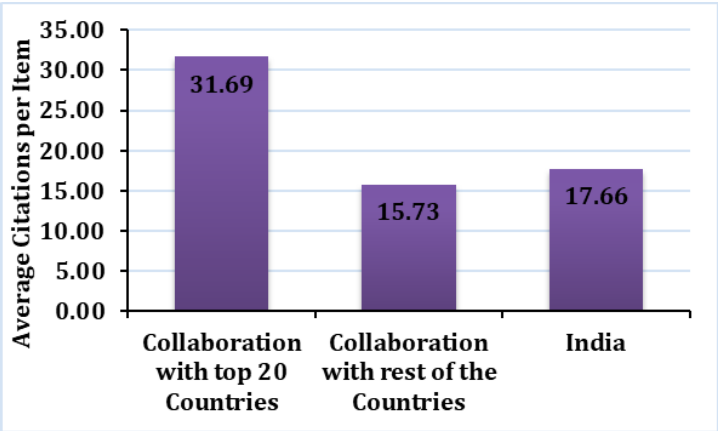


Figure 4.3.2.5: India's Average citation of total publications, collaborative publications with top 20 countries and collaborative publications with the rest of the countries.

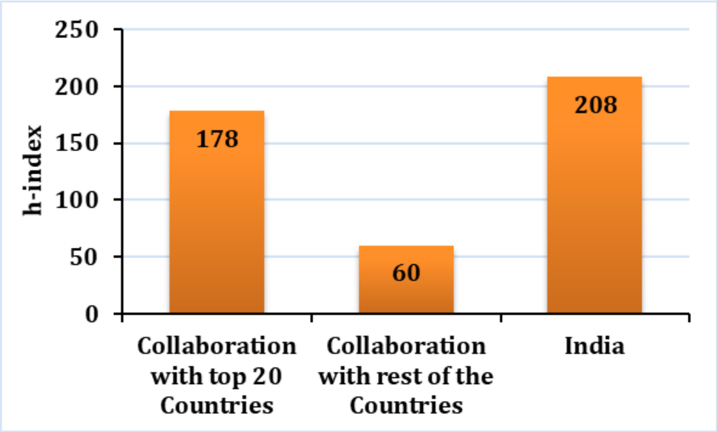


Figure 4.3.2.6: India's h-index of total publications, collaborative publications with top 20 countries and collaborative publications with rest of the countries.

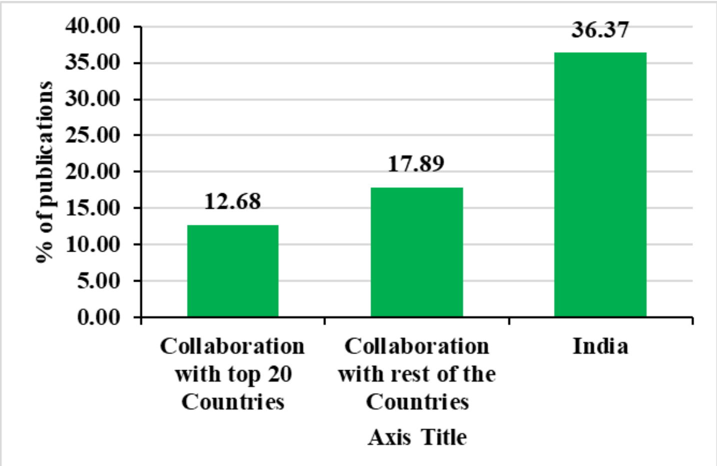


Figure 4.3.2.7: India's % of publications without any citation of total publications, collaborative publications with top 20 countries, and collaborative publications with the rest of the countries.

4.3.2.3. Collaborative national and International Organizations:

Figure 4.3.2.8 shows the number of publications by the top 20 Indian Collaborative Institute and Figure 4.3.2.9 shows the top 20 international collaborative institutes. Indian Institute of Technology Delhi is the most collaborative organization from India followed by the Indian Institute of Tropical Meteorology IITM, Indian Institute of Science IISC Bangalore, Indian Space Research Organisation. Centre National De La Recherche Scientifique CNRS is the most collaborative international organization in Indian collaborative research.

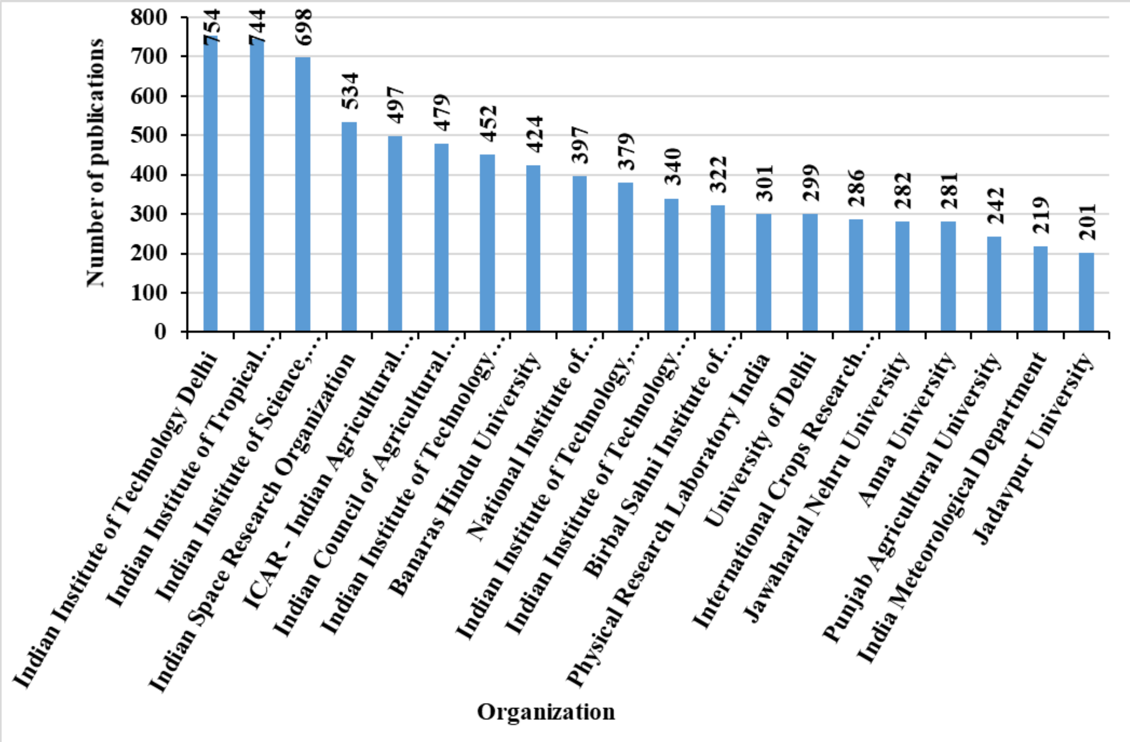


Figure 4.3.2.8: Top 20 Indian Collaborative Institute and their number of collaborative publications with India

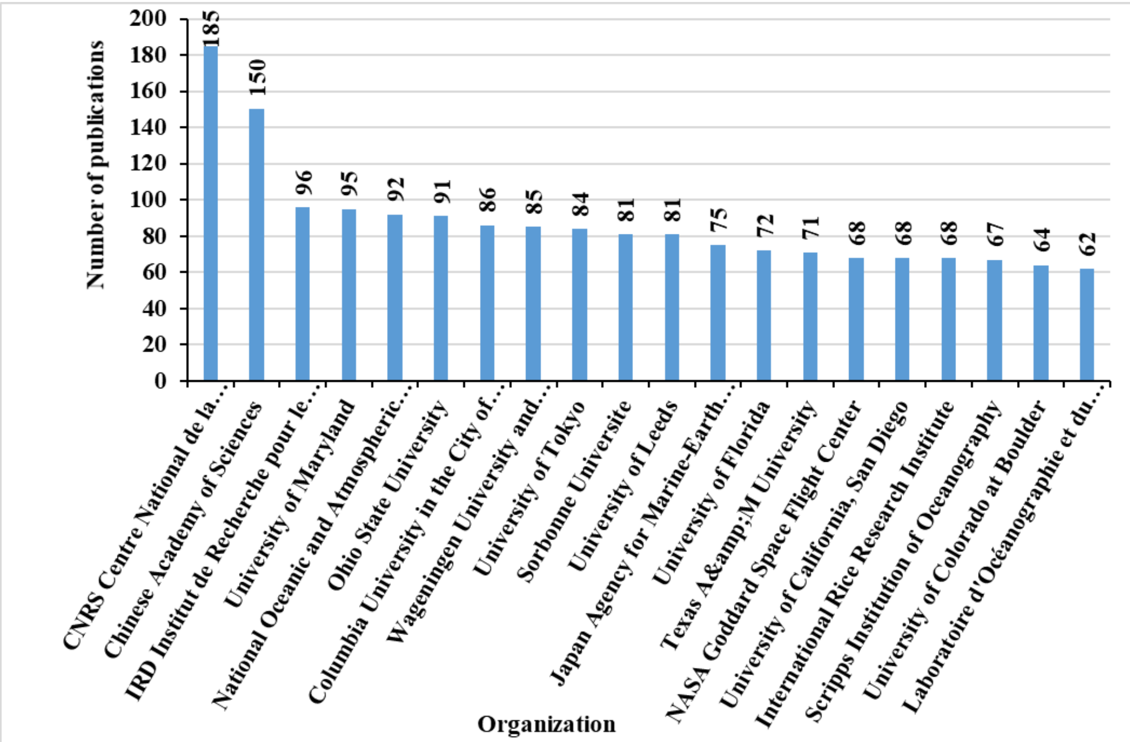


Figure 3.2.9: Top 20 International Collaborative Institute and their number of collaborative publications with India.

4.4. Evaluation of the interrelationship among the national goal on climate change and the research publications of India covering Indian Journals

4.4.1. National Solar Mission

The final search string to retrieved publication data from "Web of Science" and "Scopus" for "National Solar Mission" was as follows:

TS=((Solar AND ("power plant" OR electricity OR capacity OR "photo voltaic" OR "green energy" OR panel OR "thermal power plant" OR "thermal energy" OR reflector OR "water heat*" OR cooker OR power OR "air heater" OR collector OR cell OR irradiance OR thermals)) OR "solar grid" OR "commercial solar plant" OR "solar energy" OR "solar park" OR "hybrid solar plant" OR "renewable solar energy" OR "solar power storage" OR "solar technolog*" OR "solar chimney power plant" OR "clean energy" OR "solar array" OR "solar cooling" OR "solar mirror" OR "solar home system" OR "solar illumination")

4.4.1.1. Analysis of Web of Science publication data related to the National Solar Mission

4.4.1.1.1. Number of publications related to the National Solar Mission by top 30 countries

A total of 270916 global and 20686 Indian publications were retrieved from the Web of Science database using the final search string of National Solar Mission. Figure 4.4.1.1.1shows the publication contributions related to "National Solar Mission" by the top 30 countries. The USA is the leading country and contributed 63051 publications. India has contributed 20686 publications and secured 4th rank globally based on the number of publications.

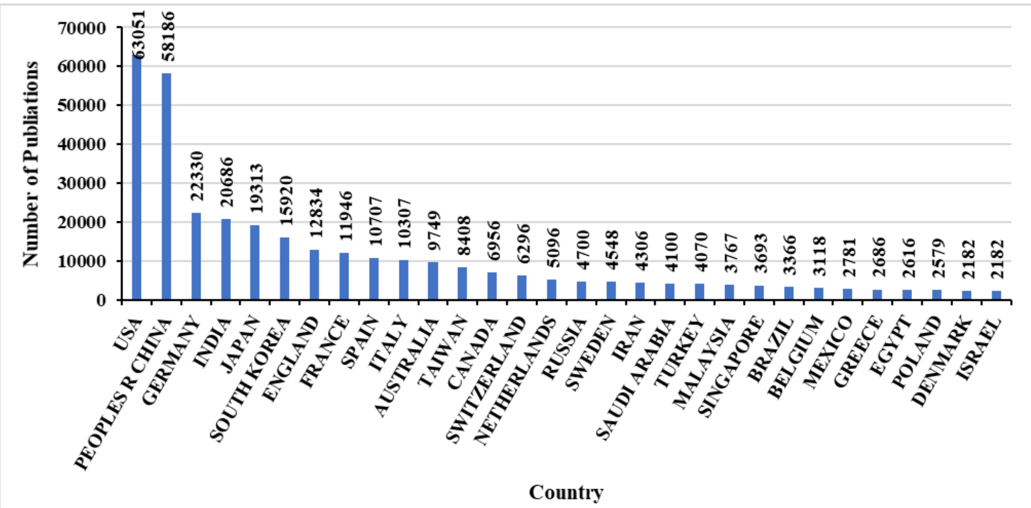


Figure 4.4.1.1.1: Total number of publications related to "National Solar Mission" of top 30 countries.

4.4.1.1.2. Year-wise Growth of global and Indian publications related to "National Solar Mission"

Figure 4.4.1.1.2 shows the year-wise growth of the number of total global and Indian publications related to "National Solar Mission". The compound annual growth rate of Indian publications is slightly lower than the total global publications during 1987-2019. The CAGR of Indian publications was lower than the total global publications before 2008 i.e. the year of the introduction of the "National Solar Mission". It is very interesting to see that the CAGR of Indian publications from 2009 to 2019 is fairly higher than the global total publications (Table 4.4.1.1.1). Therefore, it may infer that the National Solar Mission of India instigates R&D activities on various objectives of solar mission thereby the growth of publications accelerated.

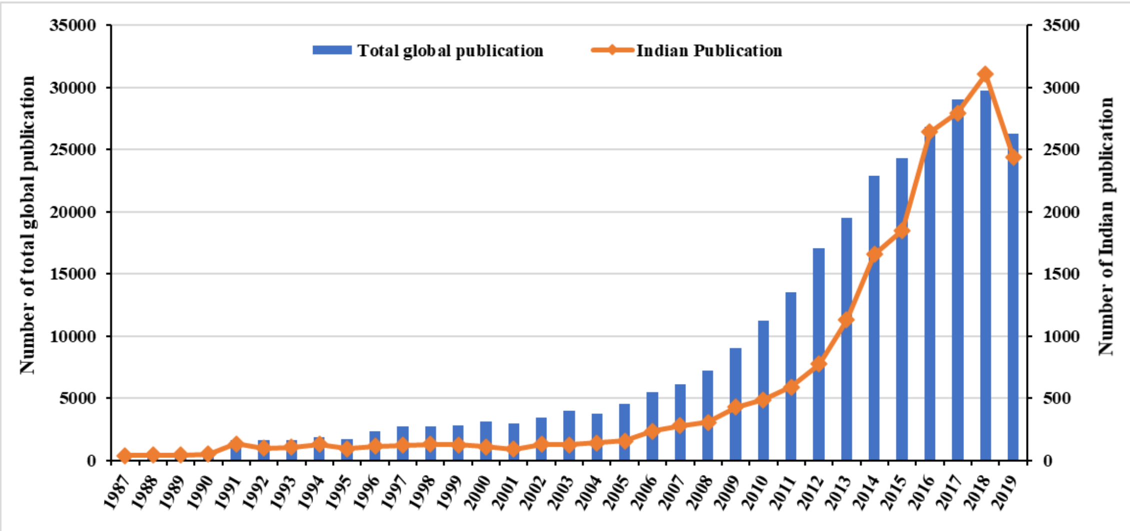


Figure 4.4.1.1.2: Year-wise global and Indian number of publications related to the "National Solar Mission".

Table 4.4.1.1.1: Global and Indian total publications, Global and Indian compound annual growth rate of publications related to the "National Solar Mission" during 1987-2019, 1987-2008 and 2008-2019

	Number of publication	CAGR of Total years	CAGR before the setting of the mission	CAGR after the setting of the mission
Global Publication	291071	13.92 %	14.69 %	12.48 %
Indian Publication	20686	13.89 %	10.44 %	20.77 %

4.4.1.1.3. Total Global and Indian comparative contribution in top 30 research areas

Total global research on the Indian "National Solar Mission" related topic has been performed in 221 research areas. The top 30 research areas of total global research on the Indian "National Solar Mission" related topic have contributed 87.72 % cumulatively (normalised). India has contributed to 159 research areas during total periods. The top 30 research areas of total Indian research on climate change have contributed 89.99 % cumulatively (normalised). India has contributed at a higher proportion than the global in some research areas namely: Energy fuel, Engineering Electrical Electronic, Physics Condensed Matter, Green Sustainable Science Technology, Thermodynamics, Mechanics and Automation Control Systems which are mainly deal with the technological development to mitigate climate change. India has contributed at a lower proportion than the global in some research areas namely: Materials Science Multidisciplinary, Physics Applied, Chemistry Physical, Chemistry Multidisciplinary, Nanoscience Nanotechnology, Astronomy Astrophysics, Optics, Environmental Sciences which are mainly deal with the causal factor identification and impact assessment of the climate change (Figure 4.4.1.1.3).

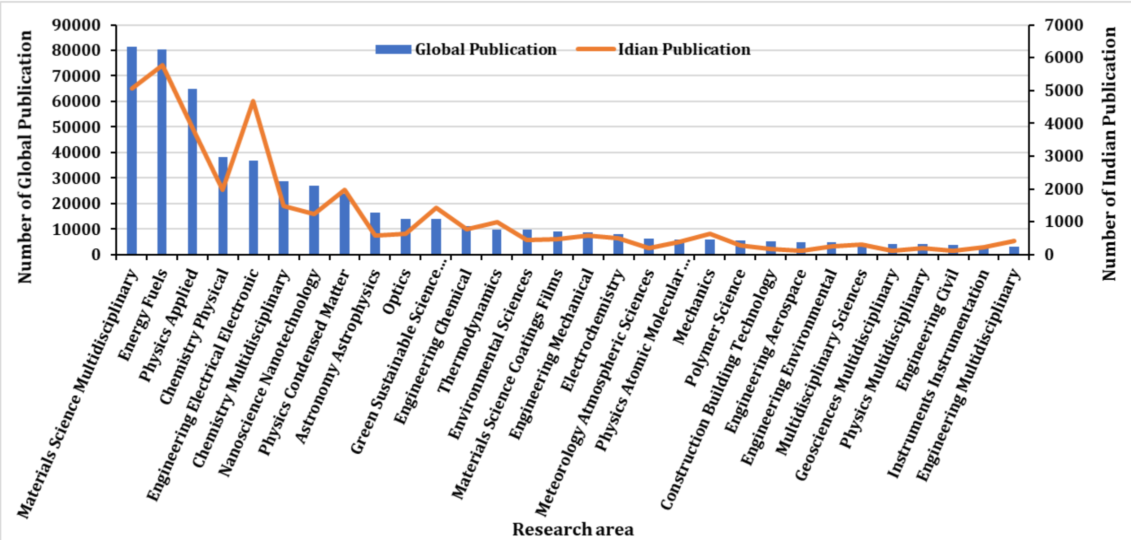


Figure 4.4.1.1.3: Global and Indian publication contribution related to "National Solar Mission" in top 30 research areas

4.4.1.1.4. Indian publication contribution in top 30 research areas before and after the adoption of the mission

Figure 4.4.1.1.4 shows the comparative contribution of the top 30 research areas of Indian publications before and after the introduction of the mission. Following research areas namely, Energy Fuels, Materials Science Multidisciplinary, Physics Applied, Physics Condensed Matter, Thermodynamics, Engineering Electrical Electronic, Mechanics and Astronomy Astrophysics were the most important research areas before the introduction of the “National Solar Mission” by contributing more than 200 publications. After the introduction of the mission, the following research areas Energy Fuels, Engineering Electrical Electronic, Materials Science Multidisciplinary, Physics Applied, Chemistry Physical, Physics Condensed Matter, Chemistry Multidisciplinary, Green Sustainable Science Technology and Nanoscience Nanotechnology were the most important and contributed more than 1000 publications.

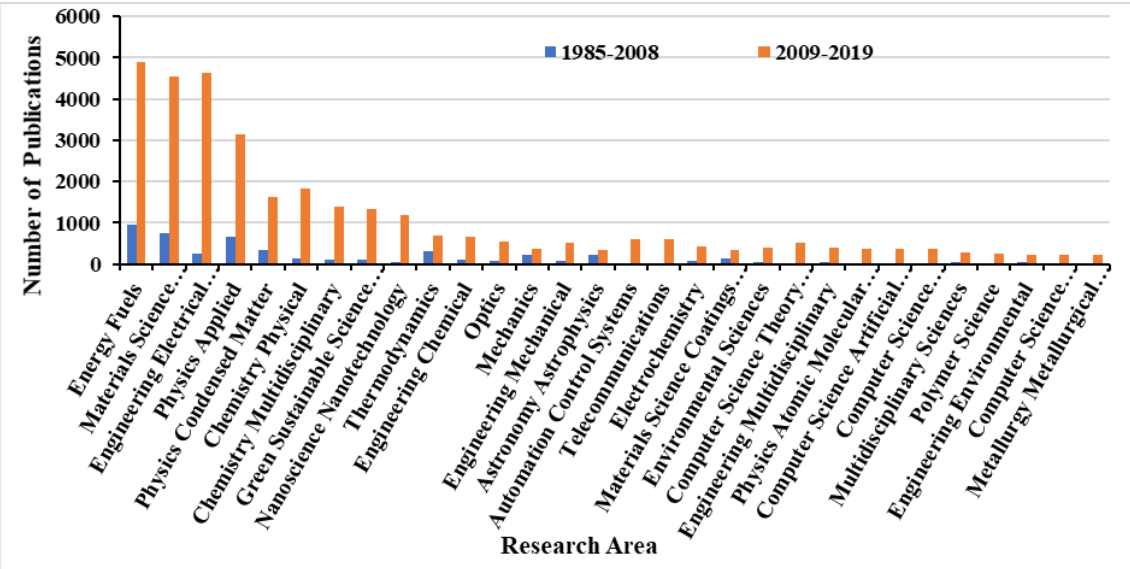


Figure 4.4.1.1.4: Indian publication contribution related to “National Solar Mission” in top 30 research areas before and after the adoption of the mission.

4.4.1.1.5. The quantitative evolution and exchange of keywords of Indian publication related to “National Solar Mission”

The quantitative evolution and exchange of keywords from the before mission to the after mission are represented in Figure 4.4.1.1.5 for total Indian publications on “National Solar Mission”. Each circle contains the number of keywords during that period which is indicated below the circle. The arrow containing the number of keywords coming towards the circle indicates newly arisen keywords. On the other hand, the arrow going outside indicates the number of keywords that are not used at successive periods. The arrow pointing from the previous to successive period represents the number of keywords exchanged (integer value) and the fraction of overlap (i.e., Similarity Index) in parentheses.

The higher value of the similarity index indicates the core themes of Indian publications on "National Solar Mission" research remain more or less continuous, whereas, the quantity of newly evolved keywords indicates the improvement of the core theme resulting in the diversification of different subthemes. The number of keywords was increased from 1012 during 1985-2008 to 2536 during 2009-2019 with a growth rate of 150.59%. Indian publications on National Solar Mission publications research after setting of the mission incorporated more than 50% keyword from research perform during before mission.

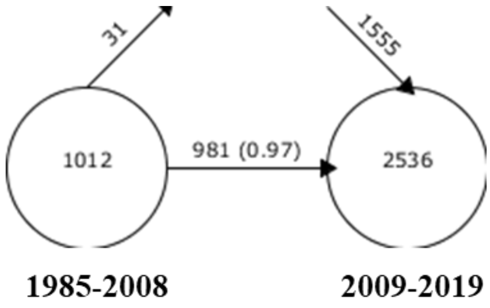


Figure 4.4.1.1.5: Overlapping map of keyword's quantitative perspective during successive periods of Indian Publications related to "National Solar Mission".

4.4.1.1.6. Quantitative and qualitative development of themes at successive periods of Indian publication related to "National Solar Mission"

Thematic evolution was represented through strategic diagrams at successive periods. Themes were plotted as circles denoting different theme clusters according to centrality and density in strategic diagrams. The size of the circle is proportional to the number of documents and referred to as document frequency (DF) in which it's linked or related keywords are present. The strategic diagrams are divided into four quadrants and they can be interpreted as follows: the top-right quadrant represents "motor themes", the top-left quadrant represents "highly developed and isolated themes", the bottom-left quadrant represents "emerging or declining themes", the bottom-right quadrant represents "basic and transversal themes".

During 1985-2008 a total of only 1012 keywords during the before mission were observed among the total 2754 publications. The initial period has registered fourteen themes with a DF range of 8 to 265. During this period "OPTICAL-PROPERTIES" was found to be the most active theme having a DF of 265 (Figure 4.4.1.1.6, Table 4.4.1.1.2). The theme "OPTICAL-PROPERTIES" received maximum document citations (8,873). The theme “OPTICAL-PROPERTIES” was positioned in the top-right quadrant with the highest centrality value (23.19) indicating itself as the most important and well-connected theme with other keywords vis-à-vis themes followed by “PERFORMANCES” with a centrality value of 22.91. The theme “CONJUGATED-POLYMERS”, “SOLAR-AIR-HEATERS” and “HETEROJUNCTIONS “ was positioned in the top-left quadrant with no centrality, thereby assigning it as an isolated theme. The themes “SEMICONDUCTOR-ELECTRODES”, “OSCILLATIONS” and “WATERS” were found to come under emerging focus, as they were positioned in the bottom-left quadrant. The theme “EFFICIENCIES” and “TEMPERATURES” appeared in the bottom-right quadrant as basic and transversal themes.

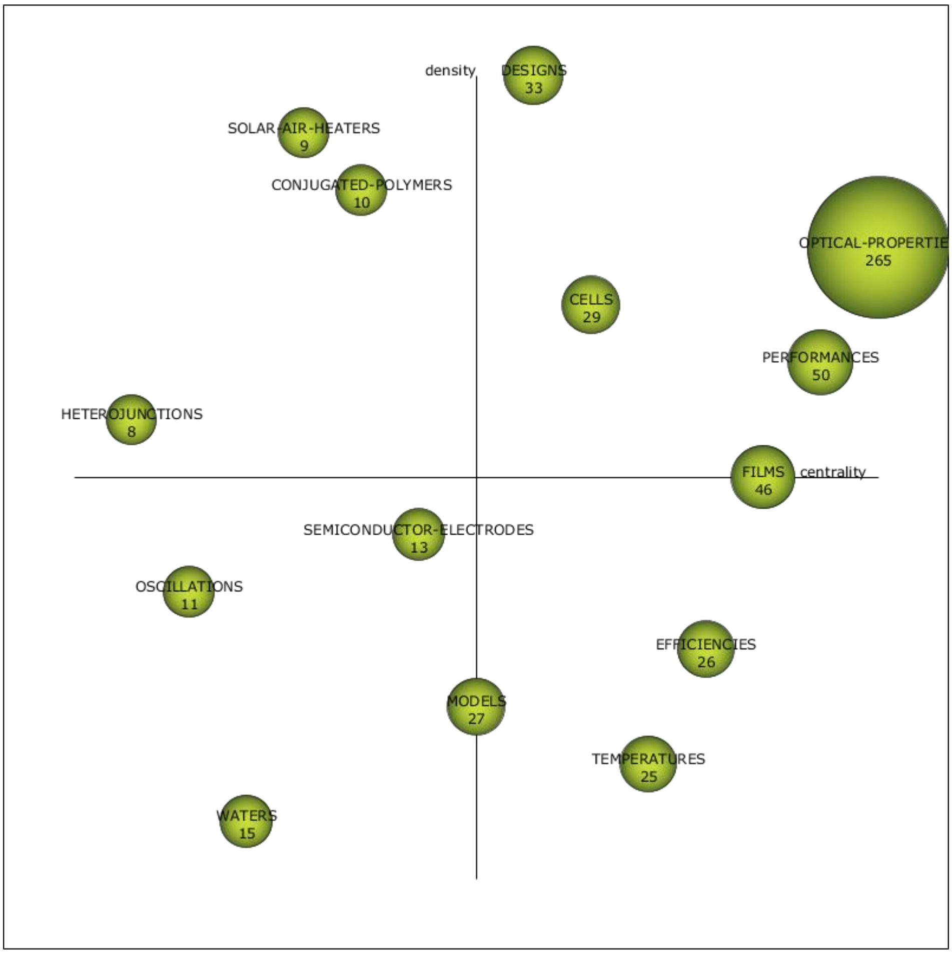


Figure 4.4.1.1.6: Strategic diagram of themes during 1985-2008 of Indian publications related to “National Solar Mission”.

Table 4.4.1.1.2: Quantitative and qualitative performance measures of themes during 1985-2008 of Indian publications related to "National Solar Mission".

Name	Centrality	Density	Core Documents Count	Core Documents sum Citations	Secondary Documents Count	Secondary Documents sum Citations
Optical-Properties	23.19	6.64	265	8,873	544	14,529
Designs	10.97	16.73	33	1,587	158	6,677
Performances	22.91	3.73	50	2,100	194	9,659
Films	19.45	3.22	46	1,456	189	5,524
Models	10.05	2.17	27	1,333	128	3,718
Temperatures	12.08	1.84	25	730	150	6,627
Efficiencies	16.38	2.25	26	798	138	6,069
Cells	11.38	6.3	29	643	145	3,565
Semiconductor-Electrodes	7.71	2.73	13	188	100	2,443
Waters	4.89	1.76	15	803	79	3,728
Oscillations	3.18	2.68	11	158	74	3,044
Conjugated-Polymers	7.54	7.06	10	283	23	1,416
Solar-Air-Heaters	6.74	9.11	9	987	33	2,200
Heterojunctions	2.63	3.72	8	973	34	1,322

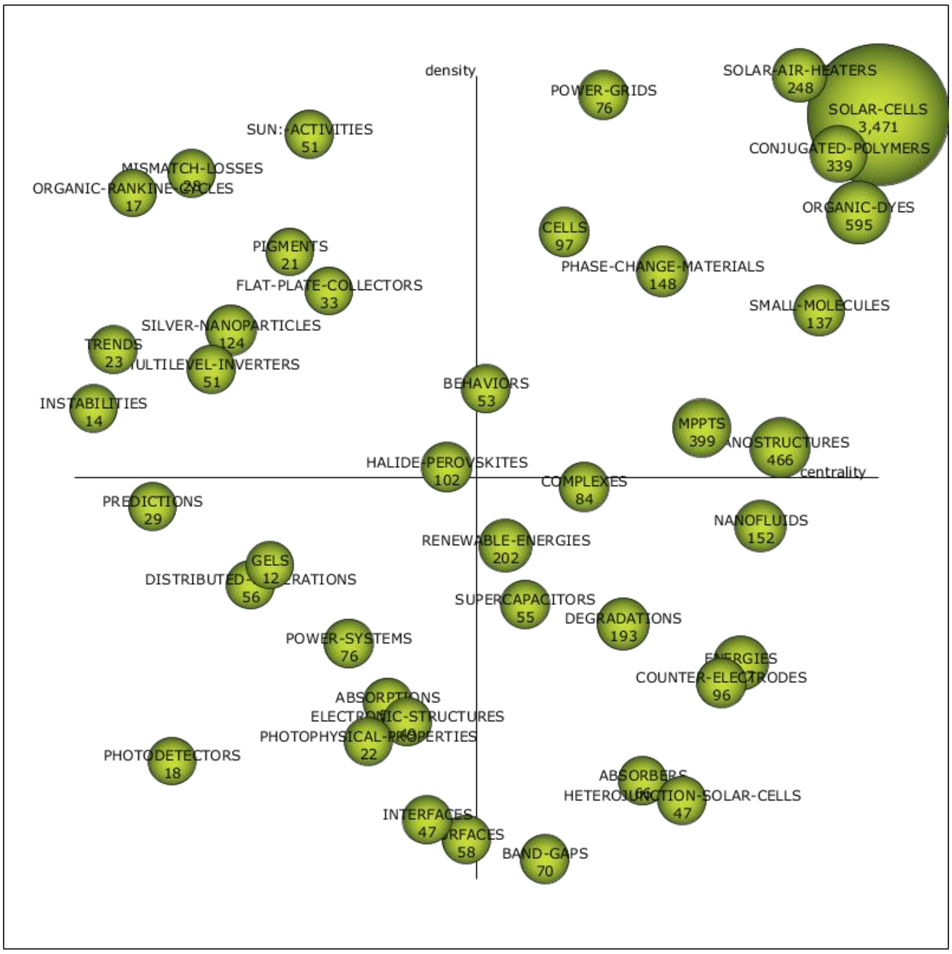


Figure 4.4.1.1.7: Strategic diagram of themes during 2009-2019 of Indian publications related to "National Solar Mission".

During 2009-2019 total keywords have increased to 2536 during 2009-2019 i.e., after the introduction of the mission with a growth rate of 150.59% among the total 18143 publications (increased by more than 558.79 %). The number of themes did also increase to 41 during that period with comparatively more DF. During this period "SOLAR-CELLS" was found to be the most active theme having a DF of 3,471 followed by "ORGANIC-DYES" with a DF of 595 and "NANOSTRUCTURES" with a DF of 466 (Figure 4.4.1.1.7, Table 4.4.1.1.3). The theme "SOLAR-CELLS" received maximum document citations (59,584) followed by "ORGANIC-DYES" (11,778), "PHASE-CHANGE-MATERIALS" (6819) and "SOLAR-AIR-HEATERS" (6525). The theme "SOLAR-CELLS" was positioned in the top-right quadrant with the highest centrality value (52.72) indicating itself as the most important and well-connected theme with other keywords vis-à-vis themes followed by "ORGANIC-DYES" (38.03). The theme "SILVER-NANOPARTICLES", "SUN:-ACTIVITIES" and "MULTILEVEL-INVERTERS" was positioned in the top-left quadrant with no centrality, thereby assigning it as an isolated theme. The themes "POWER-SYSTEMS", "ABSORBERS", "DISTRIBUTED-GENERATIONS" and "SURFACES" were found to come under emerging focus, as they were positioned in the bottom-left quadrant. The theme "ENERGIES", "RENEWABLE-ENERGIES", "DEGRADATIONS" and "NANOFLUIDS" appeared in the bottom-right quadrant as basic and transversal themes.

Table 4.4.1.1.3: Quantitative and qualitative performance measures of themes during 2009-2019 of Indian publications related to "National Solar Mission".

Name	Centrality	Density	Core Documents Count	Core Documents sum Citations	Secondary Documents Count	Secondary Documents sum Citations
Solar-Air-Heaters	22.72	18.01	248	6,525	424	9,968
Power-Grids	9.77	13.74	76	873	164	1,390
Conjugated-Polymers	28.49	5.79	339	5,351	829	12,502
Solar-Cells	52.72	7.43	3,471	59,584	5,338	91,376
Organic-Dyes	38.03	4.45	595	11,778	2,236	40,414
Phase-Change-Materials	10.98	4.27	148	6,819	1,093	22,587
Small-Molecules	23.61	3.84	137	2,284	567	8,846
Nanofluids	17.61	1.69	152	3,883	1,157	26,649
Mppts	12.03	2.08	399	3,590	1,171	12,424
Silver-Nanoparticles	4.74	3.53	124	2,909	428	7,136
Nanostructures	20.4	1.97	466	8,587	1,816	32,125
Halide-Perovskites	7.5	1.94	102	2,208	771	14,933
Renewable-Energies	8.63	1.52	202	5,699	951	15,499
Supercapacitors	8.63	1.18	55	1,800	657	13,563
Distributed-Generations	4.76	1.36	56	1,033	388	4,806
Energies	17.09	0.86	277	7,053	1,776	31,818
Degradations	10.64	1.12	193	5,633	1,212	24,224
Complexes	9.38	1.74	84	1,455	500	9,420
Counter-Electrodes	14.09	0.67	96	2,208	693	12,688
Electronic-Structures	7.38	0.63	49	315	454	8,808

Power-Systems	5.71	1.09	76	1,166	648	12,562
Absorptions	7.16	0.64	59	2,118	486	8,252
Cells	9	4.45	97	2,156	1,047	16,348
Heterojunction-Solar-Cells	11.72	0.43	47	578	577	10,649
Surfaces	7.67	0.24	58	1,232	619	11,090
Band-Gaps	8.66	0.23	70	982	896	14,782
Absorbers	10.91	0.47	66	1,592	871	16,361
Behaviors	8.49	2.12	53	953	743	12,779
Interfaces	7.43	0.3	47	871	803	13,656
Sun:-Activities	5.43	6.24	51	605	246	3,951
Multilevel-Inverters	4.37	2.26	51	399	256	2,181
Mismatch-Losses	3.25	5.71	28	475	118	1,577
Flat-Plate-Collectors	5.7	3.99	33	1,119	173	4,120
Photophysical-Properties	6.67	0.57	22	309	230	3,604
Organic-Rankine-Cycles	1.67	4.73	17	419	113	2,578
Photodetectors	2.8	0.51	18	379	416	6,658
Trends	1.05	2.88	23	398	152	3,549
Pigments	5.41	4.37	21	278	119	2,025
Instabilities	0.42	2.09	14	59	149	1,572
Predictions	2.06	1.72	29	504	194	3,274
Gels	5	1.4	12	578	148	3,110

4.4.1.2. Analysis of Scopus publication data related to "National Solar Mission"

4.4.1.2.1. Number of publications by top 30 countries related to "National Solar Mission":

A total of 3,48,464 publications were retrieved from the Scopus database using the final search string. Figure 4.4.1.2.1shows the publication contributions by the top 30 countries. The USA is the leading country and contributed 74251 publications. India has contributed 25933 publications and secured 3rd rank globally in the publications related to the "National Solar Mission".

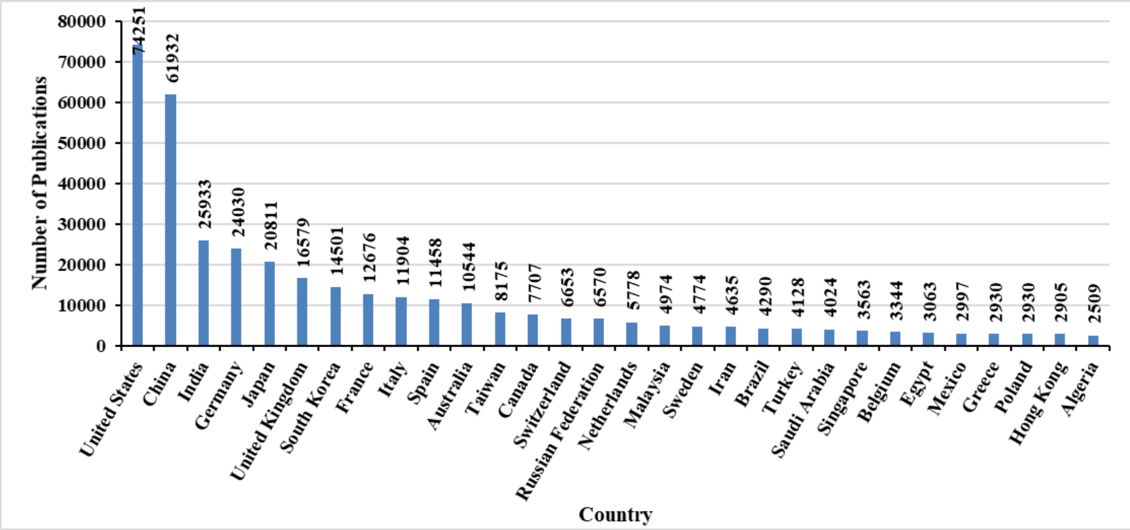


Figure 4.4.1.2.1: Total number of publications related to "National Solar Mission" of top 30 countries.

4.4.1.2.2. Year-wise Growth of global and Indian publications related to "National Solar Mission"

Figure 4.4.1.2.2 shows the year-wise growth of the number of total global and Indian publications related to the "National Solar Mission". The compound annual growth rate (11.81%) of Indian publications is higher than the total global publications during 1987-2019 (Table 4.4.1.2.1). The CAGR (5.70%) of Indian publications was higher than the total global publications up to 2008 i.e. the year of the setting of the National Solar Mission. It is very interesting to see that the CAGR (25.77 %) of Indian publications is also higher than the global total publications throughout the periods. Therefore, it may conclude that the "National Solar Mission" of India instigates the R&D activities on various objectives of solar mission thereby the growth of publications accelerated.

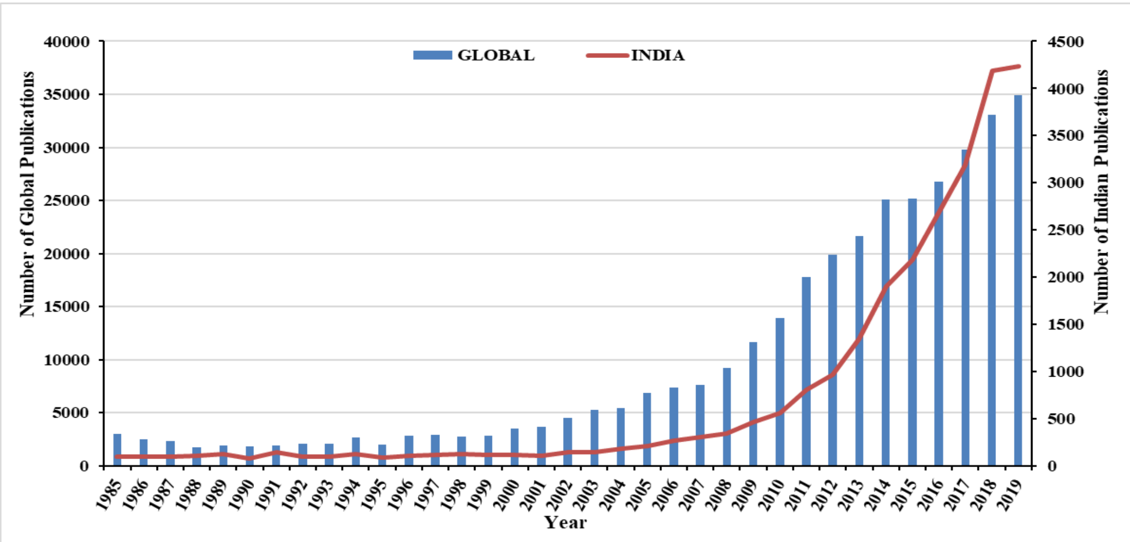


Figure 4.4.1.2.2: Year-wise global and Indian number of publications related to "National Solar Mission".

Table 4.4.1.2.1: Global and Indian total publications related to "National Solar Mission", Global and Indian compound annual growth rate of publications during 1987-2019, 1987-2008 and 2008-2019.

	Number of publication	**CAGR of Total years**	**CAGR before the setting of the mission**	**CAGR after the setting of the mission**
Global Publication	348464	7.49%	5.01%	12.89%
Indian Publication	25933	11.81%	5.70%	25.77%

4.4.1.2.3. Total global and Indian comparative contribution in top 30 research areas:

Total global researches related to the Indian "National Solar Mission" have been performed in 28 subject areas. The top 10 subject areas of total global researches related to the mission have contributed 93.09 % cumulatively (normalised). India has contributed in 27 subject areas during total periods. The top 10 subject areas of total Indian research on climate change have also contributed 93.09 % cumulatively (normalised). India has contributed at a higher proportion than the global in some research areas namely: Engineering, Energy, Chemical engineering, Computer Science, Mathematics, Social Sciences, Multidisciplinary, Decision Sciences, etc. India has contributed at a lower proportion than the global in some research areas namely: Materials Science, Physics and Astronomy, Chemistry, Earth and Planetary Sciences, Environmental Science, etc. (Figure 4.4.1.2.3).

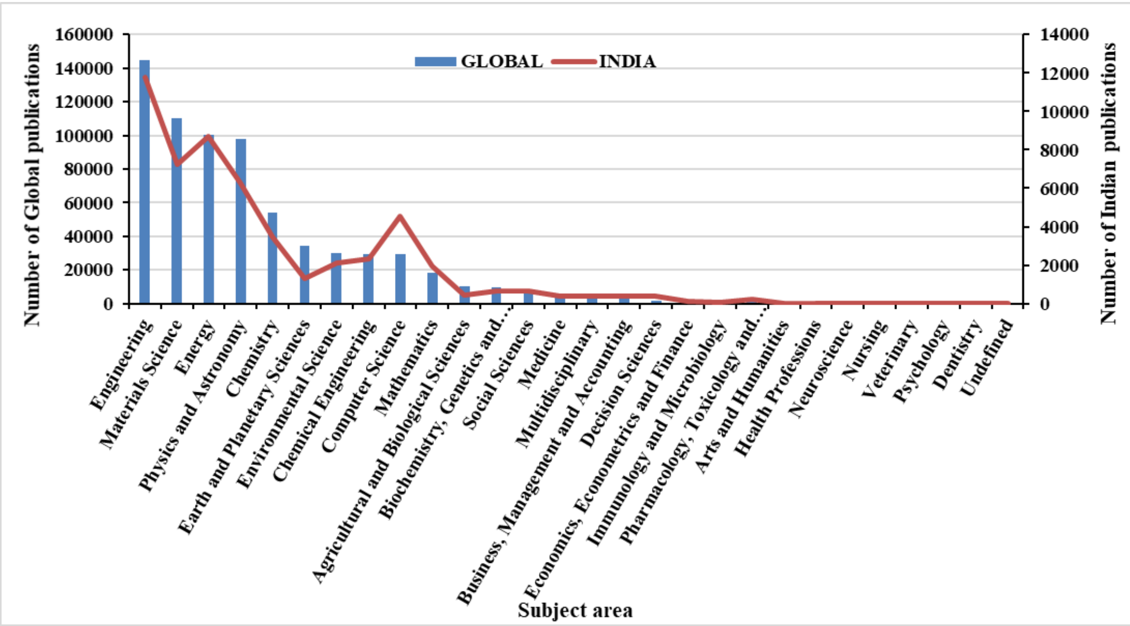


Figure 4.4.1.2.3: Global and Indian publication contribution related to "National Solar Mission" in different subject areas.

4.4.1.2.4. Indian publication contribution related to "National Solar Mission" in different research areas before and after the introduction of the mission

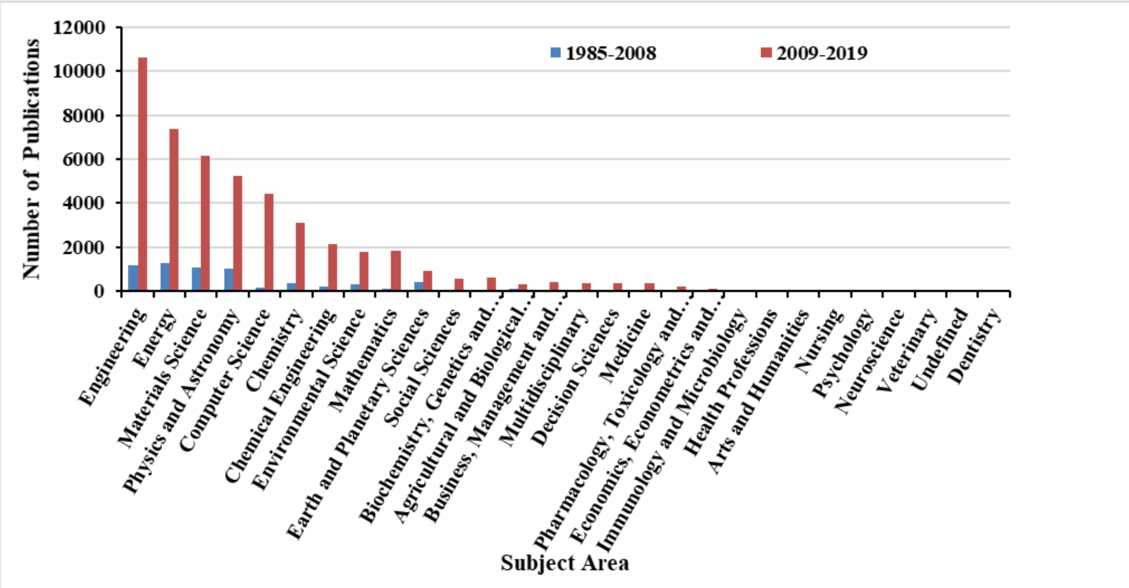


Figure 4.4.1.2.4: Indian publication contribution related to "National Solar Mission" in different subject areas before and after the adoption of the mission.

Figure 4.4.1.2.4 shows the comparative contribution of different subject areas of Indian publications before and after the introduction of the mission. Following research areas namely, Energy, Engineering, Materials Science, Physics and Astronomy, Earth and Planetary Sciences, Chemistry, Environmental Science, Chemical Engineering were the most important research areas before the introduction of the "National Solar Mission" by contributing more than 200 publications. After the introduction of the mission, the following research areas Engineering, Energy, Materials Science, Physics and Astronomy, Computer Science, Chemistry, Chemical Engineering, Mathematics, Environmental Science were the most important and contributed more than 1500 publications.

4.4.1.3. Analysis of Indian Citation Index data related to "National Solar Mission"

4.4.1.3.1. Year-wise Growth of global and Indian publications related to "National Solar Mission"

Figure 4.4.1.3.1 shows the year-wise growth of the number of global and Indian publications related to "National Solar Mission". The compound annual growth rate of Indian publications is slightly higher than the total global publications during 2005-2019. The CAGR of Indian publications was quite higher than the total global publications before 2008 i.e. the year of the introduction of the "National Solar Mission". While the CAGR of Indian publications from 2009 to 2019 is lower than the global total publications (Table 4.4.1.3.1). Therefore, it may infer that the "National Solar Mission" of India does not instigate R&D activities on various objectives of solar mission thereby the growth of publications decreased.

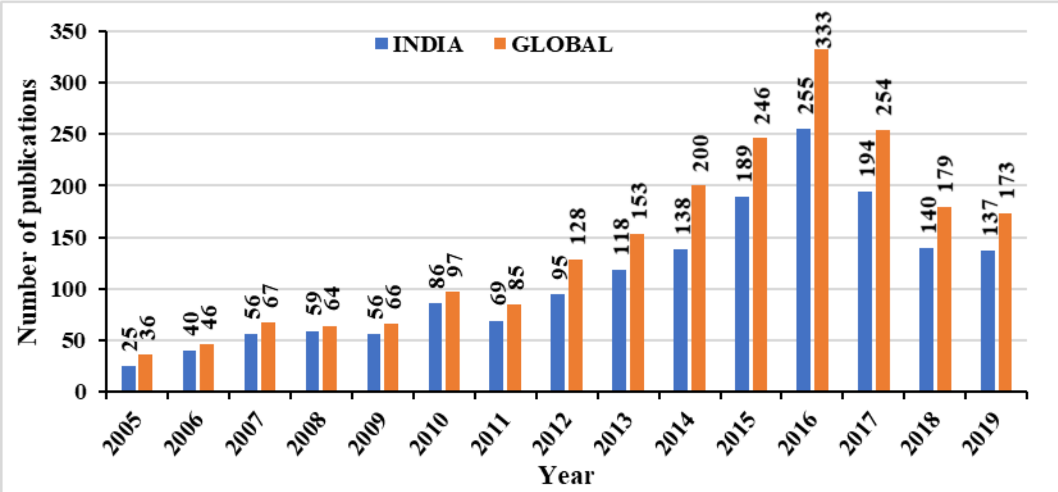


Figure 4.4.1.3.1: Year-wise global and Indian number of publications related to "National Solar Mission".

Table 4.4.1.3.1: Global and Indian total publications, Global and Indian compound annual growth rate of publications related to the "National Solar Mission" during 2005-2019, 2004-2008 and 2008-2019.

	Number of publication	CAGR of Total years	CAGR before the setting of the mission	CAGR after the setting of the mission
Global Publication	2127	11.86 %	21.14 %	10.45 %
Indian Publication	1657	12.91 %	33.13 %	8.78 %

4.4.1.3.2. Total Global and Indian comparative contribution in top 30 research areas

Total global research on the Indian "National Solar Mission" related topic has been performed in 263 research areas. The top 30 research areas of total global research on the Indian "National Solar Mission" related topic have contributed 77.23% cumulatively (normalised). India has contributed to 236 research areas during total periods. The top 30 research areas of total Indian research on climate change have contributed 77.70% cumulatively (normalised).

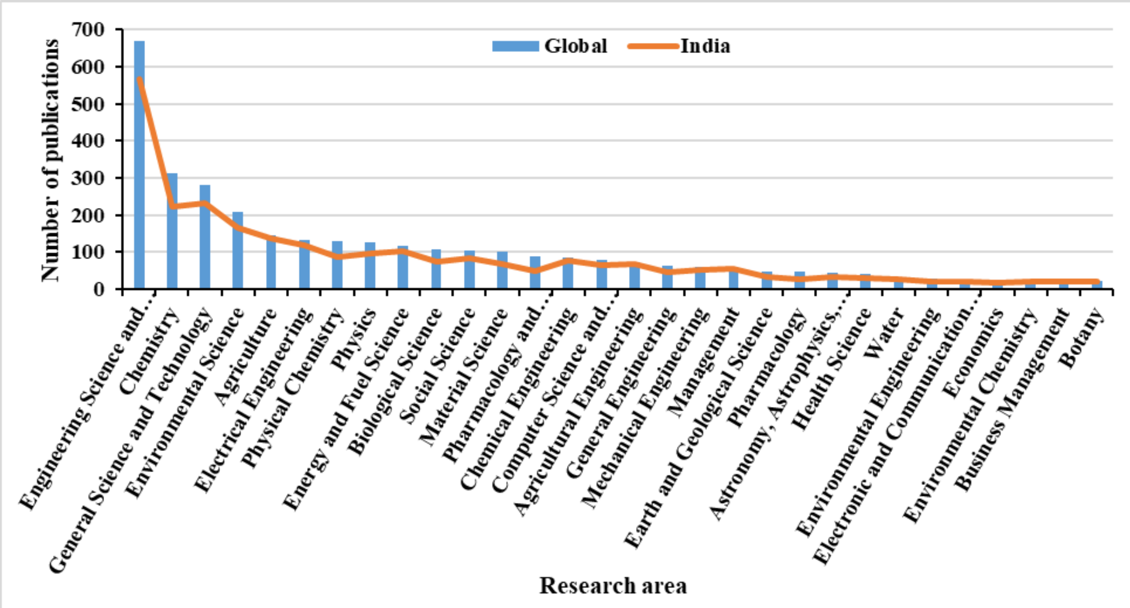


Figure 4.4.1.3.2: Global and Indian publication contribution related to “National Solar Mission” in top 30 research areas.

India has contributed at a higher proportion than the global in some research areas namely: Engineering Science and Technology, Agriculture, Electrical Engineering, Energy and Fuel Science and Chemical Engineering which are mainly deal with the solar technological development. India has contributed at a lower proportion than the global in some research areas namely: Chemistry, Physical Chemistry, Physics, Biological Science, Material Science, Pharmacology And Pharmaceutical Science, Agricultural Engineering, General Engineering, Earth And Geological Science, Pharmacology, Astronomy, Astrophysics, Space And Geodesy, Health Science, Environmental Engineering, Electronic And Communication Engineering, Economics (Figure 4.4.1.3.2).

4.4.1.3.3: Indian publication contribution in top 30 research areas before and after the adoption of the mission

Figure 4.4.1.3.3 shows the comparative contribution of the top 30 research areas of Indian publications before and after the introduction of the mission. Following research areas namely: Engineering Science and Technology, Agriculture, Physics, Chemistry, General Science and Technology, were the most important research areas before the introduction of the “National Solar Mission” by contributing more than 15 publications. After the introduction of the mission, the following research areas Engineering Science and Technology, General Science and Technology, Chemistry, Environmental Science, Agriculture, Electrical Engineering, Energy and Fuel Science were the most important and contributed more than 90 publications.

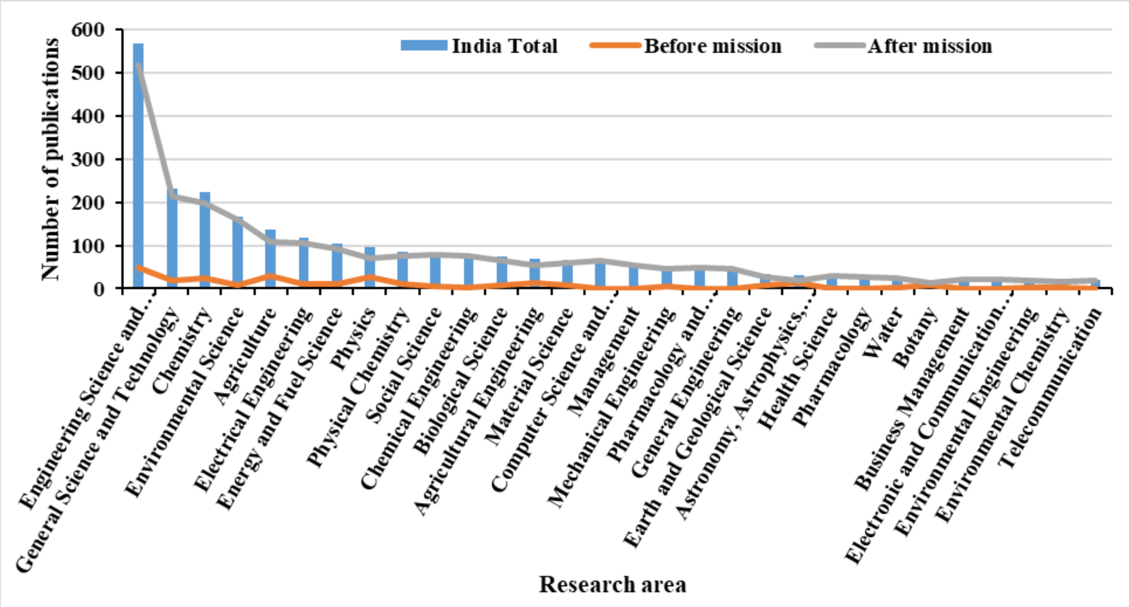


Figure 4.4.1.3.3: Indian publication contribution related to "National Solar Mission" in top 30 research areas before and after the adoption of the mission.

4.4.2. National Mission for Enhanced Energy Efficiency

The final search string to retrieved publication data from "Web of Science" and "Scopus" for "National Mission for Enhanced Energy Efficiency" was as follows:

TS=("energy efficien*" OR "energy-efficien*" OR (exerg* AND (efficien* OR analysis)) OR "energy optimization" OR ("low* energy consumption" OR "reduce* energy consumption" OR "low* power consumption" OR "reduce* power consumption") OR "energy sustainabl*" or "sustainabl* energy")

4.4.2.1. Analysis of Web of Science publication data related to the "National Mission for Enhanced Energy Efficiency

4.4.2.1.1. Number of publications related to the "National Mission for Enhanced Energy Efficiency" by top 30 countries

A total of 157811 global and 10239 Indian publications were retrieved from the Web of Science database using the final search string of "National Mission for Enhanced Energy Efficiency". Figure 4.4.2.1.1shows the publication contributions related to "National Mission for Enhanced Energy Efficiency" by the top 30 countries. The Peoples R China is the leading country and contributed 34122 publications. India has contributed 10239 publications and secured 3rd rank globally based on the number of publications.

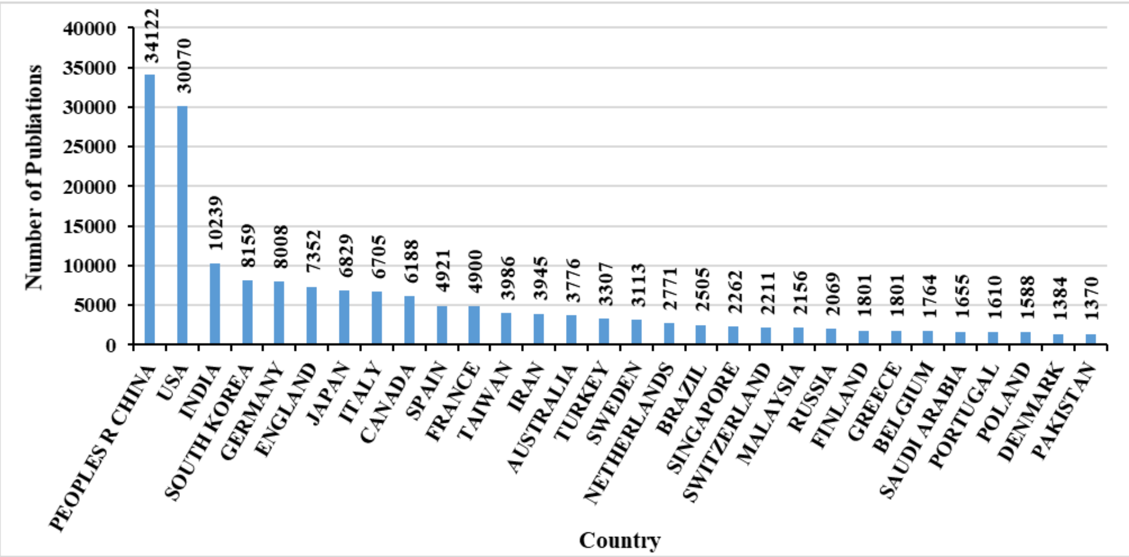


Figure 4.4.2.1.1: Total number of publications related to "National Mission for Enhanced Energy Efficiency" of top 30 countries.

4.4.2.1.2. Year-wise Growth of global and Indian publications related to "National Mission for Enhanced Energy Efficiency"

Figure 4.4.1.1.2 shows the year-wise growth of the number of total global and Indian publications related to "National Mission for Enhanced Energy Efficiency". The compound annual growth rate of Indian publications is slightly lower than the total global publications during 1987-2019. The CAGR of Indian publications was lower than the total global publications before 2008i.e. the year of the introduction of the "National Mission for Enhanced Energy Efficiency". It is very interesting to see that the CAGR of Indian publications from 2009 to 2019 is fairly higher than the global total publications (Table 4.4.2.1.1). Therefore, it may infer that the National Mission for Enhanced Energy Efficiency of India instigates R&D activities on various objectives of the mission thereby the growth of publications accelerated.

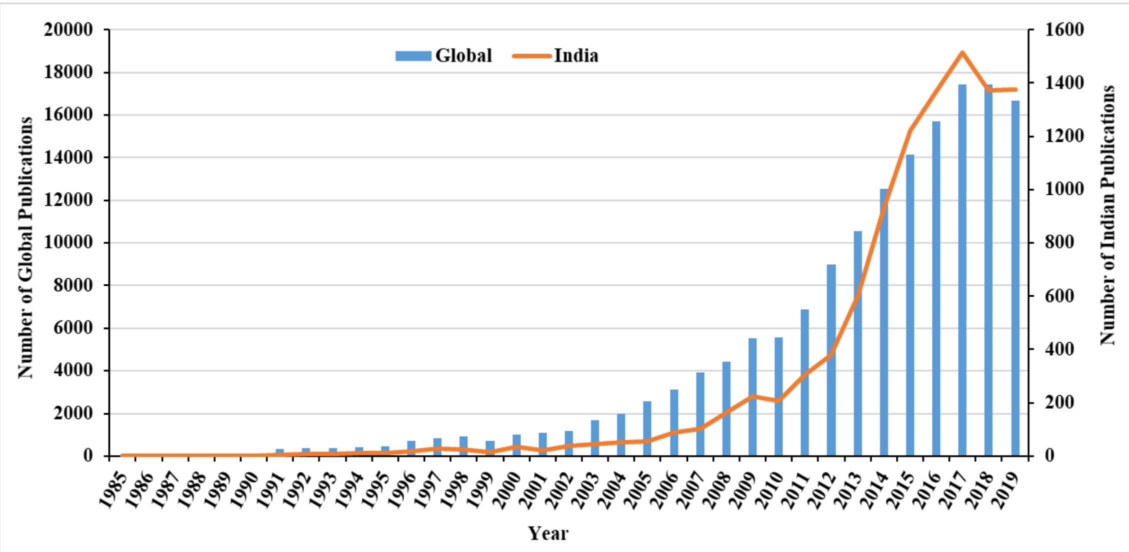


Figure 4.4.2.1.2: Year-wise global and Indian number of publications related to the "National Mission for Enhanced Energy Efficiency".

Table 4.4.2.1.1: Global and Indian total publications, Global and Indian compound annual growth rate of publications related to the "National Mission for Enhanced Energy Efficiency" during 1987-2019, 1987-2008 and 2008-2019.

	Number of publication	CAGR of all years	CAGR of Before Indian Mission	CAGR of After Indian Mission
Global Publication	157811	21.44	26.75%	12.79%
Indian Publication	10239	24.33	26.06%	21.4%

4.4.2.1.3. Total Global and Indian comparative contribution in top 30 research areas

Total global research on the Indian “National Mission for Enhanced Energy Efficiency” related topic has been performed in 225 research areas. The top 30 research areas of total global research on the Indian “National Mission for Enhanced Energy Efficiency” related topic have contributed 86.3% cumulatively (normalised). India has contributed to 141 research areas during total periods. The top 30 research areas of total Indian research on climate change have contributed 91.4% cumulatively (normalised).

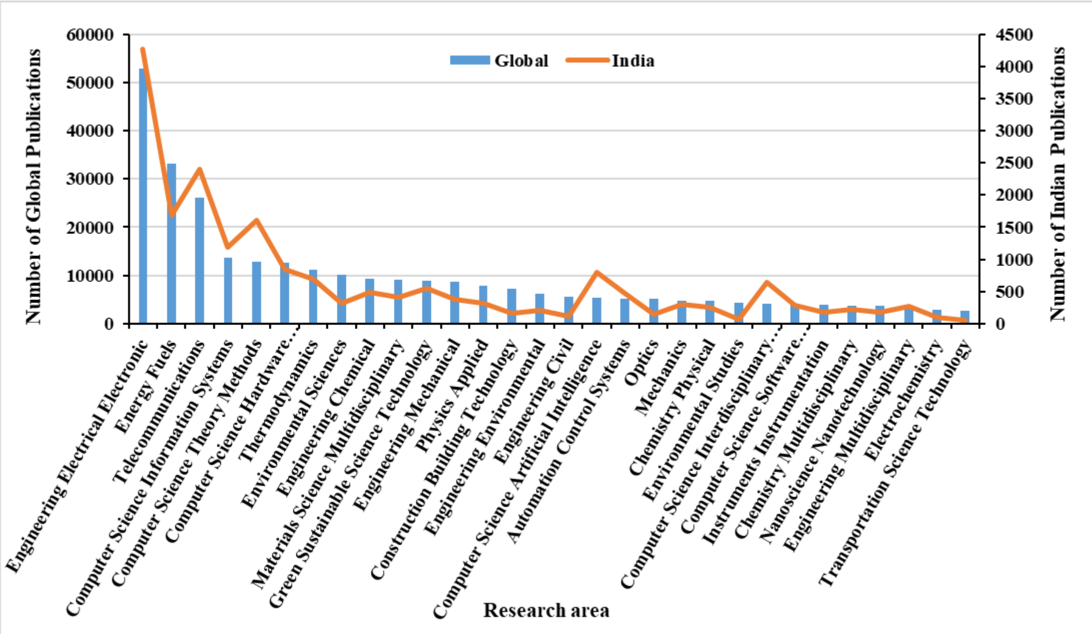


Figure 4.4.2.1.3: Global and Indian publication contribution related to “National Mission for Enhanced Energy Efficiency” in top 30 research areas.

India has contributed at a higher proportion than the global in some research areas namely: Engineering Electrical Electronic, Telecommunications, Computer Science Information Systems, Computer Science Hardware Architecture, Computer Science Theory Methods, Computer Science Artificial Intelligence, Automation Control Systems, Computer Science Interdisciplinary Applications, Computer Science Software Engineering, Engineering Multidisciplinary, which are mainly deal with the energy-related technological development to mitigate climate change. India has contributed at a lower proportion than the global in some research areas namely: Energy Fuels, Thermodynamics, Environmental Sciences, Engineering Chemical, Engineering Mechanical, Materials Science Multidisciplinary, Green Sustainable Science Technology, Physics Applied, Construction Building Technology, Engineering Environmental, Engineering Civil, Optics, Mechanics, Chemistry Physical, Environmental Studies, Instruments Instrumentation, Nanoscience Nanotechnology, Transportation Science Technology, Chemistry

Multidisciplinary,Electrochemistry which are mainly deal with the causal factor identification and impact assessment of the climate change (Figure 4.4.2.1.3).

4.4.2.1.4: Indian publication contribution in top 30 research areas before and after the adoption of the mission

Figure 4.4.2.1.4 shows the comparative contribution of the top 30 research areas of Indian publications before and after the introduction of the mission. Following research areas namely, Energy Fuels, Engineering Electrical Electronic,Telecommunications were the most important research areas before the introduction of the "National Mission for Enhanced Energy Efficiency" by contributing more than 100 publications. After the introduction of the mission, the following research areas Energy Fuels, Engineering Electrical Electronic, Telecommunications, Computer Science Theory Methods, Computer Science Information Systems were the most important and contributed more than 1000 publications.

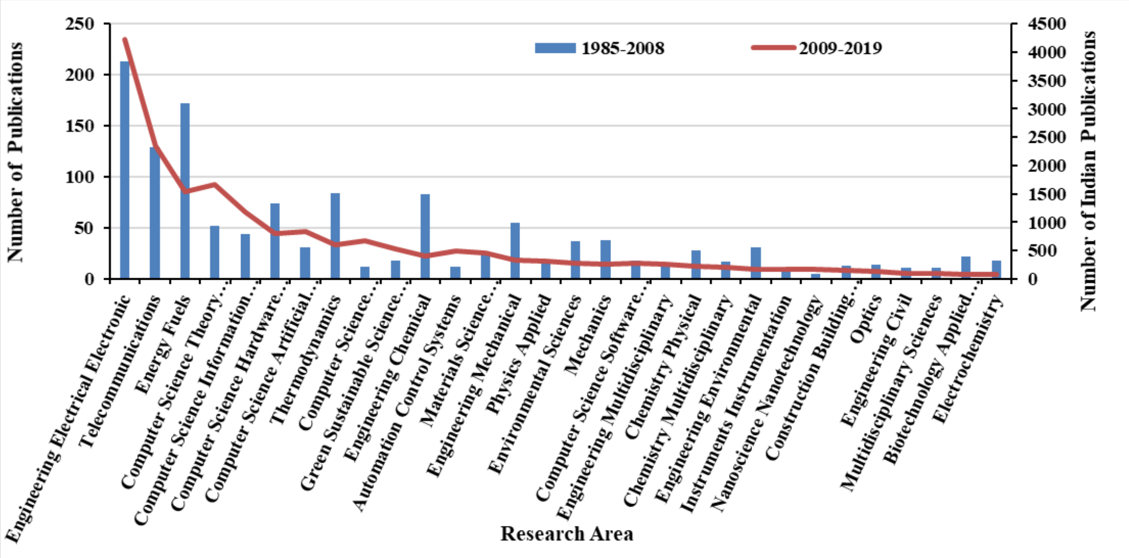


Figure 4.4.2.1.4: Indian publication contribution related to "National Mission for Enhanced Energy Efficiency" in top 30 research areas before and after the adoption of the mission.

4.4.2.1.5. The quantitative evolution and exchange of keywords of Indian publication related to "National Mission for Enhanced Energy Efficiency"

The quantitative evolution and exchange of keywords from the before mission to the after mission are represented in Figure for total Indian publications on National Mission for Enhanced Energy Efficiency. Each circle contains the number of keywords during that period which is indicated below the circle. The arrow containing the number of keywords coming towards the circle indicates newly arisen keywords. On the other hand, the arrow going outside indicates the number of keywords that are not used at successive periods. The arrow pointing from the previous to successive period represents the number of keywords exchanged (integer value) and the fraction of overlap (i.e., Similarity Index) in parentheses.

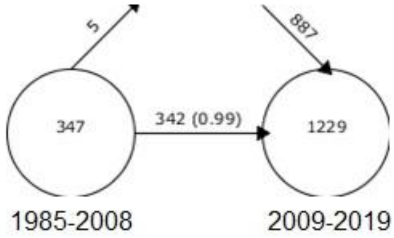


Figure4.4.2.1.5: Overlapping map of keyword's quantitative perspective during successive periods of Indian Publications on "National Mission for Enhanced Energy Efficiency".

The higher value of the similarity index indicates the core themes of Indian publications on National Mission for Enhanced Energy Efficiency research remain more or less continuous, whereas, the quantity of newly evolved keywords indicates the advancement of the core theme in different subthemes. The number of keywords did increase from 347 before the mission to 1229 after the mission with a growth rate of 254.18%. Indian publications on National Mission for Enhanced Energy Efficiency publications research after setting of the mission incorporated maximum keyword from research perform during before mission.

4.4.2.1.6. Quantitative and qualitative development of themes at successive periods of Indian publication related to "National Mission for Enhanced Energy Efficiency"

Thematic evolution was represented through strategic diagrams at successive periods. Themes were plotted as circles denoting different theme clusters according to centrality and density in strategic diagrams. The size of the circle is proportional to the number of documents and referred to as document frequency (DF) in which it's linked or related keywords are present. The strategic diagrams are divided into four quadrants and they can be interpreted as follows: the top-right quadrant represents "motor themes", the top-left quadrant represents "highly developed and isolated themes", the bottom-left quadrant represents "emerging or declining themes", the bottom-right quadrant represents "basic and transversal themes".

During 1985-2008 a total of only 347 keywords during the before mission were observed among the total 737 publications. The initial period has registered two themes with a DF range of 16 to 39. During this period "ENERGIES" was found to be the most active theme having a DF of 39 with document citations (1,403) (Figure 4.4.2.1.6, Table 4.4.2.1.2). The theme "ENERGIES" was positioned in the top-right quadrant with the highest centrality value (18.01) indicating itself as the most important and well-connected theme with other keywords vis-à-vis themes. The theme "ENERGY-EFFICIENCIES" was positioned in the top-left quadrant with no centrality, thereby assigning it as an isolated theme, also found to come under emerging focus, as they were positioned in the bottom-left quadrant and appeared in the bottom-right quadrant as basic and transversal themes.

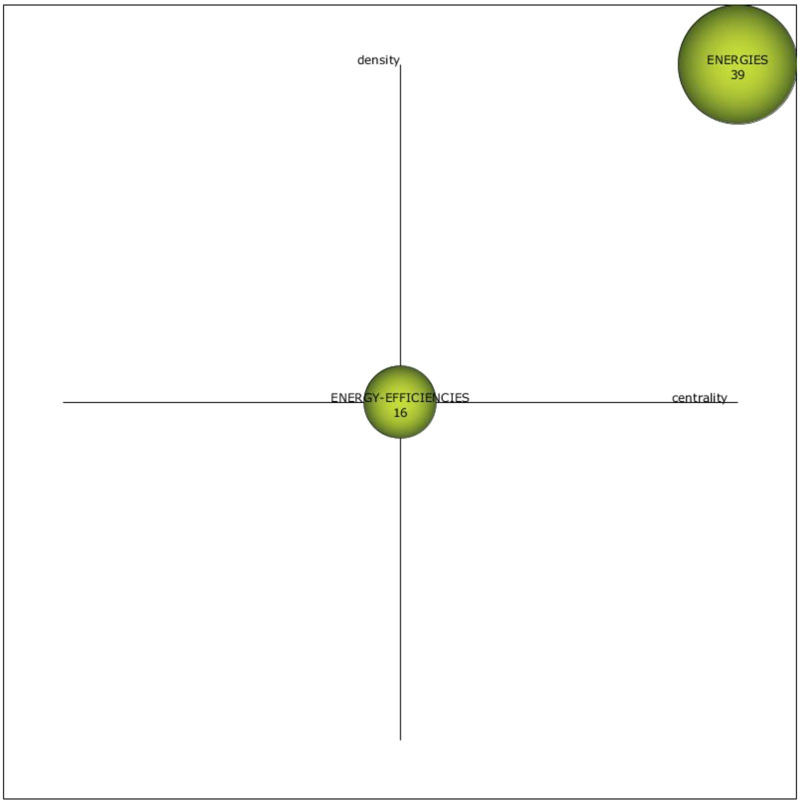


Figure 4.4.2.1.6: Strategic diagram of themes during 1985-2008 of Indian publications related to "National Mission for Enhanced Energy Efficiency".

Table 4.4.2.1.2: Quantitative and qualitative performance measures of themes during 1985-2008 of Indian publications related to "National Mission for Enhanced Energy Efficiency".

Name	Centrality	Density	Core Documents documents Count	Core Documents sum Citations	Secondary Documents documents Count	Secondary Documents sum Citations
Energies	18.01	5.38	39	1,403	105	3,486
Energy-Efficiencies	5.05	1.89	16	251	81	1,091

During 2009-2019 total keywords have increased to 1229 during the after mission with a growth rate of 254.18% among the total 9832 publications (increased by maximum). The number of themes did also increase to seven after the mission with comparatively more DF. During this period “WIRELESS-SENSOR-NETWORK” was found to be the most active theme having a DF of 941 followed by “ENERGIES” with a DF of 455 (Figure 4.4.2.1.7, Table 4.4.2.1.3). The theme “ENERGIES” received maximum document citations (6,092) followed by “WIRELESS-SENSOR-NETWORK” (4,294). The theme “ENERGIES” was positioned in the top-right quadrant with the highest centrality value (16.71) indicating itself as the most important and well-connected theme with other keywords vis-à-vis themes followed by “FLOWS” (11.5). The theme “COGNITIVE-RADIO-NETWORKS” was positioned in the top-left quadrant with no centrality, thereby assigning it as an isolated theme. The themes “WSNS”, “GREEN-COMMUNICATIONS” and “CO2-EMISSIONS” were found to come under emerging focus, as they were positioned in the bottom-left quadrant. The theme “DESIGNS” appeared in the bottom-right quadrant as basic and transversal themes.

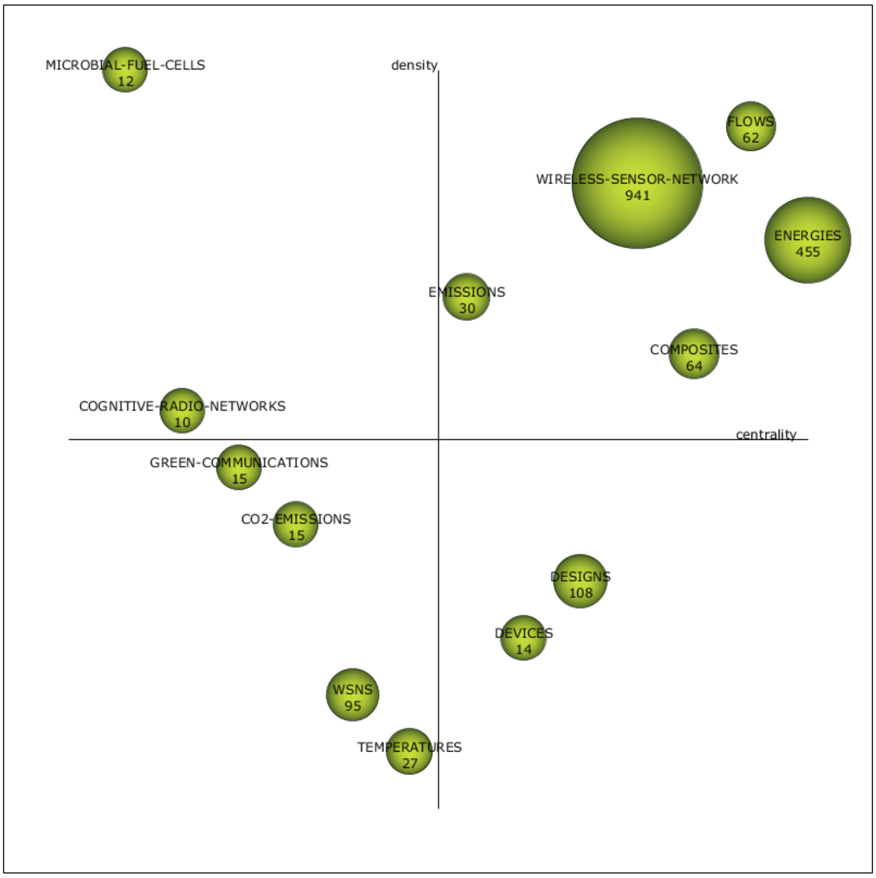


Figure 4.4.2.1.7: Strategic diagram of themes during 2009-2019 of Indian publications related to "National Mission for Enhanced Energy Efficiency".

Table 4.4.2.1.3: Quantitative and qualitative performance measures of themes during 2009-2019 of Indian publications related to "National Mission for Enhanced Energy Efficiency".

Name	**Centrality**	**Density**	**Core Documents Count**	**Core Documents sum Citations**	**Secondary Documents Count**	**Secondary Documents sum Citations**
Flows	11.5	5.59	62	860	284	4,078
Energies	16.71	3.52	455	6,092	1,246	15,048
Wireless-Sensor-Network	10.11	4.01	941	4,294	2,094	10,485
Composites	10.95	3.07	64	1,615	279	4,242
Designs	7.13	1.64	108	1,006	637	5,154
Wsns	4.22	0.53	95	280	809	2,840
Emissions	4.68	3.46	30	454	208	2,751
Temperatures	4.38	0.46	27	402	241	3,126
Green-Communications	2.93	1.8	15	240	122	567

Devices	6.84	1.44	14	75	98	445
Co2-Emissions	3.4	1.68	15	473	116	1,866
Microbial-Fuel-Cells	0.56	5.86	12	133	42	536
Cognitive-Radio-Networks	2.56	2.19	10	17	100	588

4.4.2.2. Analysis of Scopus publication data related to "National Mission for Enhanced Energy Efficiency"

4.4.2.2.1. Number of publications by top 30 countries related to "National Mission for Enhanced Energy Efficiency"

A total of 2,72,519 publications were retrieved from the Scopus database using the final search string. Figure 4.4.2.2.1shows the publication contributions by the top 30 countries. China is the leading country and contributed 52439 publications. India has contributed 19094 publications and secured 3rd rank globally in the publications related to the "National Mission for Enhanced Energy Efficiency".

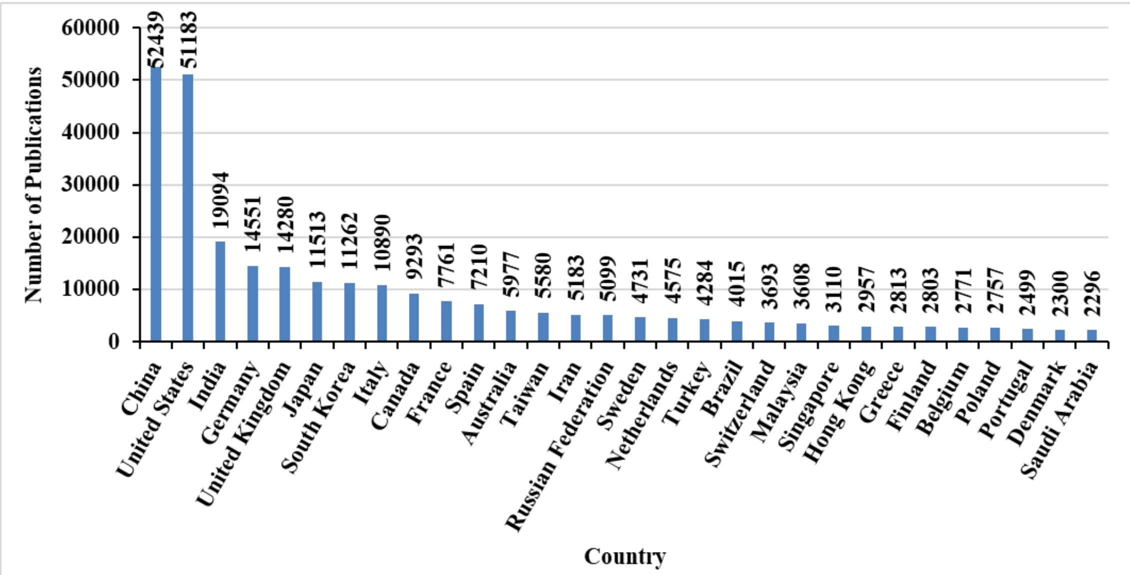


Figure 4.4.2.2.1: Total number of publications related to "National Mission for Enhanced Energy Efficiency" of top 30 countries.

4.4.2.2.2. Year-wise Growth of global and Indian publications related to "National Mission for Enhanced Energy Efficiency"

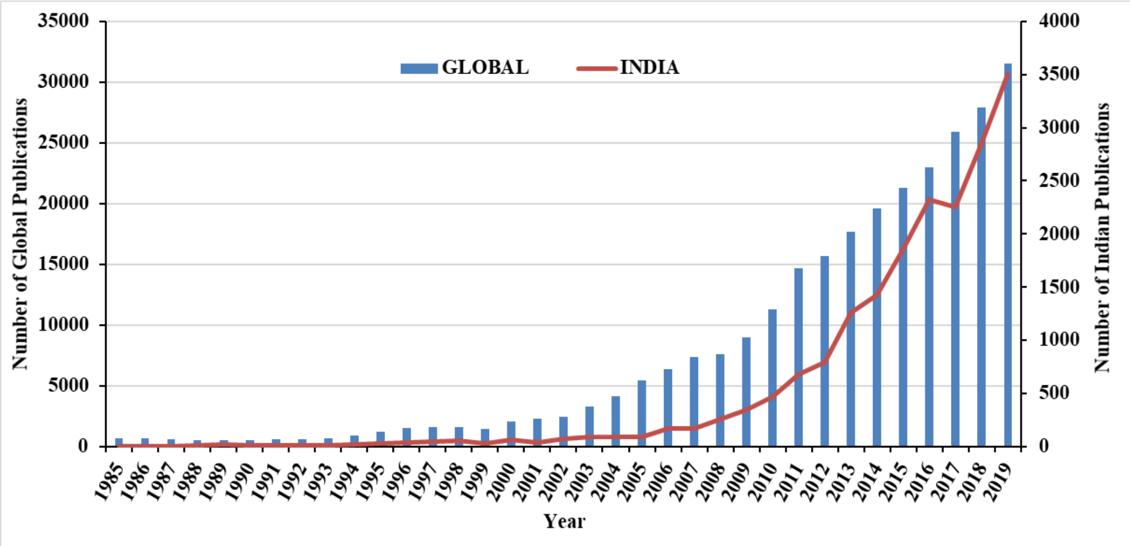


Figure 4.4.2.2.2: Year-wise global and Indian number of publications related to "National Mission for Enhanced Energy Efficiency".

Figure 4.4.2.2.2 shows the year-wise growth of the number of total global and Indian publications related to the "National Mission for Enhanced Energy Efficiency". The compound annual growth rate (24.55%) of Indian publications is higher than the total global publications during 1987-2019 (Table 4.4.2.2.1). The CAGR (23.48 %) of Indian publications was higher than the total global publications up to 2008 i.e. the year of the setting of the "National Mission for Enhanced Energy Efficiency". It is very interesting to see that the CAGR (26.83 %) of Indian publications is also higher than the global total publications during last period. Therefore, it may conclude that the "National Mission for Enhanced Energy Efficiency" of India instigates the R&D activities on various objectives of solar mission thereby the growth of publications accelerated.

Table 4.4.2.2.1.: Global and Indian compound annual growth rate of publications related to "National Mission for Enhanced Energy Efficiency" during 1987-2019, 1987-2008 and 2008-2019.

	Number of publications	CAGR of all years	CAGR of Before Indian Mission	CAGR of After Indian Mission
Global Publication	272519	11.96 %	11.09 %	13.79 %
Indian Publication	19094	24.55 %	23.48 %	26.83 %

4.4.2.2.3. Total Global and Indian comparative contribution in different subject areas

Total global research on the Indian "National Mission for Enhanced Energy Efficiency" related topic has been performed in 28subject areas. The top 10 subject areas of total global research on Indian "National Mission for Enhanced Energy Efficiency" related topic have contributed 91.38% cumulatively (normalised). India has contributed in 26 subject areas during total periods. The top 10 subject areas of total Indian research on climate change have contributed 90.61% cumulatively (normalised).

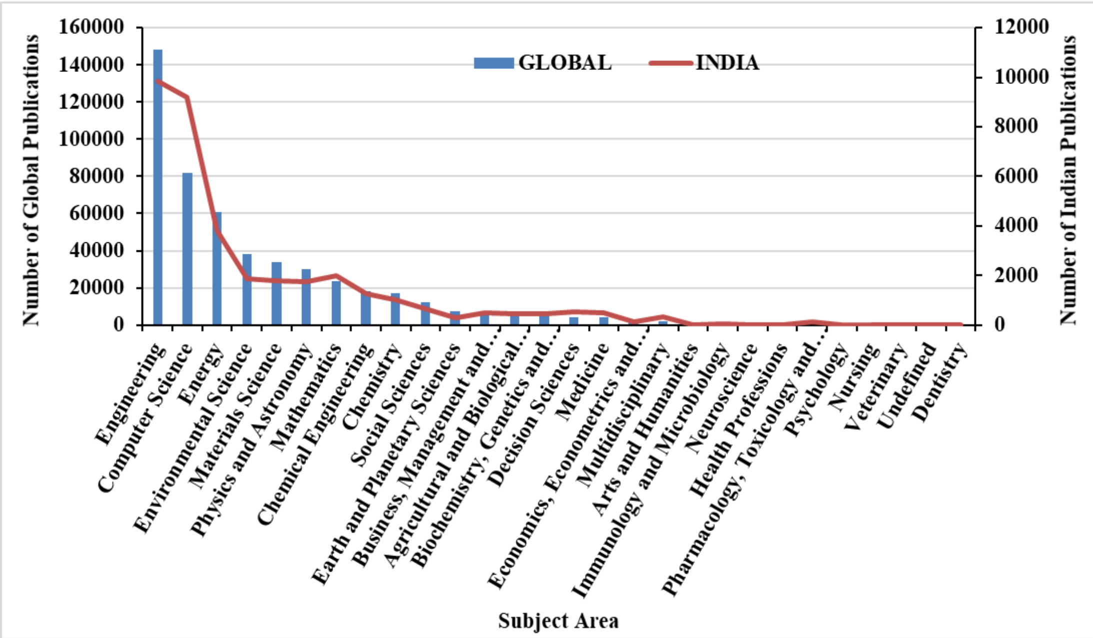


Figure 4.4.2.2.3.: Global and Indian publication contribution related to "National Mission for Enhanced Energy Efficiency" in different subject areas.

India has contributed at a higher proportion than the global in some subject areas namely: Computer Science, Mathematics, Medicine, Decision Sciences, Veterinary. India has contributed at a lower proportion than the global in some subject areas namely: Engineering, Energy, Chemical engineering, Materials Science, Physics and Astronomy, Chemistry, Earth and Planetary Sciences, Environmental Science, Business, Management and Accounting, Social Sciences, Agricultural and Biological Sciences, Multidisciplinary, Biochemistry, Genetics and Molecular Biology, Economics, Econometrics and Finance, Arts and Humanities, Health Professions, Neuroscience, Immunology and Microbiology, Nursing, Pharmacology, Toxicology and Pharmaceutics, Psychology, Dentistry, Undefined. (Figure 4.4.2.2.3).

4.4.2.2.4. Indian publication contribution in top 30 research areas before and after the introduction of the mission

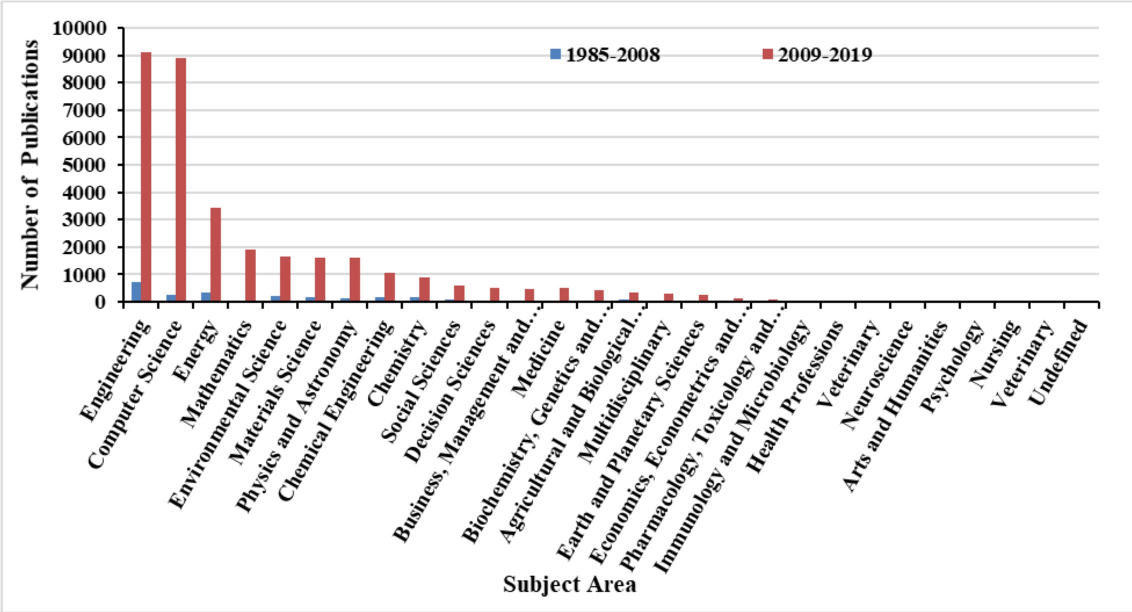


Figure 4.4.2.2.4 Indian publication contribution related to "National Mission for Enhanced Energy Efficiency" in different research areas before and after the introduction of the mission.

Figure 4.4.2.2.4 shows the comparative contribution of different subject areas of Indian publications before and after the introduction of the mission. Following research areas namely, Energy, Engineering, Computer Science. Materials Science, Chemistry, Environmental Science, Chemical Engineering were the most important research areas before the introduction of the "National Mission for Enhanced Energy Efficiency" by contributing more than 150 publications. After the introduction of the mission, the following research areas Energy, Engineering, Computer Science. Materials Science, Chemistry, Environmental Science, Chemical Engineering, Mathematics, Physics and Astronomy were the most important and contributed more than 1000 publications.

4.4.2.3. Analysis of Indian Citation Index data related to "National Mission for Enhanced Energy Efficiency"

4.4.2.3.1. Year-wise Growth of global and Indian publications related to "National Mission for Enhanced Energy Efficiency"

Figure 4.4.1.3.1 shows the year-wise growth of the number of global and Indian publications related to "National Mission for Enhanced Energy Efficiency". The compound annual growth rate of Indian publications is slightly lower than the total global publications during 2005-2019. The CAGR of Indian publications was quite higher than the total global publications before 2008i.e. the year of the introduction of the "National Mission for Enhanced Energy Efficiency". While the CAGR of Indian publications from 2009 to 2019 is lower than the global total publications (Table 4.4.2.3.1). Therefore, it may infer that the "National Mission for Enhanced Energy Efficiency" of India does not instigate R&D activities on various objectives of "National Mission for Enhanced Energy Efficiency" thereby the growth of publications decreased.

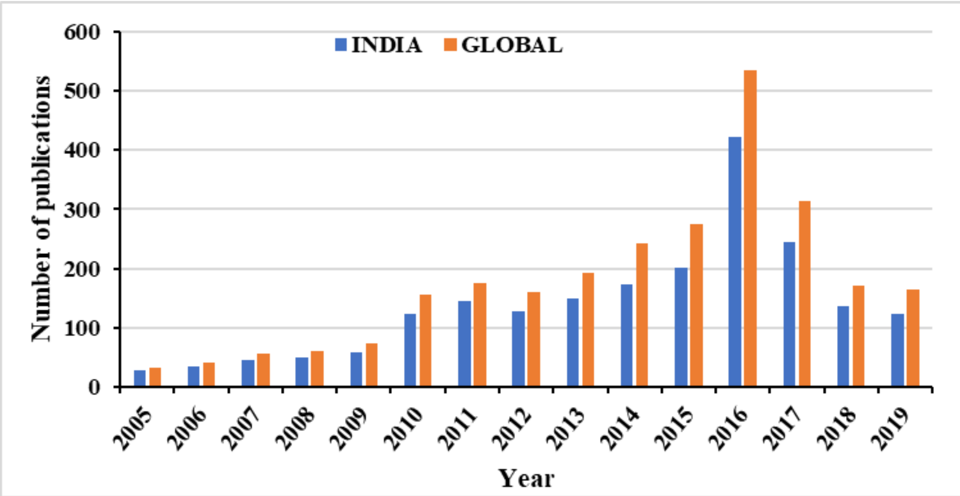


Figure 4.4.2.3.1: Year-wise global and Indian number of publications related to "National Mission for Enhanced Energy Efficiency".

Table 4.4.2.3.1: Global and Indian total publications, Global and Indian compound annual growth rate of publications related to the "National Mission for Enhanced Energy Efficiency" during 2005-2019, 2004-2008 and 2008-2019.

	Number of publications	CAGR of all years	CAGR of before Indian Mission	CAGR of after Indian Mission
Global Publication	2649	12.18 %	22.72 %	10.46 %
Indian Publication	2055	11.43 %	22.80 %	9.42 %

4.4.2.3.2. Total Global and Indian comparative contribution in different subject areas

Total global research on the Indian "National Mission for Enhanced Energy Efficiency" related topic has been performed in 263 research areas. The top 30 research areas of total global research on the Indian "National Mission for Enhanced Energy Efficiency" related topic have contributed 76.19% cumulatively (normalised). India has contributed to 248 research areas during total periods. The top 30 research areas of total Indian research on climate change have contributed 76.54% cumulatively (normalised).

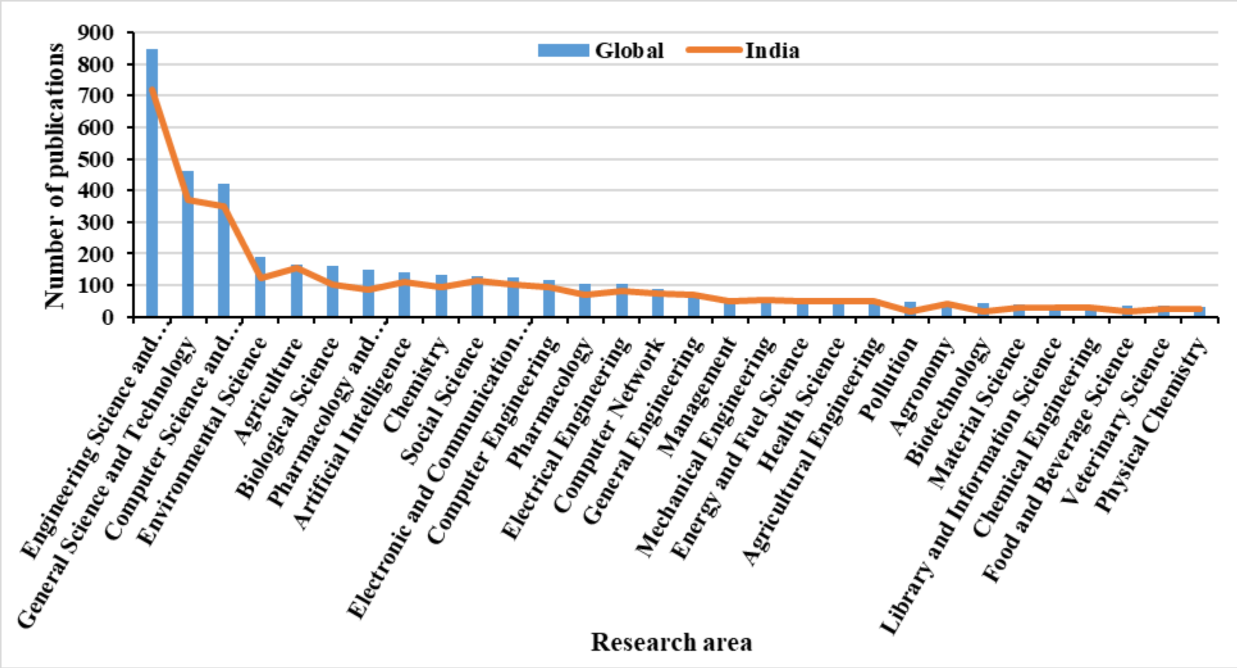


Figure 4.4.2.3.2: Global and Indian publication contribution related to "National Mission for Enhanced Energy Efficiency" in top 30 research areas.

India has contributed at a higher proportion than the global in some research areas namely Engineering Science And Technology, General Science And Technology, Computer Science And Technology, Agriculture, Artificial Intelligence, Social Science, Electronic And Communication Engineering, Computer Engineering, Computer Network, General Engineering, Management, Mechanical Engineering, Energy And Fuel Science, Health Science, Agricultural Engineering, Agronomy, Material Science, Library And Information Science which are mainly deal with the energy-related technological development. India has contributed at a lower proportion than the global in some research areas namely: Environmental Science, Biological Science, Pharmacology And Pharmaceutical Science, Chemistry, Pharmacology, Electrical Engineering, Pollution, Biotechnology, Chemical Engineering, Food And Beverage Science, Veterinary Science, Physical Chemistry(Figure 4.4.2.3.2).

4.4.2.3.3: Indian publication contribution in top 30 research areas before and after the adoption of the mission

Figure 4.4.2.3.3 shows the comparative contribution of the top 30 research areas of Indian publications before and after the introduction of the mission. Following research areas namely: Engineering Science and Technology, Agriculture, Computer Science And Technology, Electrical Engineering, Mechanical Engineering, Agricultural Engineering, General Science and Technology were the most important research areas before the introduction of the "National Mission for Enhanced Energy Efficiency" by contributing more than 10 publications. After the introduction of the mission, the following research areas Engineering Science And Technology, General Science And Technology, Computer Science And Technology, Environmental Science, Agriculture, Electronic And Communication Engineering, Artificial Intelligence, Social Science were the most important and contributed more than 100 publications.

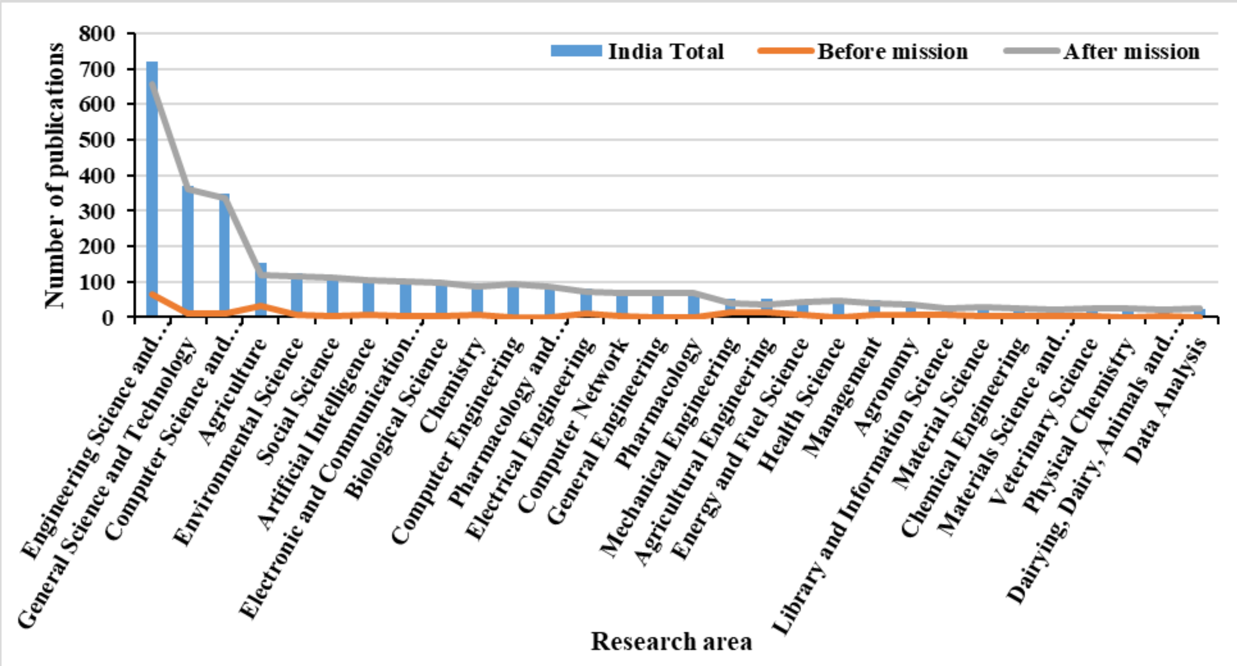


Figure 4.4.2.3.3: Indian publication contribution related to "National Mission for Enhanced Energy Efficiency" in top 30 research areas before and after the adoption of the mission.

4.4.3. National Mission on Sustainable Habitat

The final search string to retrieved publication data from "Web of Science" and "Scopus" for "National Mission on Sustainable Habitat" was as follows:

TS=((("energy efficien*" OR "energy consum*" OR "energy sav*" OR "energy conserv*" OR "energy price*") AND (resident* OR commercial OR office OR building* OR industr* OR construct* OR applianc* OR equipment OR fan OR lamp OR "tube light" OR chiller* OR insulat* OR electric*)) OR (transport* AND (vehicle* OR passenger* OR freight OR motorcycle* OR scooter* OR cars OR personal* OR road OR buses OR railway* OR infrastructureOR automobile OR urban)) AND (GHG OR CNG OR CO2 OR biofule* OR bio-diesel OR "greenhouse gas*" OR ethanol OR gasoline OR "reduc* energy" OR price* OR electric* OR diesel OR petrol)) OR (manage* OR recycl* OR reuse OR dispos* OR treatment OR collection OR compost*) AND (waste AND (solid OR municipal OR "bio hazard" OR medical OR plastic))))

4.4.3.1. Analysis of Web of Science publication data of "National Mission on Sustainable Habitat"

4.4.3.1.1. Number of publications related to the "National Mission on Sustainable Habitat"by top 30 countries

A total of 1,66,865 global and 7187 Indian publications were retrieved from the Web of Science database using the final search string of "National Mission on Sustainable Habitat". Figure 4.4.3.1.1shows the publication contributions related to "National Mission on Sustainable Habitat" by the top 30 countries. The Peoples R China is the leading country and contributed 35085 publications. India has contributed 7187 publications and secured 7th rank globally based on the number of publications.

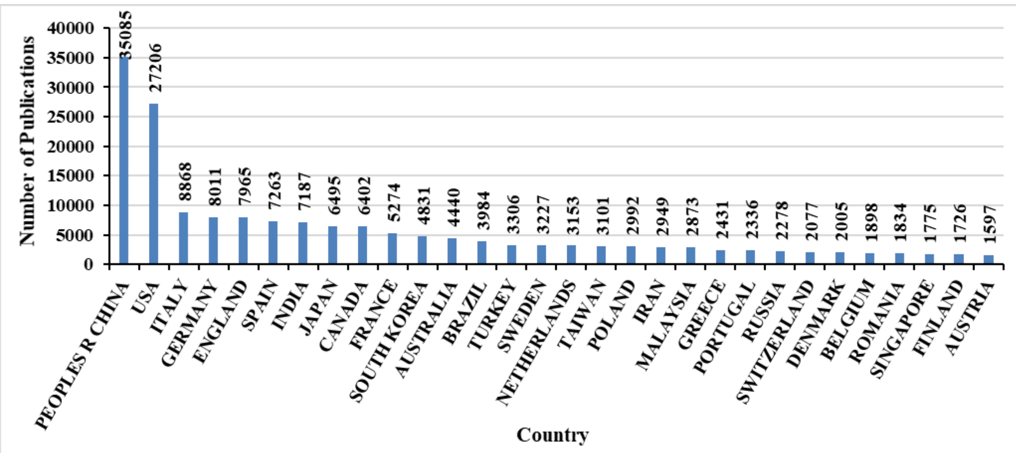


Figure 4.4.3.1.1: Total number of publications related to "National Mission on Sustainable Habitat" of top 30 countries.

4.4.3.1.2. Year-wise Growth of global and Indian publications related to "National Mission on Sustainable Habitat"

Figure 4.4.1.1.2 shows the year-wise growth of the number of total global and Indian publications related to "National Mission on Sustainable Habitat". The compound annual growth rate of Indian publications is slightly lower than the total global publications during 1987-2019. The CAGR of Indian publications was lower than the total global publications before 2008 i.e. the year of the introduction of the "National Mission on Sustainable Habitat". It is very motivating to see that the CAGR of Indian publications from 2009 to 2019 is fairly higher than the global total publications (Table 4.4.3.1.2). Therefore, it may infer that the "National Mission on Sustainable Habitat" of India instigates R&D activities on various objectives of solar mission thereby the growth of publications accelerated.

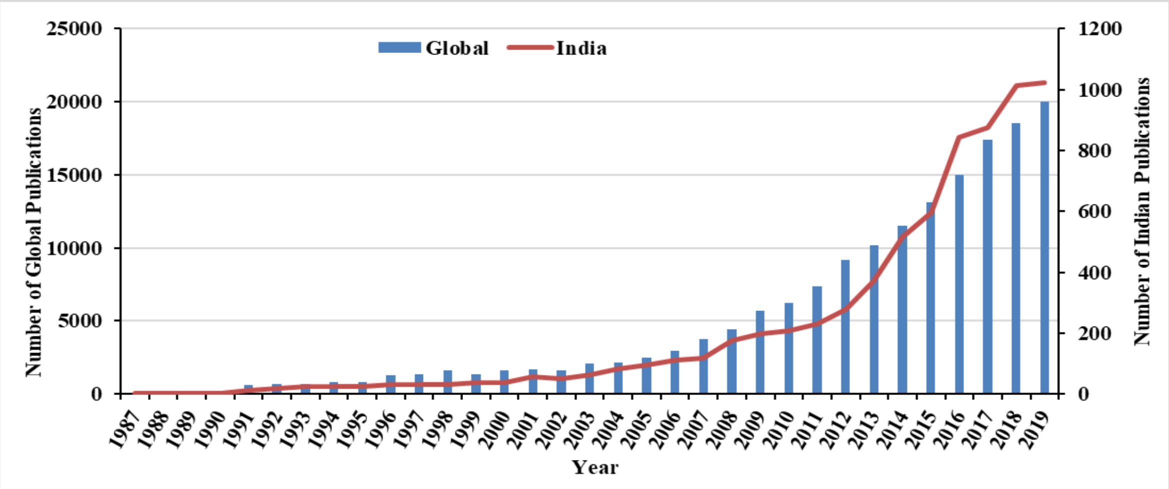


Figure 4.4.3.1.2: Year-wise global and Indian number of publications related to the "National Mission on Sustainable Habitat".

Table 4.4.3.1.1: Global and Indian total publications, Global and Indian compound annual growth rate of publications related to the "National Mission on Sustainable Habitat" during 1987-2019, 1987-2008 and 2008-2019.

	Number of publications	CAGR of all years	CAGR of before Indian Mission	CAGR of after Indian Mission
Global Publication	166865	19.59%	22.23%	14.66%
Indian Publication	7187	24.17%	27.91%	17.33%

4.4.3.1.3. Total Global and Indian comparative contribution in top 30 research areas:

Total global research on the Indian “National Mission on Sustainable Habitat” related topic has been performed in 221 research areas. The top 30 research areas of total global research on the Indian “National Solar Mission” related topic have contributed 80.88% cumulatively (normalised). India has contributed to 159 research areas during total periods. The top 30 research areas of total Indian research on climate change have contributed 83.71% cumulatively (normalised). India has contributed at a higher proportion than the global in some research areas namely: Engineering Electrical Electronic, Engineering Chemical, Green Sustainable Science Technology, Computer Science Information Systems,Computer Science Theory Methods, Biotechnology Applied Microbiology, Automation Control Systems, Chemistry Multidisciplinary, Engineering Multidisciplinary, Chemistry Physical, Computer Science Interdisciplinary Applications, Computer Science Artificial Intelligence, Computer Science Hardware Architecture, Agricultural Engineering which are mainly deal with the sustainable development related technology to mitigate climate change. India has contributed at a lower proportion than the global in some research areas namely: Energy Fuels, Environmental Sciences, Engineering Environmental, Construction Building Technology, Engineering Civil, Materials Science Multidisciplinary, Thermodynamics, Engineering Mechanical, Telecommunications, Water Resources, Transportation Science Technology, etc. (Figure 4.4.3.1.3).

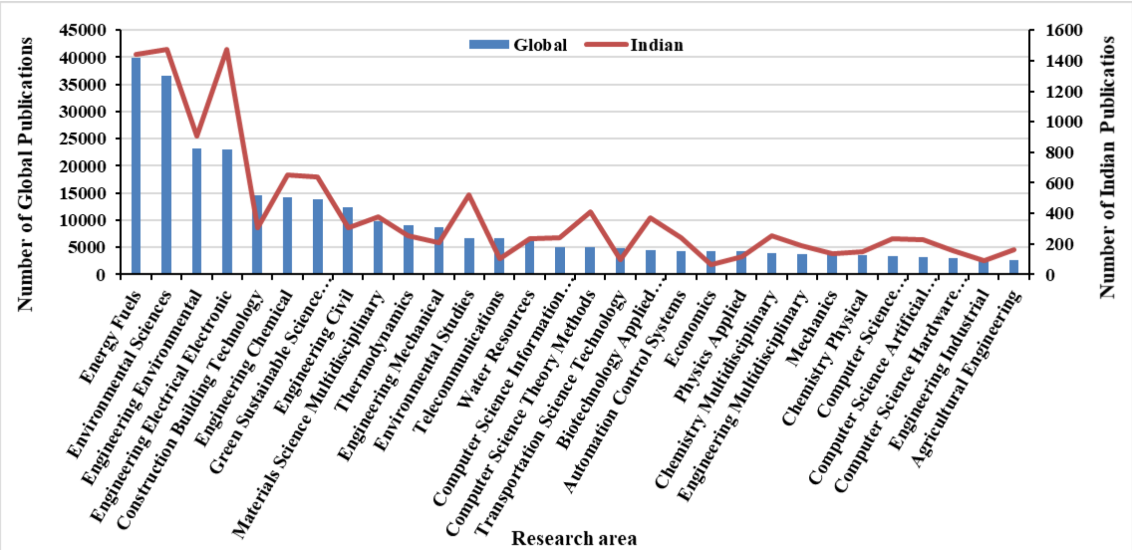


Figure 4.4.3.1.3: Global and Indian publication contribution related to “National Mission on Sustainable Habitat” in top 30 research areas.

4.4.3.1.4. Indian publication contribution in top 30 research areas before and after the adoption of the mission

Figure 4.4.3.1.4 shows the comparative contribution of the top 30 research areas of Indian publications before and after the introduction of the mission. Following research areas namely, Environmental Sciences, Energy Fuels, Engineering Environmental, Engineering Chemical, Biotechnology Applied Microbiology, Engineering Electrical Electronics, Thermodynamics, Water Resources were the most important research areas before the introduction of the "National Mission on Sustainable Habitat" by contributing more than 50 publications. After the introduction of the mission, the following research areas Engineering Electrical Electronic, Energy Fuels, Environmental Sciences, Engineering Environmental, Green Sustainable Science Technology, Engineering Chemical, Telecommunications were the most important and contributed to more than 500 publications.

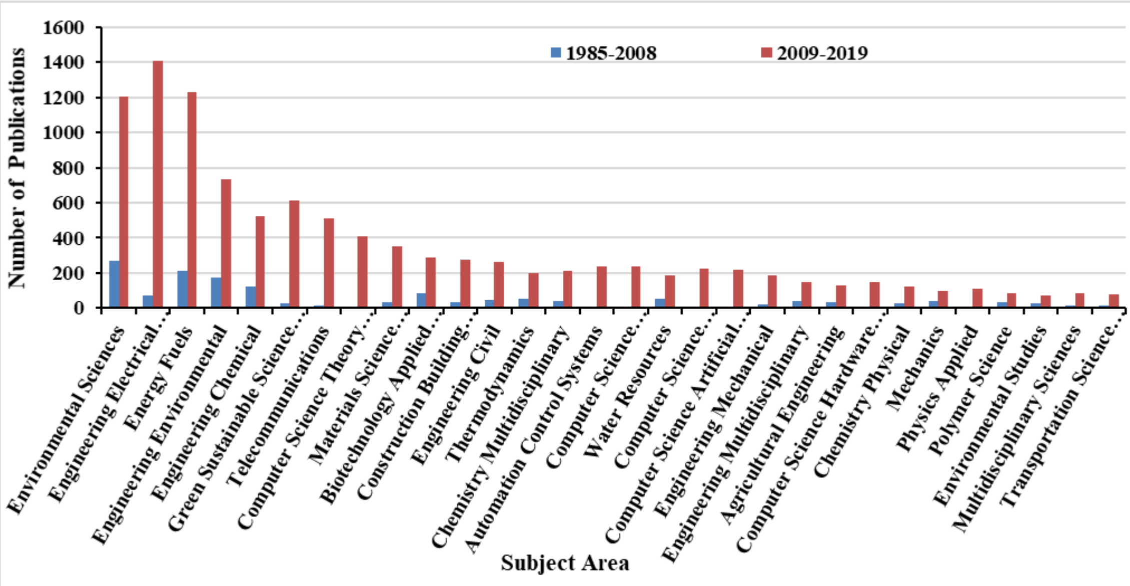


Figure 4.4.3.1.4: Indian publication contribution related to "National Mission on Sustainable Habitat" in top 30 research areas before and after the adoption of the mission.

4.4.3.1.5. The quantitative evolution and exchange of keywords of Indian publication related to "National Mission on Sustainable Habitat"

The quantitative evolution and exchange of keywords from the before mission to the after mission are represented in Figure for total Indian publications on National Mission on Sustainable Habitat. Each circle contains the number of keywords during that period which is indicated below the circle. The arrow containing the number of keywords coming towards the circle indicates newly arisen keywords. On the other hand, the arrow going outside indicates the number of keywords that are not used at successive periods. The arrow pointing from the previous to successive period represents the number of keywords exchanged (integer value) and the fraction of overlap (i.e., Similarity Index) in parentheses.

The higher value of the similarity index indicates the core themes of Indian publications on National Mission on Sustainable Habitat research remain more or less continuous, whereas, the quantity of newly evolved keywords indicates the advancement of the core theme in different subthemes. The number of keywords did increase from 468 during before the mission to 1144 during the after mission with a growth rate of 144.44%. Indian publications on National Mission on Sustainable Habitat publications research after setting of the mission incorporated more than 50% keyword from research perform during before mission.

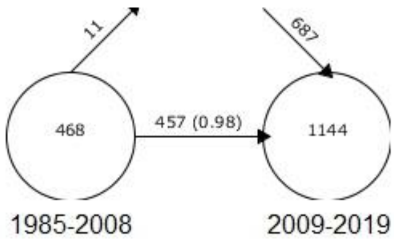


Figure4.4.3.1.5: Overlapping map of keyword's quantitative perspective during successive periods of Indian Publications on "National Mission on Sustainable Habitat".

4.4.3.1.6. Quantitative and qualitative development of themes at successive periods

Thematic evolution was represented through strategic diagrams at successive periods. Themes were plotted as circles denoting different theme clusters according to centrality and density in strategic diagrams. The size of the circle is proportional to the number of documents and referred to as document frequency (DF) in which it's linked or related keywords are present. The strategic diagrams are divided into four quadrants and it can be interpreted as follows: the top-right quadrant represents "motor themes", the top-left quadrant represents "highly developed and isolated themes", the bottom-left quadrant represents "emerging or declining themes", the bottom-right quadrant represents "basic and transversal themes".

During 1985-2008 a total of only 468 keywords during the before mission were observed among the total 1033 publications. The initial period has registered six themes with DF. During this period "AQUEOUS-SOLUTIONS" was found to be the most active theme having a DF of 42 (Figure 4.4.3.1.6, Table 4.4.3.1.2). The theme "AQUEOUS-SOLUTIONS" received maximum document citations (7232). The theme "AQUEOUS-SOLUTIONS" was positioned in the top-right quadrant with the highest centrality value (24.65) indicating itself as the most important and well-connected theme with other keywords vis-à-vis themes. The theme "LEACHATES" and "COMPOSITES" was positioned in the top-left quadrant with no centrality, thereby assigning it as an isolated theme. The themes "SYSTEMS" were found to come under emerging focus, as they were positioned in the bottom-left quadrant and also appeared in the bottom-right quadrant as basic and transversal themes. The theme "SOILS" appeared in the bottom-right quadrant as basic and transversal themes.

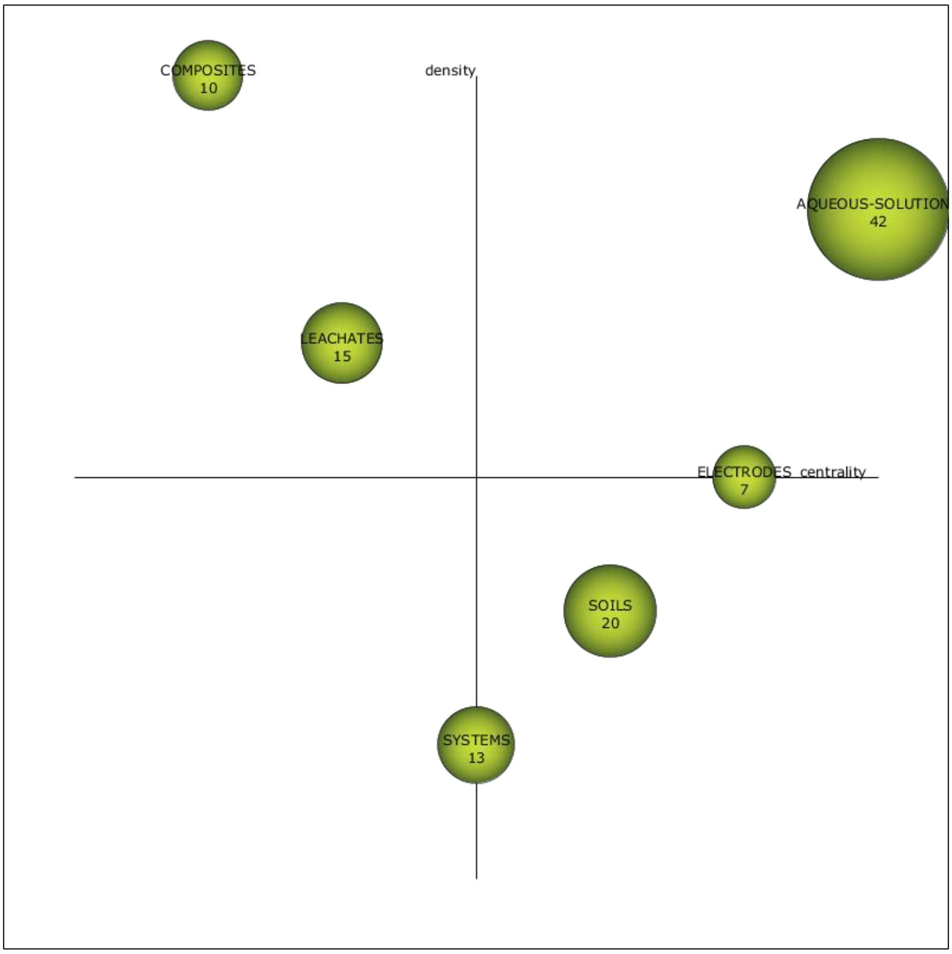


Figure 4.4.3.1.6.: Strategic diagram of themes during 1985-2008 of Indian publications related to **"**National Mission on Sustainable Habitat".

Table4.4.3.1.2. : Quantitative and qualitative performance measures of themes during 1985-2008 of Indian publications related to “National Mission on Sustainable Habitat”.

Name	Centrality	Density	Core Documents Count	Core Documents sum Citations	Secondary Documents Count	Secondary Documents sum Citations
Aqueous-Solutions	**24.65**	**15.96**	**42**	**7,232**	**97**	**5,458**
Soils	**4.3**	**4.44**	**20**	**601**	**65**	**2,776**
Systems	**3.03**	**3.85**	**13**	**1,290**	**69**	**2,255**
Leachates	**2.5**	**7.65**	**15**	**575**	**28**	**1,329**
Composites	**0.13**	**19.42**	**10**	**216**	**20**	**1,775**
Electrodes	**4.49**	**5.93**	**7**	**511**	**33**	**2,218**

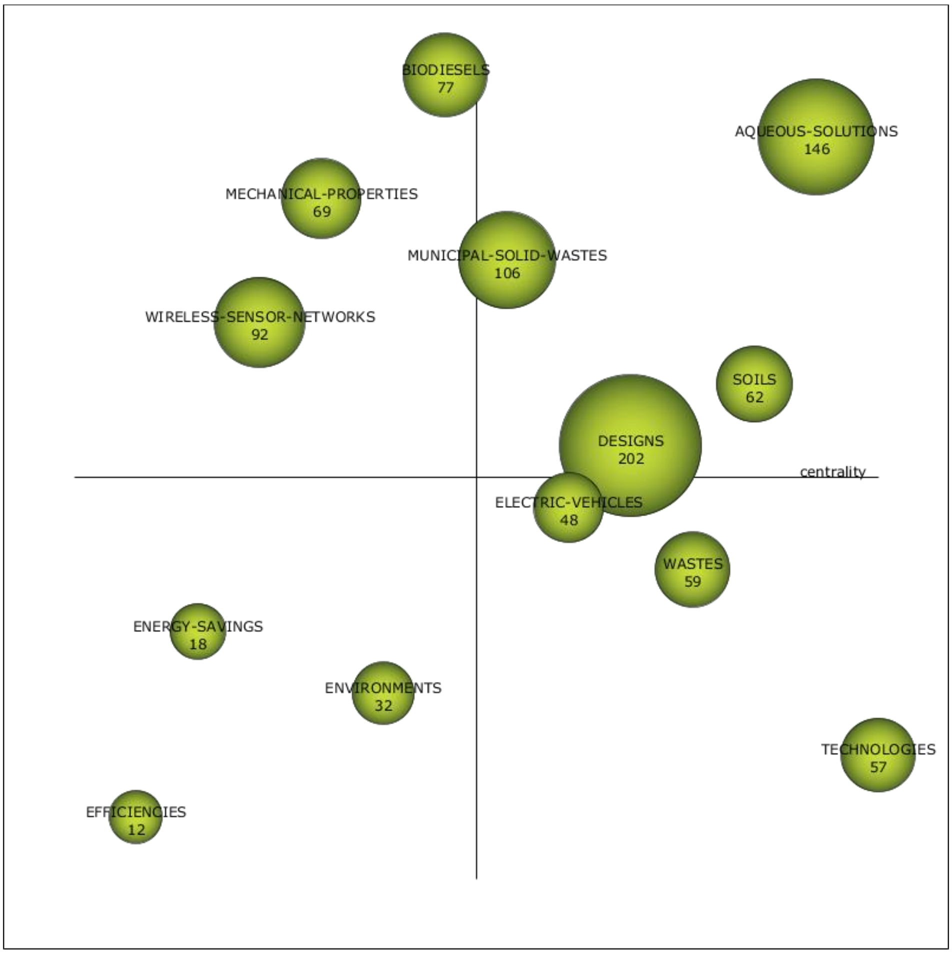


Figure 4.4.3.1.7: Strategic diagram of themes during 2009-2019 of Indian publications related to “National Mission on Sustainable Habitat”.

During 2009-2019 total keywords have increased to 1144 during the after mission with a growth rate of 144.44% among the total 6165 publications (increased by more than 50%). The number of themes did also increase to thirteen after the mission with comparatively more DF. During this period “DESIGNS” was found to be the most active theme having a DF of 202 followed by “AQUEOUS-SOLUTIONS” with a DF of 146 and “MUNICIPAL-SOLID-WASTES” with a DF of 106 (Figure 4.4.3.1.7, Table 4.4.3.1.3). The theme “AQUEOUS-SOLUTIONS” received maximum document citations (4,868) followed by “DESIGNS” (3,539). The theme “AQUEOUS-SOLUTIONS” was positioned in the top-right quadrant with the highest centrality value (11.62) indicating itself as the most important and well-connected theme with other keywords vis-à-vis themes followed by “DESIGNS” (8.11). The theme “WIRELESS-SENSOR-NETWORKS”, “MECHANICAL-PROPERTIES” and “BIODIESELS” was positioned in the top-left quadrant with no centrality, thereby assigning it as an isolated theme. The themes “ENVIRONMENTS”, “ENERGY-SAVINGS” and “EFFICIENCIES” were found to come under emerging focus, as they were positioned in the bottom-left quadrant. The theme “TECHNOLOGIES” appeared in the bottom-right quadrant as basic and transversal themes with the highest centrality value of 15.92.

Table4.4.3.1.3: Quantitative and qualitative performance measures of themes during 2009-2019 of Indian publications related to **“**National Mission on Sustainable Habitat”**.**

Name	**Centrality**	**Density**	**Core Documents Count**	**Core Documents sum Citations**	**Secondary Documents Count**	**Secondary Documents sum Citations**
Aqueous-Solutions	11.62	8.39	146	4,868	416	11,682
Biodiesels	5.21	9.25	77	1,412	273	5,632
Mechanical-Properties	2.61	5.15	69	2,122	231	5,943
Municipal-Solid-Wastes	6.63	2.69	106	2,328	346	7,676
Designs	8.11	1.89	202	3,539	822	12,352
Electric-Vehicles	7.3	1.74	48	305	272	2,139
Soils	9.04	2.02	62	1,022	392	7,617
Technologies	15.92	0.65	57	1,409	528	11,337
Wastes	8.14	1.43	59	1,005	379	7,477

Wireless-Sensor-Networks	1.96	2.21	92	637	329	2,317
Environments	4.54	1.11	32	584	382	7,715
Energy-Savings	1.65	1.21	18	301	145	2,142
Efficiencies	0.67	0.59	12	201	138	1,956

4.4.3.2. Analysis of Scopus publication data related to "National Mission on Sustainable Habitat"

4.4.3.2.1. Number of publications by top 30 countries related to "National Mission on Sustainable Habitat"

A total of 3,23,457 publications were retrieved from the Scopus database using the final search string. Figure 4.4.3.2.1shows the publication contributions by the top 30 countries. China is the leading country and contributed 57147 publications. India has contributed 16651 publications and secured 3rd rank globally in the publications related to the "National Mission on Sustainable Habitat".

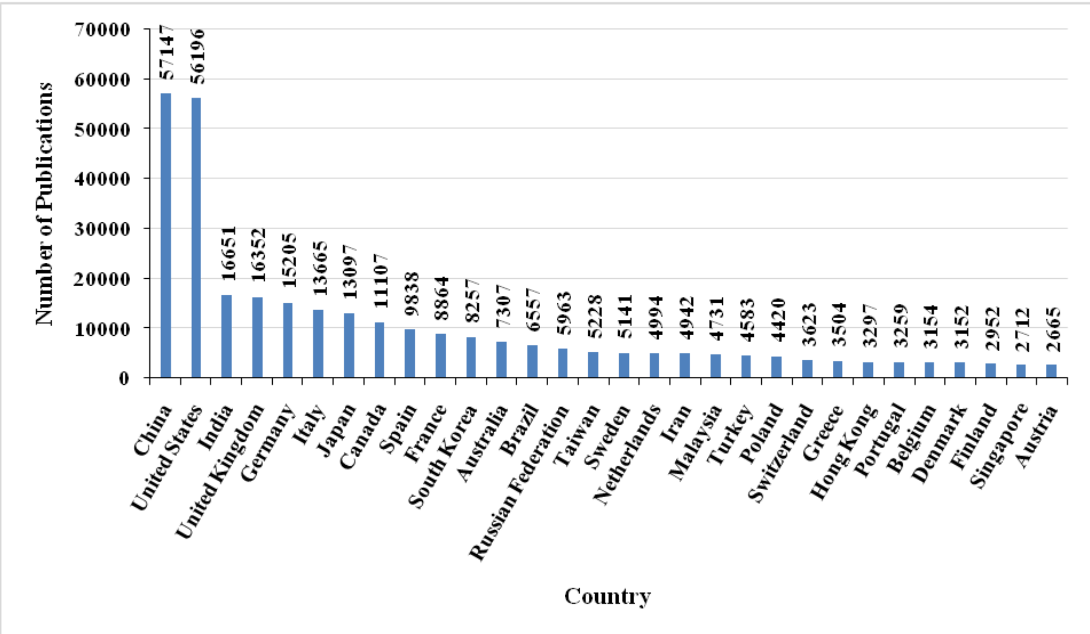


Figure 4.4.3.2.1: Total number of publications related to "National Mission on Sustainable Habitat" of top 30 countries.

4.4.3.2.2. Year-wise Growth of global and Indian publications related to "National Mission on Sustainable Habitat"

Figure 4.4.3.2.2 shows the year-wise growth of the number of total global and Indian publications related to the "National Mission on Sustainable Habitat". The compound annual growth rate (16.76%) of Indian publications is higher than the total global publications during 1987-2019 (Table 4.4.3.2.2). The CAGR (17.02%) of Indian publications was higher than the total global publications up to 2008 i.e. the year of the setting of the "National Mission on Sustainable Habitat". It is very inspiring to see that the CAGR (16.22%) of Indian publications is higher than the global total publications after the introduction of the mission. Therefore, it may conclude that the "National Solar Mission" of India instigates the R&D activities on various objectives of solar mission thereby the growth of publications accelerated.

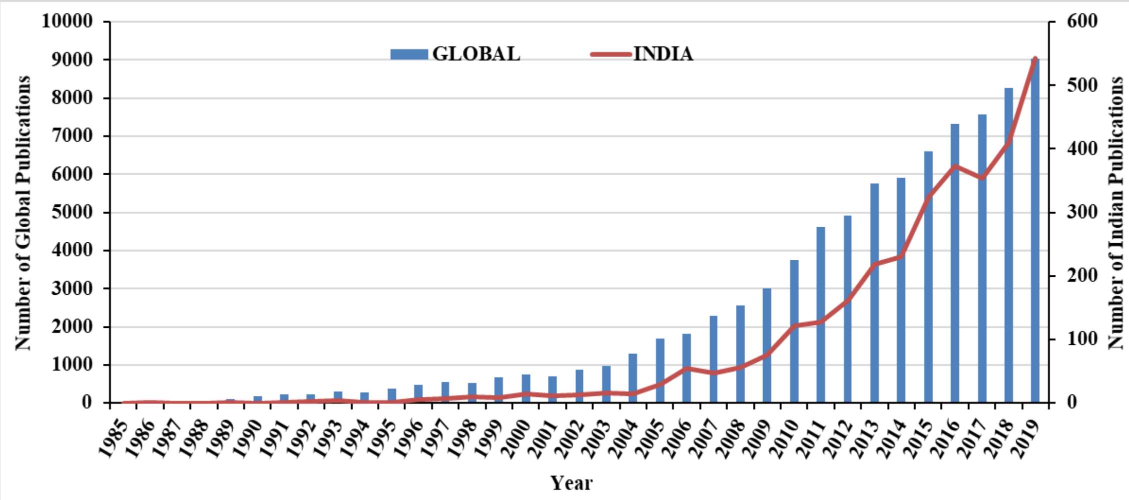


Figure 4.4.3.2.2: Year-wise global and Indian number of publications related to "National Mission on Sustainable Habitat".

Table 4.4.3.2.1: Global and Indian total publications related to "National Mission on Sustainable Habitat" Global and Indian compound annual growth rate of publications during 1987-2019, 1987-2008 and 2008-2019.

	Number of publications	CAGR of all years	CAGR for 1987-2008	CAGR for 2009-2019
Global Publication	323457	7.81%	6.69%	10.86%
Indian Publication	16651	16.76%	17.02%	16.22%

4.4.3.2.3. Total Global and Indian comparative contribution in different subject areas:

Total global researches related to the Indian "National Mission on Sustainable Habitat" have been performed in 28 subject areas. The top 10 subject areas of total global researches related to the mission have contributed 85.92% cumulatively (normalised). India has contributed in 27 subject areas during total periods. The top 10 subject areas of total Indian research on climate change have also contributed 84.03% cumulatively (normalised). India has contributed at a higher proportion than the global in some research areas namely: Computer Science, Chemical Engineering, Mathematics, Agricultural and Biological Sciences Medicine, Business, Management and Accounting, Biochemistry, Genetics and Molecular Biology, Immunology and Microbiology, Pharmacology, Toxicology and Pharmaceutics etc. India has contributed at a lower proportion than the global in some research areas namely: Engineering, Environmental Science, Energy, Computer Science, Materials Science, Chemical Engineering, Chemistry, Physics and Astronomy, Mathematics, Social Sciences, Earth and Planetary Sciences, Agricultural and Biological Sciences, Medicine, Business, Management and Accounting, Biochemistry, Genetics and Molecular Biology, Economics, Econometrics and Finance, Decision Sciences, Immunology and Microbiology, Multidisciplinary, Pharmacology, Toxicology and Pharmaceutics, etc. (Figure 4.4.3.2.3).

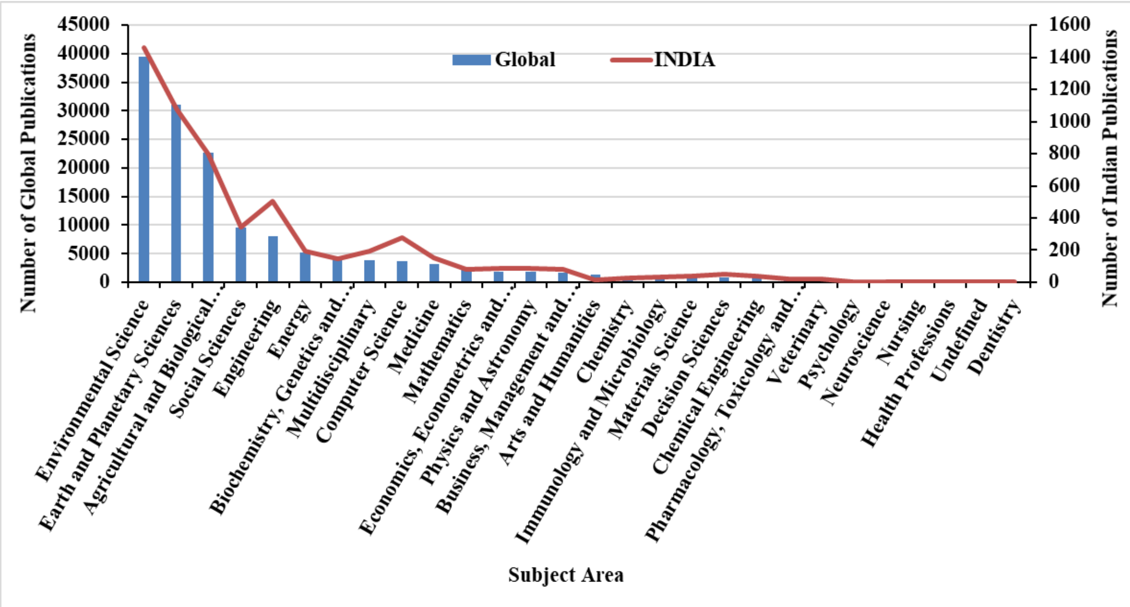


Figure 4.4.3.2.3: Global and Indian publication contribution related to "National Mission on Sustainable Habitat" in different subject areas.

4.4.3.2.4: Indian publication contribution related to "National Mission on Sustainable Habitat" in different research areas before and after the introduction of the mission:

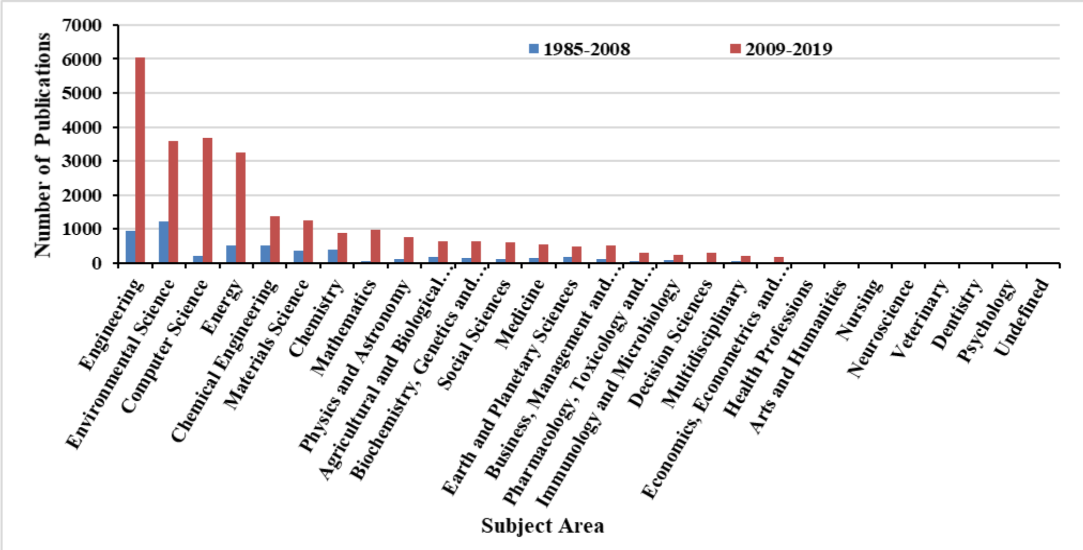


Figure 4.4.3.2.4: Indian publication contribution related to "National Mission on Sustainable Habitat" in different subject areas before and after the adoption of the mission.

Figure 4.4.3.2.4 shows the comparative contribution of different subject areas of Indian publications before and after the introduction of the mission. Following research areas namely Engineering, Environmental Science, Energy, Chemical Engineering, Materials Science, Chemistry were the most important research areas before the introduction of the "National Mission on Sustainable Habitat" by contributing more than 300 publications. After the introduction of the mission, the following research areas Engineering, Environmental Science, Computer Science, Energy, Chemical Engineering, Materials Science were the most important and contributed to more than 1000 publications.

4.4.3.3. Analysis of Indian Citation Index data related to "National Mission on Sustainable Habitat"

4.4.3.3.1. Year-wise Growth of global and Indian publications related to "National Mission on Sustainable Habitat"

Figure 4.4.3.3.1 shows the year-wise growth of the number of global and Indian publications related to "National Mission on Sustainable Habitat". The compound annual growth rate of Indian publications is slightly lower than the total global publications during 2005-2019. The CAGR of Indian publications was quite lower than the total global publications before 2008 i.e. the year of the introduction of the "National Mission on Sustainable Habitat". While the CAGR of Indian publications from 2009 to 2019 is lower than the global total publications (Table 4.4.3.3.1). Therefore, it may infer that the "National Mission on

Sustainable Habitat"of India does not instigate R&D activities on various objectives of "National Mission on Sustainable Habitat" thereby the growth of publications decreased.

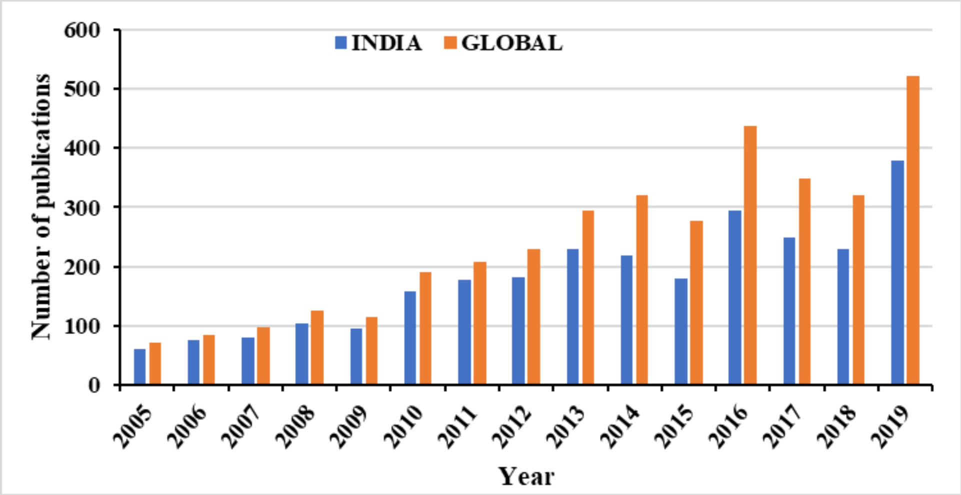


Figure 4.4.3.3.1: Year-wise global and Indian number of publications related to "National Mission on Sustainable Habitat".

Table 4.4.3.3.1: Global and Indian total publications, Global and Indian compound annual growth rate of publications related to the "National Mission on Sustainable Habitat" during 2005-2019, 2004-2008 and 2008-2019

	Number of publications	CAGR of all years	CAGR before setting of the mission	CAGR after setting of the mission
Global Publication	3640	15.43 %	21.32 %	15.37 %
Indian Publication	2713	14.09 %	20.12 %	13.83 %

4.4.3.3.2. Total Global and Indian comparative contribution in different subject areas:

Total global research on the Indian "National Mission on Sustainable Habitat" related topic has been performed in 336 research areas. The top 30 research areas of total global research on the Indian "National Mission on Sustainable Habitat" related topic have contributed 74.86% cumulatively (normalised). India has contributed to 299 research areas during total periods. The top 30 research areas of total Indian research on climate change have contributed 73.61% cumulatively (normalised).

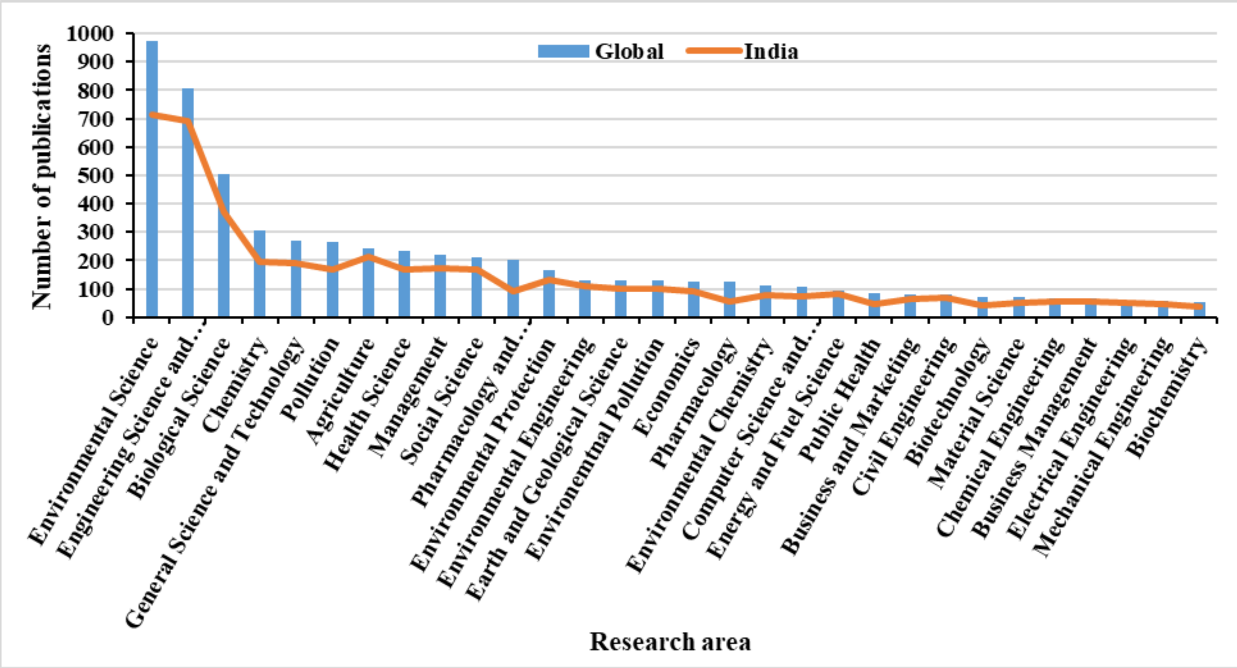


Figure 4.4.3.3.2: Global and Indian publication contribution related to "National Mission on Sustainable Habitat" in top 30 research areas

India has contributed at a higher proportion than the global in some research areas namely: Engineering Science and Technology, Agriculture, Electrical Engineering, Energy And Fuel Science and Chemical Engineering which are mainly deal with technology related to sustainable habitat development. India has contributed at a lower proportion than the global in some research areas namely: Chemistry, Physical Chemistry, Physics, Biological Science, Material Science, Pharmacology And Pharmaceutical Science, Agricultural Engineering, General Engineering, Earth And Geological Science, Pharmacology, Astronomy, Astrophysics, Space And Geodesy, Health Science, Environmental Engineering, Electronic And Communication Engineering, Economics (Figure 4.4.3.3.2).

4.4.3.3.3: Indian publication contribution in top 30 research areas before and after the adoption of the mission

Figure 4.4.3.3.3 shows the comparative contribution of the top 30 research areas of Indian publications before and after the introduction of the mission. Following research areas namely: Environmental Science, Engineering Science and Technology, Biological Science were the most important research areas before the introduction of the "National Mission on Sustainable Habitat" by contributing more than 50 publications. After the introduction of the mission, the following research areas Environmental

Science, Engineering Science And Technology, Biological Science, Agriculture, Chemistry, General Science And Technology, Management, Social Science, Health Science were the most important and contributed more than 150 publications.

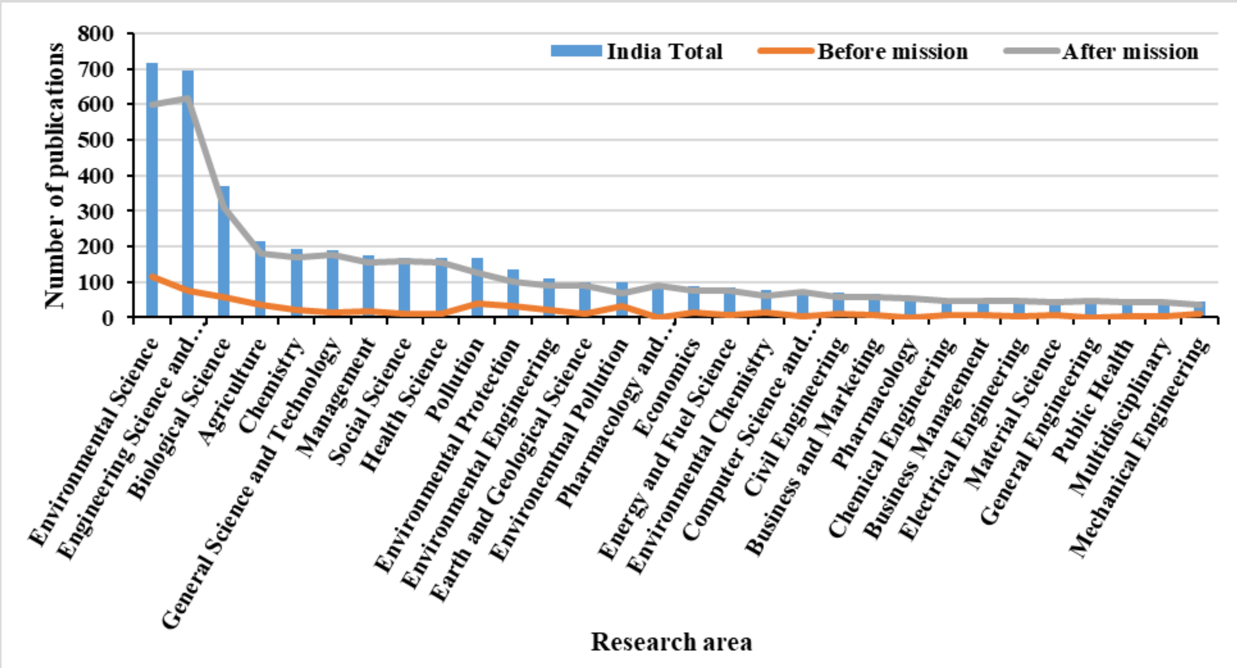


Figure 4.4.3.3.3: Indian publication contribution related to “National Mission on Sustainable Habitat” in top 30 research areas before and after the adoption of the mission.

4.4.4. National Water Mission

The final search string to retrieved publication data from "Web of Science" and "Scopus" for "National Water Mission" was as follows:

TS= (((management OR resource* OR recycl*) AND ("surface water" OR groundwater)) OR "water irrigat*" OR (rainwater AND harvest*) OR "water use efficien*" OR (wastewater AND (management OR recycl* OR drainage)) OR (water AND desalination) OR (freshwater AND (resource* OR storage OR recycl*)) OR (wetland* AND conserv*) OR (groundwater AND (recharge OR recycl*)))

4.4.4.1. Analysis of Web of Science publication data related to the "National Water Mission"

4.4.4.1.1. Number of publications related to the "National Water Mission" by top 30 countries:

A total of 103673 global and 5416 Indian publications were retrieved from the Web of Science database using the final search string of "National Water Mission". Figure 4.4.4.1.1shows the publication contributions related to the "National Water Mission" by the top 30 countries. The USA is the leading country and contributed 25985 publications. India has contributed 5416 publications and secured 5th rank globally based on the number of publications.

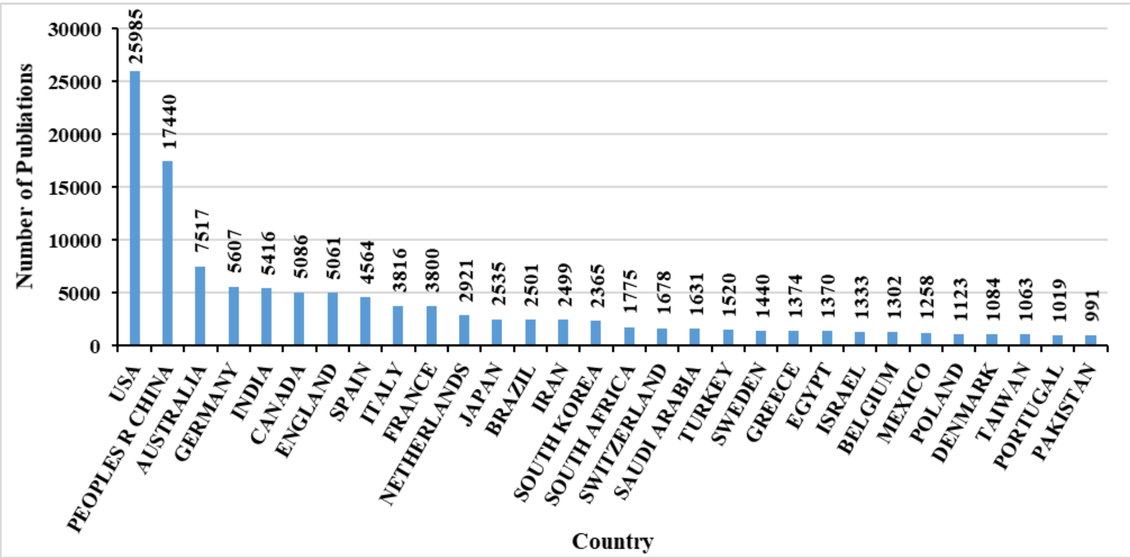


Figure 4.4.4.1.1: Total number of publications of top 30 countries

4.4.4.1.2. Year-wise Growth of global and Indian publications related to "National Water Mission"

Figure 4.4.4.1.2 shows the year-wise growth of the number of total global and Indian publications related to "National Water Mission". The compound annual growth rate of Indian publications is slightly lower than the total global publications during 1987-2019. The CAGR of Indian publications was lower than the total global publications before 2008 i.e. the year of the introduction of the "National Water Mission". The CAGR of Indian publications from 2009 to 2019 is also lower than the global total publications (Table 4.4.4.1.2). Therefore, it may infer that the "National Water Mission" of India did not instigate R&D activities on various objectives of the mission.

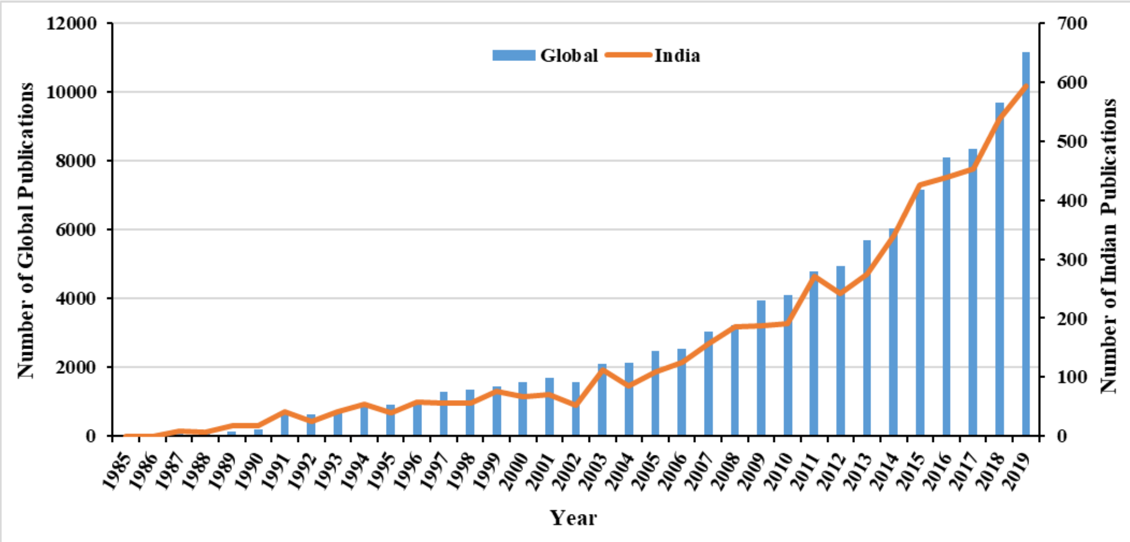


Figure 4.4.4.1.2: Year-wise global and Indian number of publications related to the "National Water Mission".

Table 4.4.4.1.1: Global and Indian total publications, Global and Indian compound annual growth rate of publications related to the "National Water Mission" during 1987-2019, 1987-2008 and 2008-2019.

	Number of publication	CAGR of all years	CAGR before setting of the mission	CAGR after setting of the mission
Global Publication	103673	16.37%	18.81%	11.91%
Indian Publication	5416	13.98%	15.48%	11.17%

4.4.4.1.3. Total Global and Indian comparative contribution in top 30 research areas:

Total global research on the Indian "National Water Mission" related topic has been performed in 211 research areas. The top 30 research areas of total global research on the Indian "National Water Mission" related topic have contributed 87.72 % cumulatively (normalised). India has contributed to 140 research areas during total periods. The top 30 research areas of total Indian research on climate change have contributed 89.99 % cumulatively (normalised). India has contributed at a higher proportion than the global in some research areas namely: Water Resources, Geosciences Multidisciplinary, Engineering

Chemical, Agronomy, Engineering Civil, Energy Fuels, Green Sustainable Science Technology, Agriculture Multidisciplinary, Chemistry Multidisciplinary, Multidisciplinary Sciences, Biotechnology Applied Microbiology which are mainly deal with the water resources management and development to mitigate the impact of climate change. India has contributed at a lower proportion than the global in some research areas namely: Environmental Sciences, Engineering Environmental, Ecology, Plant Sciences, Marine Freshwater Biology, Soil Science, Limnology, Materials Science Multidisciplinary, Biodiversity Conservation, Meteorology Atmospheric Sciences, Forestry, Agricultural Engineering, Horticulture, Environmental Studies, Geochemistry Geophysics, Chemistry Physical, Polymer Science, Computer Science Interdisciplinary Applications, Geography Physical (Figure 4.4.1.1.3).

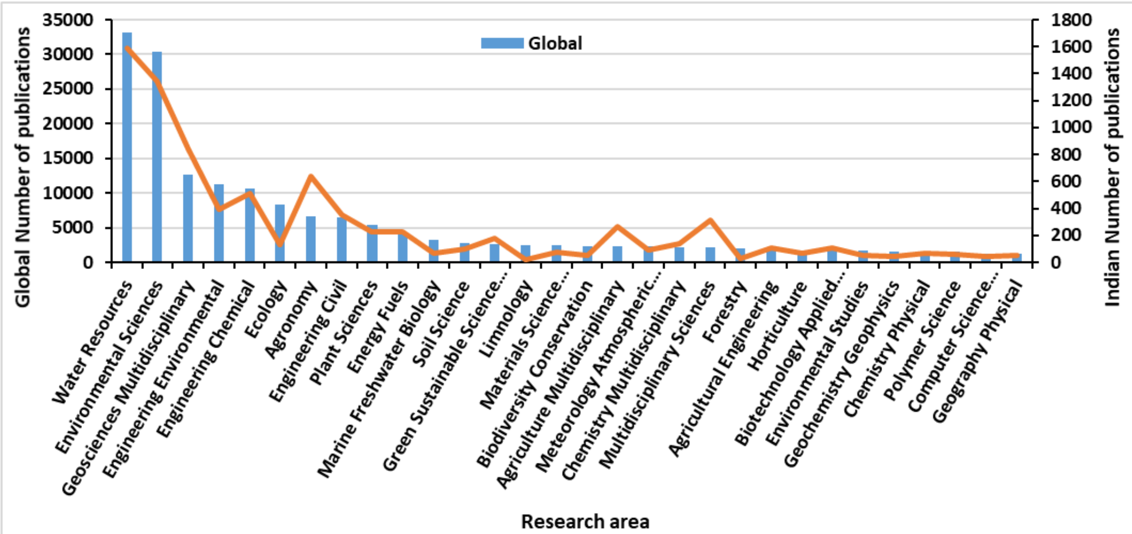


Figure 4.4.4.1.3: Global and Indian publication contribution related to “National Water Mission” in top 30 research areas.

4.4.4.1.4: Indian publication contribution in top 30 research areas before and after the adoption of the mission

Figure 4.4.4.1.4 shows the comparative contribution of the top 30 research areas of Indian publications before and after the introduction of the mission. Following research areas namely, Water Resources, Environmental Sciences, Geosciences Multidisciplinary, Agronomy, Multidisciplinary Sciences, Agriculture Multidisciplinarywere the most important research areas before the introduction of the “National Water Mission” by contributing more than 100 publications. After the introduction of the mission, the following research areas Water Resources, Environmental Sciences, Geosciences

Multidisciplinary, Agronomy, Engineering Chemical, Engineering Environmental, Engineering Civilwere the most important and contributed more than 200 publications.

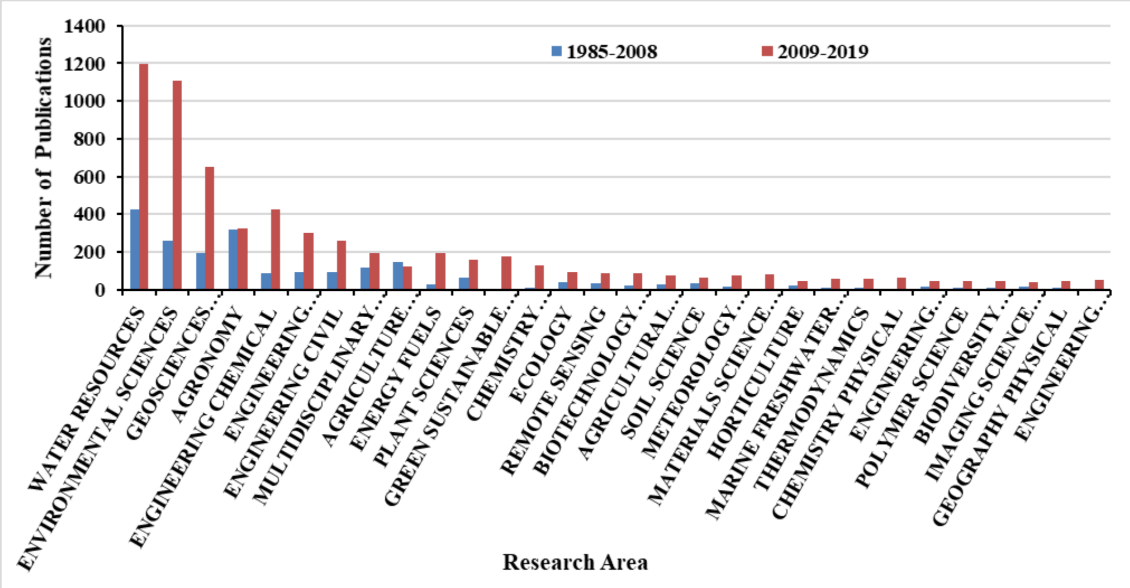


Figure 4.4.4.1.4: Indian publication contribution related to “National Water Mission” in top 30 research areas before and after the adoption of the mission.

4.4.4.1.5. The quantitative evolution and exchange of keywords of Indian publication related to “National Water Mission”

The quantitative evolution and exchange of keywords from the before mission to the after mission are represented in Figure for total Indian publications on Nation Water Mission. Each circle contains the number of keywords during that period which is indicated below the circle. The arrow containing the number of keywords coming towards the circle indicates newly arisen keywords. On the other hand, the arrow going outside indicates the number of keywords that are not used at successive periods. The arrow pointing from the previous to successive period represents the number of keywords exchanged (integer value) and the fraction of overlap (i.e., Similarity Index) in parentheses.

The higher value of the similarity index indicates the core themes of Indian publications on Nation Water Mission research remain more or less continuous, whereas, the quantity of newly evolved keywords indicates the advancement of the core theme in different subthemes. The number of keywords did increase from 469 before the mission to 842 during the after mission with a growth rate of 79.53%.

Indian publications on Nation Water Mission publications research after setting of the mission incorporated more than 50% keyword from research perform during before mission.

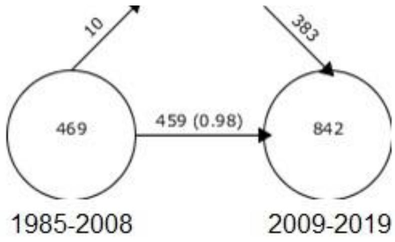


Figure 4.4.4.1.5: Overlapping map of keyword's quantitative perspective during successive periods of Indian Publications on "Nation Water Mission".

4.4.4.1.6. Quantitative and qualitative development of themes at successive periods of Indian publication related to "Nation Water Mission"

Thematic evolution was represented through strategic diagrams at successive periods. Themes were plotted as circles denoting different theme clusters according to centrality and density in strategic diagrams. The size of the circle is proportional to the number of documents and referred to as document frequency (DF) in which it's linked or related keywords are present. The strategic diagrams are divided into four quadrants and they can be interpreted as follows: the top-right quadrant represents "motor themes", the top-left quadrant represents "highly developed and isolated themes", the bottom-left quadrant represents "emerging or declining themes", the bottom-right quadrant represents "basic and transversal themes".

During 1985-2008 a total of only 469 keywords during the before mission were observed among the total 1456 publications. The initial period has registered five themes with fewer DF. During this period "AQUIFER" was found to be the most active theme having a DF of 81 (Figure, Table). The theme "AQUIFER" received maximum document citations (4,228). The theme "AQUIFER" was positioned in the top-right quadrant with the highest centrality value (23.69) indicating itself as the most important and well-connected theme with other keywords vis-à-vis themes followed by "RIVER" (16.64). The theme "WATER-USE-EFFICIENCY" was positioned in the top-left quadrant with no centrality, thereby assigning it as an isolated theme with the highest DF (123) AND also highest document citations of 5,123. The themes "FLOW" were found to come under emerging focus, as they were positioned in the bottom-left quadrant and also appeared in the bottom-right quadrant as basic and transversal themes. The theme "SYSTEM" appeared in the bottom-right quadrant as basic and transversal themes.

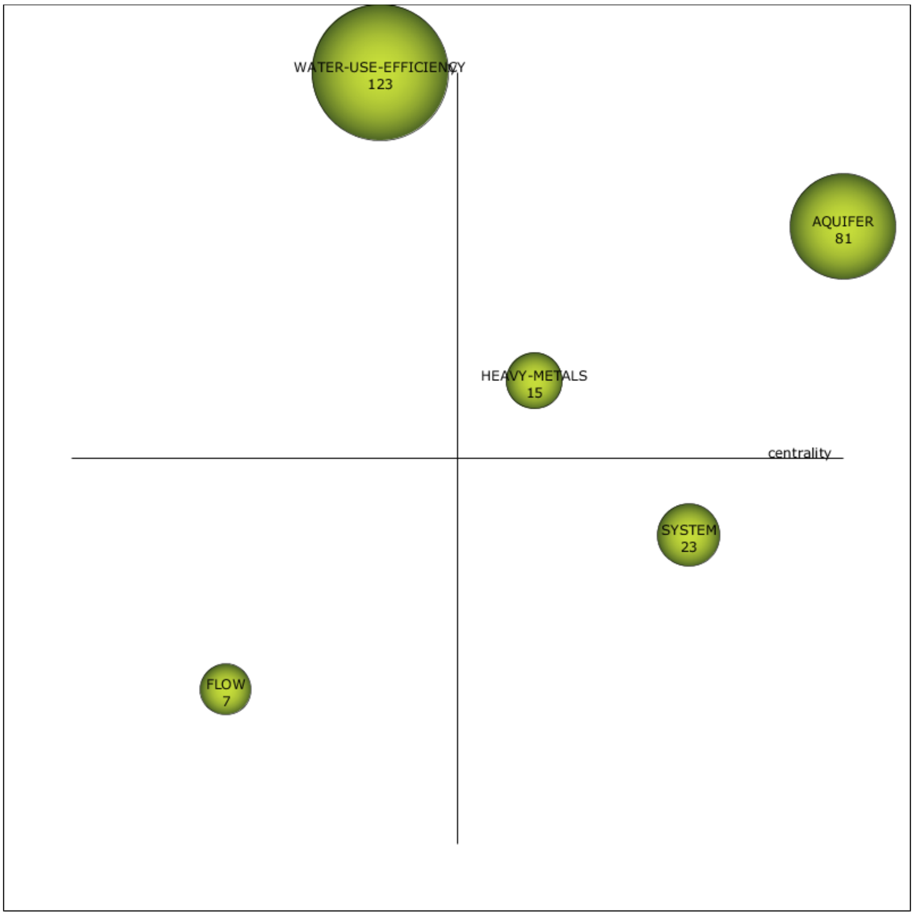


Figure4.4.4.1.6: Strategic diagram of themes during 1985-2008 of Indian publications related to "Nation Water Mission".

Table4.4.4.1.2: Quantitative and qualitative performance measures of themes during 1985-2008 of Indian publications related to "Nation Water Mission".

Name	**Centrality**	**Density**	**Core Documents Count**	**Core Documents sum Citations**	**Secondary Documents Count**	**Secondary Documents sum Citations**
Aquifer	23.69	5.55	81	4,228	225	9,188
Water-Use-Efficiency	10.47	5.58	123	5,123	220	5,873
System	13.67	4.55	23	680	118	4,368
Heavy-Metals	12.3	4.64	15	1,753	60	3,619
Flow	5.64	3.43	7	78	27	645

During 2009-2019 total keywords have increased to 842 during the after mission with a growth rate of 79.53% among the total 4006 publications (increased by more than 50%). The number of themes did also increase to seventeen during after mission with comparatively more DF. During this period "DISTRICT" was found to be the most active theme having a DF of 252 followed by "WATER-USE-EFFICIENCY" with a DF of 203, and "SOLAR-STILL" with a DF of 117 (Figure 4.4.4.1.7, Table 4.4.4.1.3). The theme "DISTRICT" received maximum document citations (4,070) followed by "SOLAR-STILL" (2,827). The theme "DISTRICT" was positioned in the top-right quadrant with the highest centrality value (16.4) indicating itself as the most important and well-connected theme with other keywords vis-à-vis themes. The theme "AQUEOUS-SOLUTION", "ARTIFICIAL-NEURAL-NETWORK" and "NANOFILTRATION-MEMBRANES" was positioned in the top-left quadrant with no centrality, thereby assigning it as an isolated theme. The themes "MEMBRANE", "REGION" and "LAKE" were found to come under emerging focus, as they were positioned in the bottom-left quadrant. The theme "HEAVY-METALS", "MODEL" and "RIVER" appeared in the bottom-right quadrant as basic and transversal themes.

Table 4.4.4.1.3: Quantitative and qualitative performance measures of themes during 2009-2019 of Indian publications related to "Nation Water Mission".

Name	**Centrality**	**Density**	**Core Documents documents Count**	**Core Documents sum Citations**	**Secondary Documents documents Count**	**Secondary Documents sum Citations**
Aqueous-Solution	5.14	8.02	87	3,638	196	4,713
Water-Use-Efficiency	7.81	3.85	203	2,334	399	5,140
Heavy-Metals	11.42	2.61	114	2,004	725	10,486
Solar-Still	6.96	8.77	117	2,827	494	7,587
District	16.4	4.48	252	4,070	560	8,178
Model	12.03	2.23	124	1,823	605	6,896
River	9.86	1.37	64	618	336	4,392
Membrane	6.51	1.33	39	854	236	4,579
Nanofiltration-Membranes	3.09	12.56	30	1,104	67	1,529
Artificial-Neural-Network	5.87	3.77	22	275	105	1,405

Region	3.65	0.8	18	154	165	2,055
Lake	2.05	0.61	10	89	165	2,176

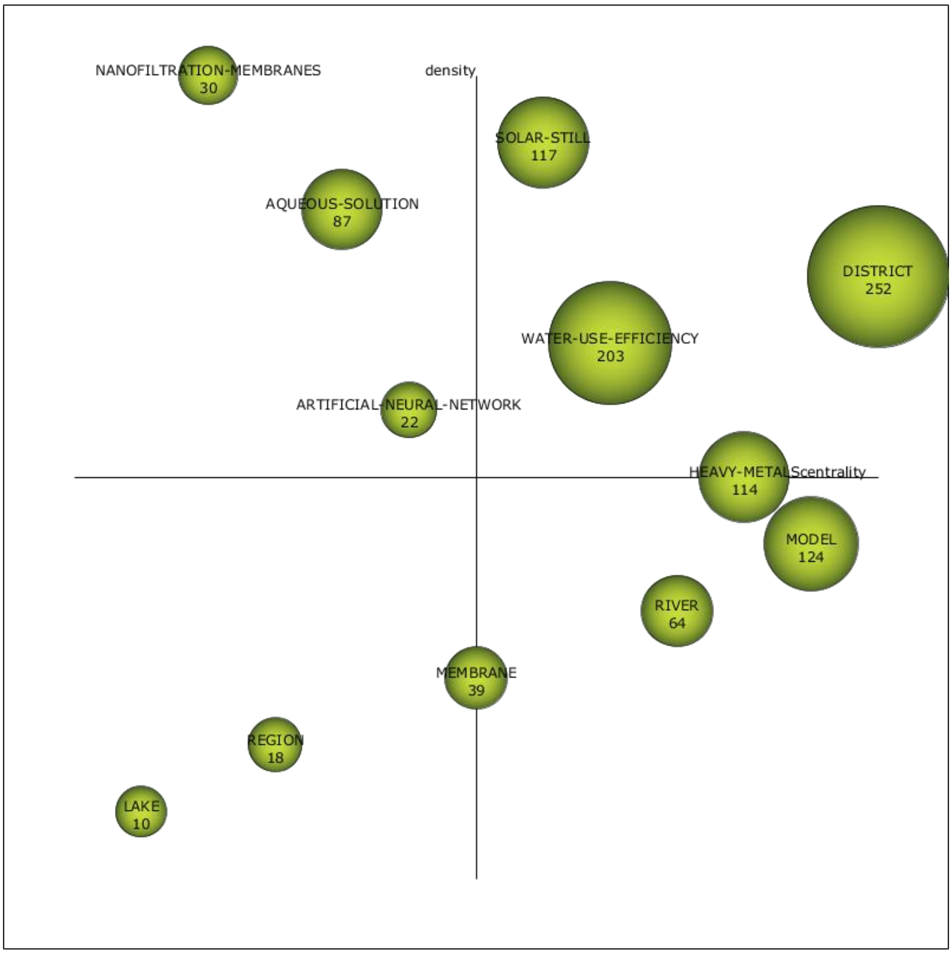


Figure 4.4.4.1.7: Strategic diagram of themes during 2009-2019 of Indian publications related to "Nation Water Mission".

4.4.4.2. Analysis of Scopus publication data related to "Nation Water Mission"

4.4.4.2.1. Number of publications by top 30 countries related to "Nation Water Mission"

A total of 2,08,795 publications were retrieved from the Scopus database using the final search string. Figure 4.4.4.2.1shows the publication contributions by the top 30 countries. The USA is the leading country and contributed 48028 publications. India has contributed 12049 publications and secured 3rd rank globally in the publications related to the "National Water Mission".

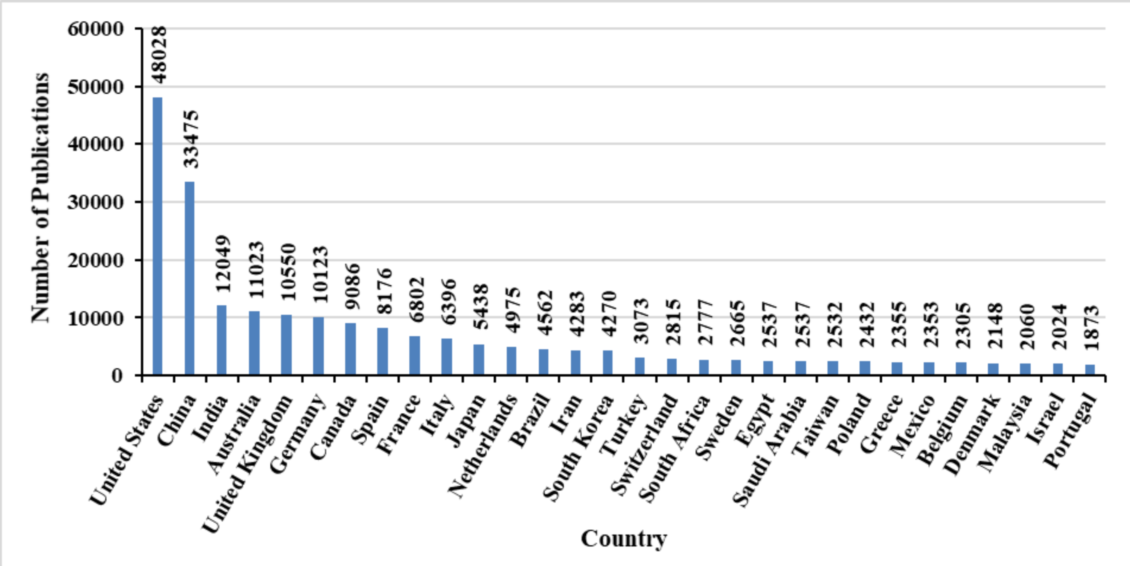


Figure 4.4.4.2.1: Total number of publications related to “National Water Mission” of top 30 countries.

4.4.4.2.2. Year-wise Growth of global and Indian publications related to “National Water Mission”

Figure 4.4.4.2.2 shows the year-wise growth of the number of total global and Indian publications related to the “National Water Mission”. The compound annual growth rate (11.09%) of Indian publications is higher than the total global publications during 1987-2019 (Table 4.4.4.2.1). The CAGR (12.3%) of Indian publications was higher than the total global publications up to 2008 i.e. the year of the setting of the “National Water Mission”. The CAGR (8.8%) of Indian publications is also higher than the global total publications after the introduction of the mission. Although the CAGR was lower than the CAGR before of the mission

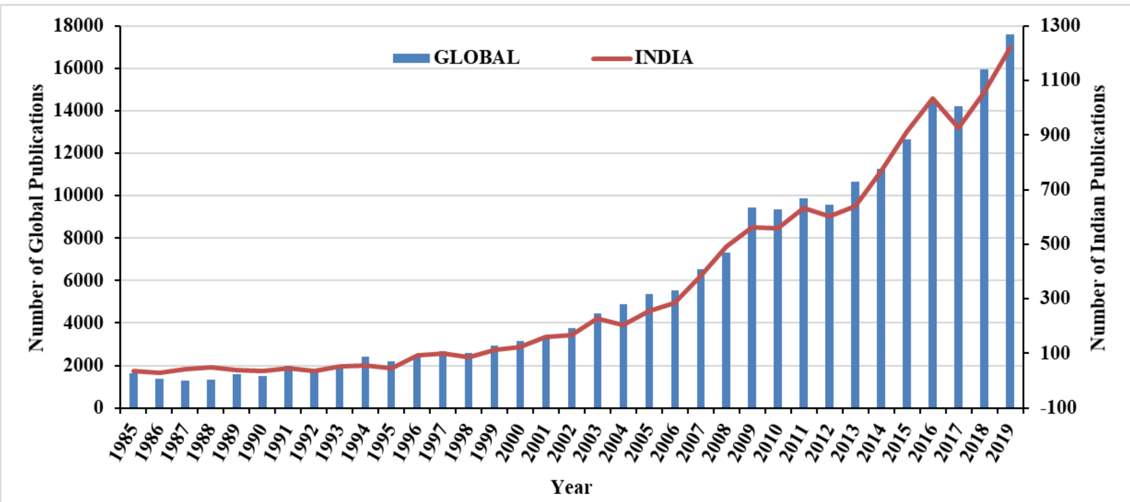


Figure 4.4.4.2.2: Year-wise global and Indian number of publications related to “National Water Mission”

Table 4.4.4.2.1: Global and Indian total publications related to "National Water Mission" Global and Indian compound annual growth rate of publications during 1987-2019, 1987-2008 and 2008-2019

	Number of publications	CAGR of all years	CAGR before setting of the mission	CAGR after setting of the mission
Global Publication	208795	7.27%	6.77%	8.3%
Indian Publication	12049	11.09%	12.3%	8.8%

4.4.4.2.3. Total Global and Indian comparative contribution in different subject areas

Total global researches related to the Indian "National Water Mission" have been performed in 28 subject areas. The top 10 subject areas of total global researches related to the mission have contributed 91.66% cumulatively (normalised). India has contributed in 27 subject areas during total periods. The top 10 subject areas of total Indian research on climate change have also contributed 89.05% cumulatively (normalised).

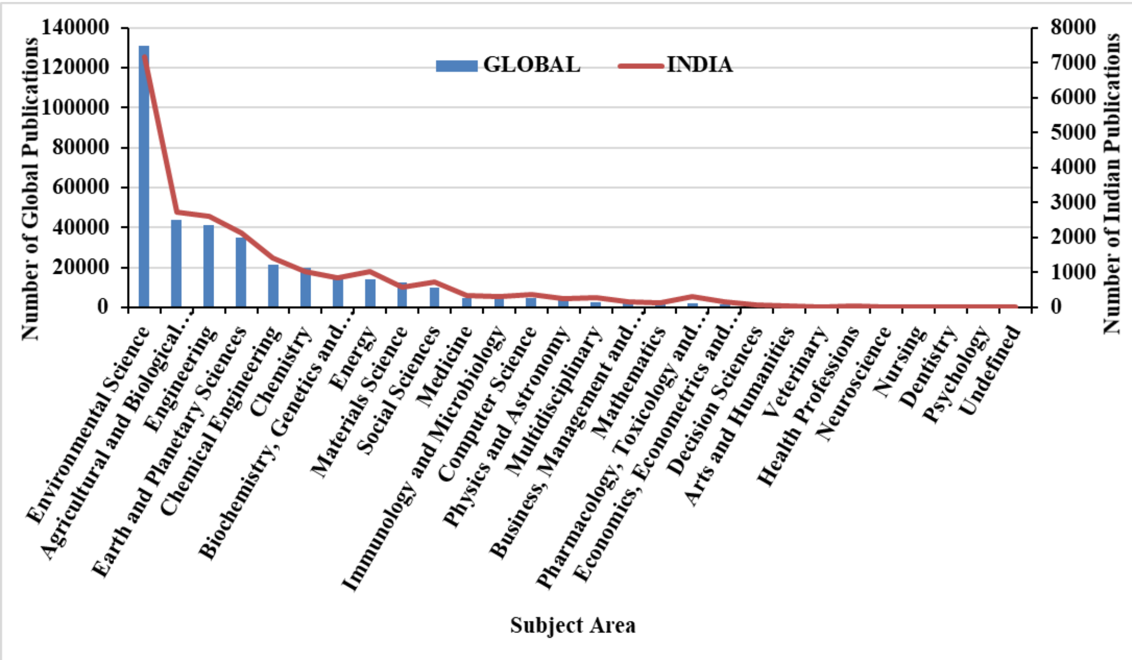


Figure 4.4.4.2.3: Global and Indian publication contribution related to "National Water Mission" in different subject areas

India has contributed at a higher proportion than the global in some research areas namely: Agricultural and Biological Sciences, Engineering, Chemical Engineering, Biochemistry, Genetics and Molecular Biology, Energy, Social Sciences, Medicine, Immunology and Microbiology, Computer Science, Multidisciplinary, Business, Management and Accounting, Mathematics, Pharmacology, Toxicology and Pharmaceutics, Economics, Econometrics and Finance, Decision Sciences etc. India has contributed at a lower proportion than the global in some research areas namely: Environmental Science, Earth and Planetary Sciences, Chemistry, Materials Science, Physics and Astronomy, Arts and Humanities, Veterinary, Health Professions, Neuroscience, Nursing, Dentistry, Psychology, Undefinedetc. (Figure 4.4.4.2.3).

4.4.4.2.4: Indian publication contribution related to "National Water Mission" in different research areas before and after the introduction of the mission:

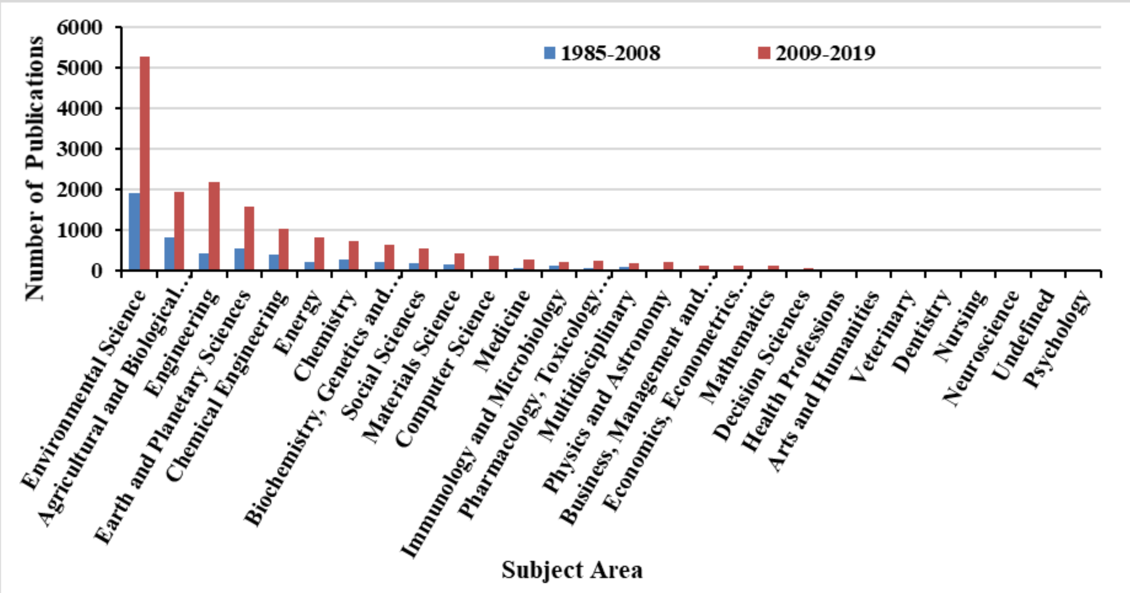


Figure 4.4.4.2.4: Indian publication contribution related to "National Water Mission" in different subject areas before and after the adoption of the mission.

Figure 4.4.4.2.4 shows the comparative contribution of different subject areas of Indian publications before and after the introduction of the mission. Following research areas namely, Environmental Science, Agricultural and Biological Sciences, Engineering, Earth and Planetary Sciences, Chemical Engineering were the most important research areas before the introduction of the "National Water Mission" by contributing more than 300 publications. After the introduction of the mission, the following research areas Environmental Science, Agricultural and Biological Sciences, Engineering, Earth and Planetary Sciences, Chemical Engineering were the most important and contributed more than 1000 publications.

4.4.3. Analysis of Indian Citation Index data related to "National Water Mission"

4.4.3.2. Year-wise Growth of global and Indian publications related to "National Water Mission"

Figure 4.4.4.3.1 shows the year-wise growth of the number of global and Indian publications related to "National Water Mission"**.** The compound annual growth rate of Indian publications is slightly lower than the total global publications during 2005-2019. The CAGR of Indian publications was quite higher than the total global publications before 2008 i.e. the year of the introduction of the "National Water Mission". While the CAGR of Indian publications from 2009 to 2019 is lower than the global total publications (Table 4.4.4.3.1).

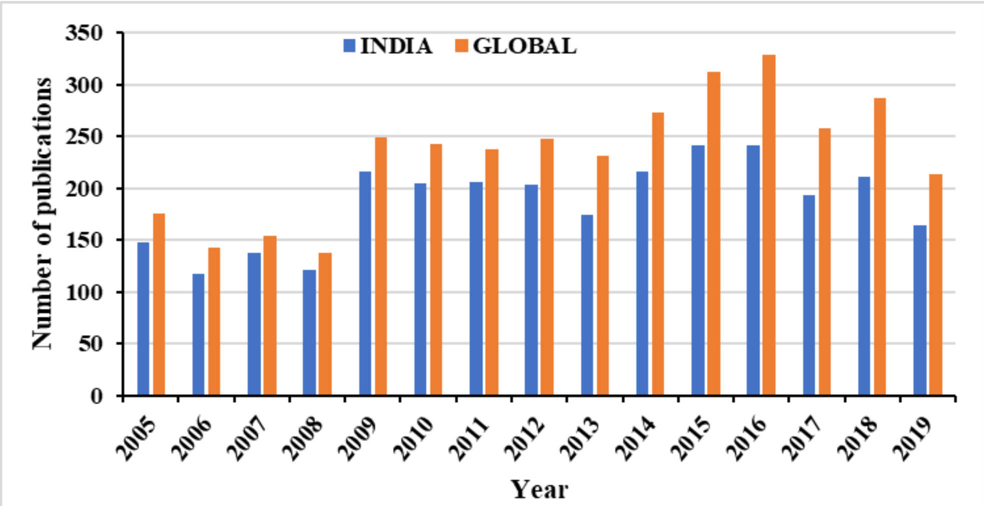


Figure 4.4.4.3.1: Year-wise global and Indian number of publications related to "National Water Mission".

Table 4.4.4.3.1: Global and Indian total publications, Global and Indian compound annual growth rate of publications related to the "National Water Mission" during 2005-2019, 2004-2008 and 2008-2019.

	Number of publications	CAGR of all years	CAGR before setting of the mission	CAGR after setting of the mission
Global Publication	3490	1.45%	-7.61%	4.48%
Indian Publication	2794	0.74%	-6.49%	3.09%

4.4.4.3.2. Total Global and Indian comparative contribution in different subject areas:

Total global research on the Indian "National Water Mission" related topic has been performed in 262 research areas. The top 30 research areas of total global research on the Indian "National Water Mission" related topic have contributed 78.11% cumulatively (normalised). India has contributed to 249 research areas during total periods. The top 30 research areas of total Indian research on climate change have contributed 78.30% cumulatively (normalised).

India has contributed at a higher proportion than the global in some research areas namely: Agriculture, Earth And Geological Science, Engineering Science And Technology, General Science And Technology, Water, Environmental Geology, Environmental Engineering, Watershed Management, Irrigation, Water Pollution, Agricultural Engineering, Environmental Pollution, Remote Sensing, Zoology, Botany, Economics, Agronomy, Environmental Protection which are mainly deal with the water resources management related technology development. India has contributed at a lower proportion than the global in some research areas namely: Environmental Science, Biological Science, Chemistry, Pollution, Social Science, Environmental Chemistry, Ecology And Environment, Pharmacology And Pharmaceutical Science, Geography, Pharmacology, Biodiversity, Health Science (Figure 4.4.4.3.2).

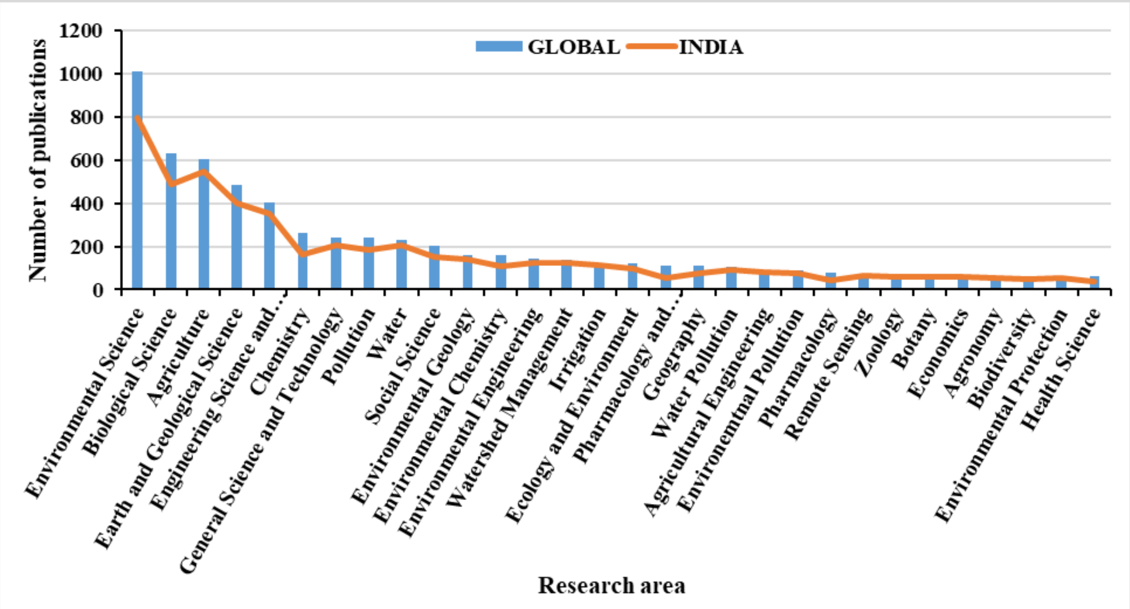


Figure 4.4.4.3.2: Global and Indian publication contribution related to "National Water Mission" in top 30 research areas

4.4.4.3.3. Indian publication contribution in top 30 research areas before and after the adoption of the mission

Figure 4.4.4.3.3shows the comparative contribution of the top 30 research areas of Indian publications before and after the introduction of the mission. Following research areas namely: Environmental Science, Agriculture, Biological Science, Earth And Geological Science, Engineering Science and

Technology, Water were the most important research areas before the introduction of the "National Water Mission" by contributing more than 50 publications. After the introduction of the mission, the following research areas Environmental Science, Agriculture, Biological Science, Earth and Geological Science, Engineering Science And Technology, General Science And Technology, Water, Pollution, Chemistry, Social Science, Environmental Geology, Watershed Management were the most important and contributed more than 100 publications.

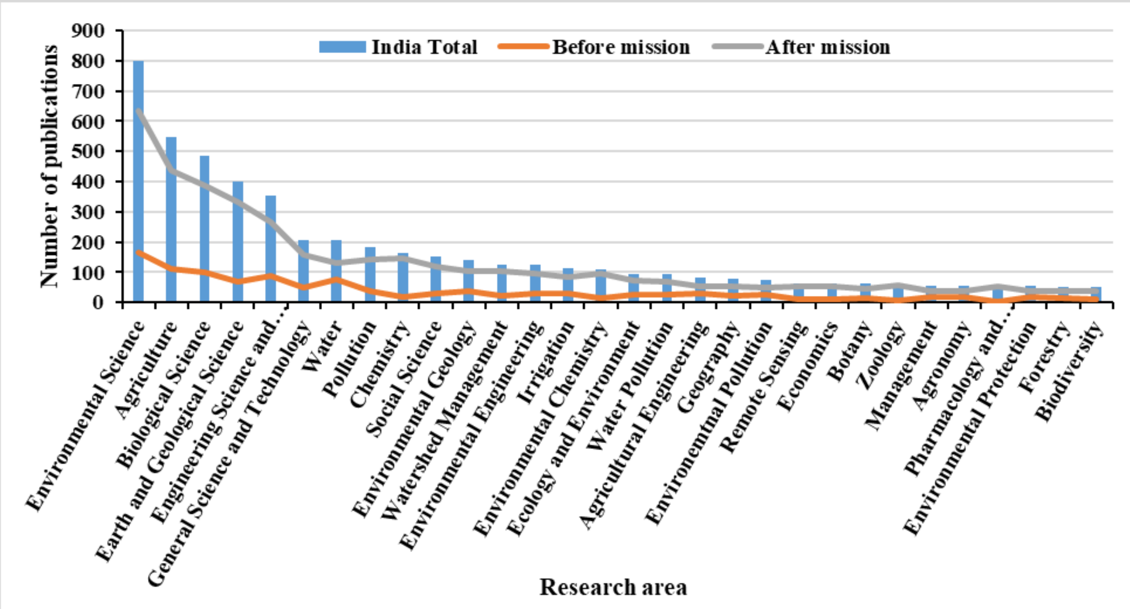


Figure 4.4.4.3.3: Indian publication contribution related to "National Water Mission" in top 30 research areas before and after the adoption of the mission.

4.4.5. National Mission for Sustaining the Himalayan Ecosystem

The final search string to retrieved publication data from "Web of Science" and "Scopus" for "National Mission for Sustaining the Himalayan Ecosystem" was as follows:

TS=(Himalaya* AND (ecosystem* OR *glaci* OR mitigat* OR biodiversit* OR "wild life" OR livelihood OR rehabilitation OR (climat* AND chang*) OR ethni* OR herb* OR "land slide" OR precipitation OR touris* OR water OR "natural resource*" OR adapt* OR impact* OR mission* OR agricult* OR "biological diversity" OR fragmentation OR deforestation OR flora OR fauna OR flood OR conservation OR threat* OR "soil erosion" OR "global warm*" OR bio-resource OR urbanization OR "mountain ecosystem" OR corridor* OR farming OR restor* OR "natural hazard*" OR endanger* OR species OR snow* OR river* OR hazard*))

4.4.5.1. Analysis of Web of Science publication data related to the "National Mission for Sustaining the Himalayan Ecosystem"

4.4.5.1.1. Number of publications related to the "National Mission for Sustaining the Himalayan Ecosystem" by top 30 countries:

A total of 15308 global and 7291 Indian publications were retrieved from the Web of Science database using the final search string of the "National Mission for Sustaining the Himalayan Ecosystem".Figure 4.4.5.1.1shows the publication contributions related to "National Mission for Sustaining the Himalayan Ecosystem" by the top 30 countries. India is the leading country and contributed 7291 publications.

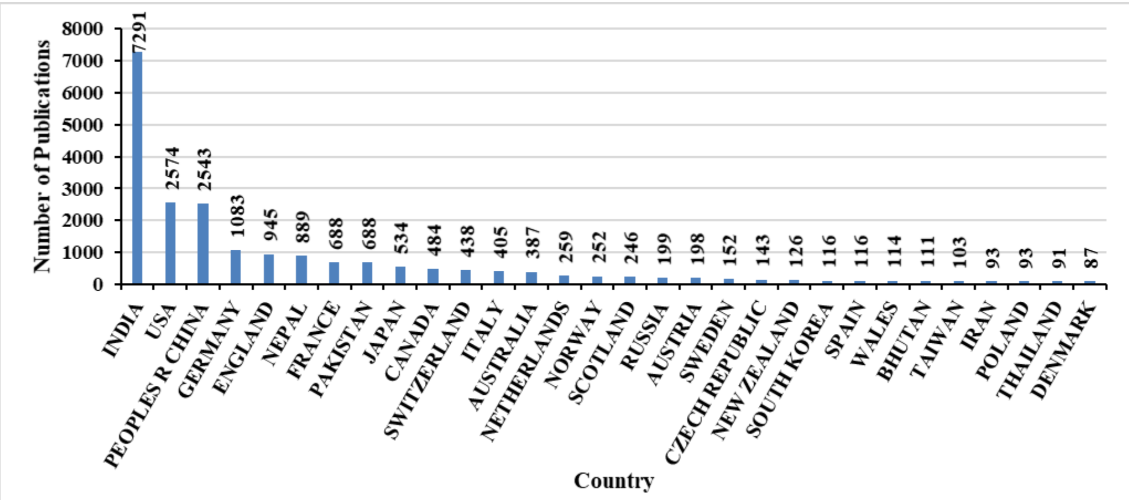


Figure 4.4.5.1.1: Total number of publications related to "National Mission for Sustaining the Himalayan Ecosystem" of top 30 countries.

4.4.5.1.2. Year-wise Growth of global and Indian publications related to "National Mission for Sustaining the Himalayan Ecosystem"

Figure 4.4.5.1.2 shows the year-wise growth of the number of total global and Indian publications related to "National Mission for Sustaining the Himalayan Ecosystem".The compound annual growth rate of Indian publications is slightly lower than the total global publications during 1987-2019. The CAGR of Indian publications was lower than the total global publications before 2008 i.e. the year of the introduction of the Mission. It is very motivating to see that the CAGR of Indian publications from 2009 to 2019 is fairly higher than the global total publications (Table 4.4.5.1.1). Although the CAGR during after mission was lower as compared to the CAGR of before the mission.

Table 4.4.5.1.1: Global and Indian total publications, Global and Indian compound annual growth rate of publications related to the "National Mission for Sustaining the Himalayan Ecosystem".during 1987-2019, 1987-2008 and 2008-2019.

	Number of publications	CAGR of all years	CAGR before setting of the mission	CAGR after setting of the mission
Global Publication	15308	14.63%	16.81%	10.57%
Indian Publication	7291	15.32%	17.24%	11.73%

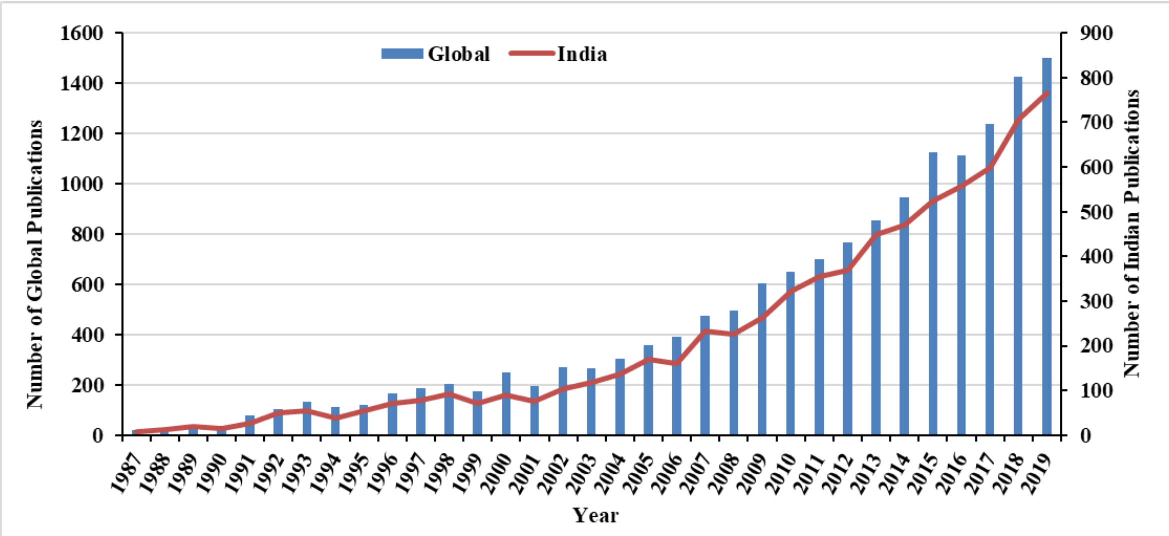


Figure 4.4.5.1.2: Year-wise global and Indian number of publications related to the "National Mission for Sustaining the Himalayan Ecosystem".

4.4.5.1.3. Total Global and Indian comparative contribution in top 30 research areas:

Total global research on the Indian "National Mission for Sustaining the Himalayan Ecosystem" related topic has been performed in 193 research areas. The top 30 research areas of total global research on the Indian "National Mission for Sustaining the Himalayan Ecosystem" related topic have contributed 85.22% cumulatively (normalised). India has contributed to 154 research areas during total periods. The top 30 research areas of total Indian research on climate change have contributed 84.09% cumulatively (normalised). India has contributed at a higher proportion than the global in some research areas namely: Environmental Sciences, Multidisciplinary Sciences, Water Resources, Remote Sensing, Agronomy, Forestry, Engineering Civil, Imaging Science, Holographic Technology, Soil Science, Agriculture Multidisciplinary, Entomology, Engineering Geological, Biotechnology Applied Microbiology, Microbiology those are mainly deal with the Himalayan Ecosystem development to mitigate the impact climate change. India has contributed at a lower proportion than the global in some research areas namely: Geosciences Multidisciplinary, Plant Sciences, Geography Physical, Meteorology Atmospheric Sciences, Ecology, Geochemistry Geophysics, Zoology, Geology, Biodiversity Conservation, Genetics Heredity, Evolutionary Biology, Paleontology, Biochemistry Molecular Biology, Biology, Mycology, Pharmacology Pharmacy (Figure 4.4.5.1.3).

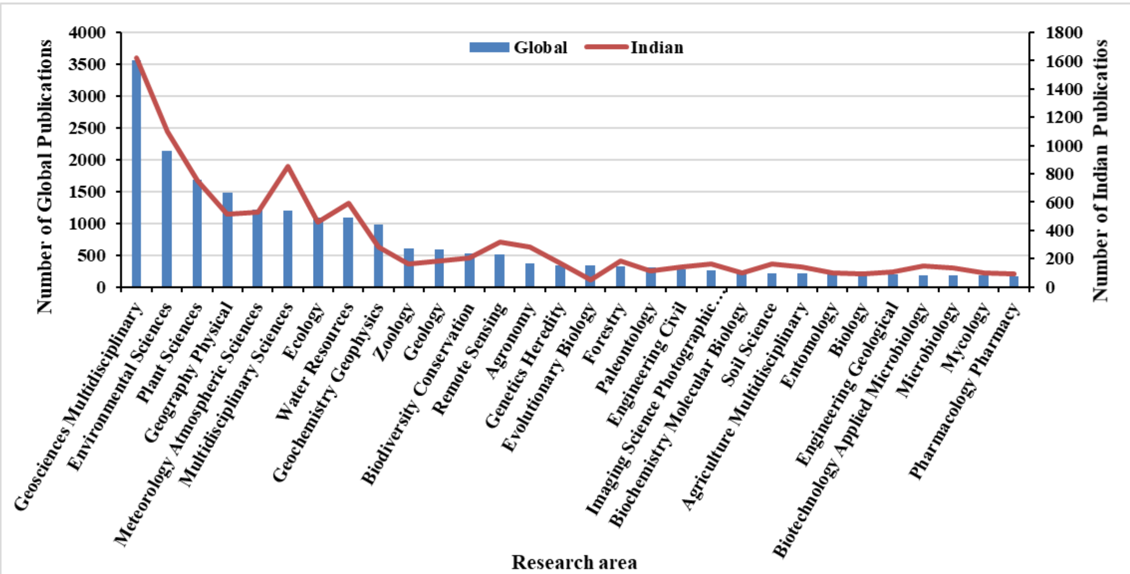


Figure 4.4.5.1.3: Global and Indian publication contribution related to "National Mission for Sustaining the Himalayan Ecosystem" in top 30 research areas.

4.4.5.1.4. Indian publication contribution in top 30 research areas before and after the adoption of the mission

Figure 4.451.1.4 shows the comparative contribution of the top 30 research areas of Indian publications before and after the introduction of the mission. Following research areas namely, Geosciences Multidisciplinary, Environmental Sciences, Multidisciplinary Sciences, Plant Sciences, Water Resources were the most important research areas before the introduction of the “National Mission for Sustaining the Himalayan Ecosystem” by contributing more than 150 publications. After the introduction of the mission, the following research areas Geosciences Multidisciplinary, Environmental Sciences, Multidisciplinary Sciences, Plant Sciences, Water Resources, Meteorology Atmospheric Sciences, Geography Physical were the most important and contributed more than 400 publications.

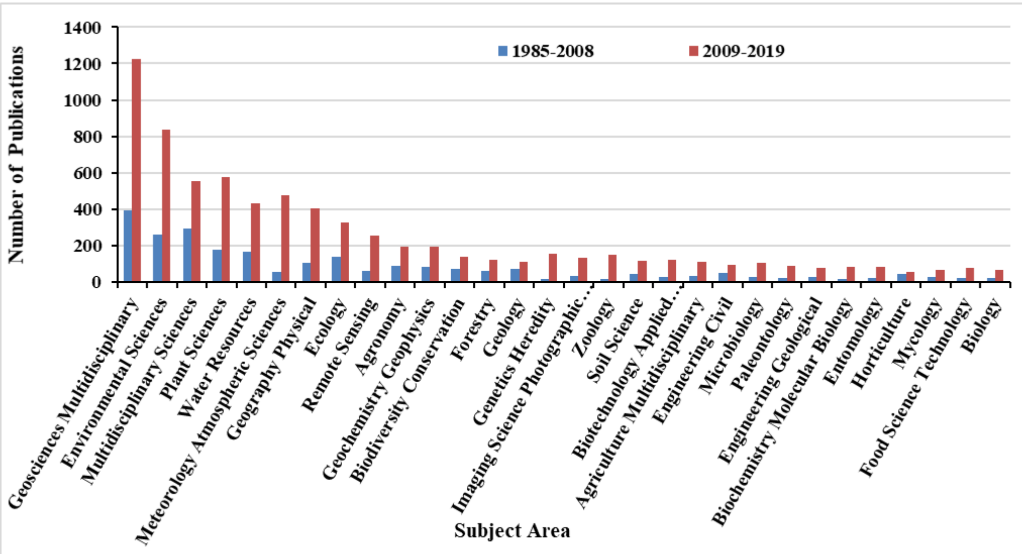


Figure 4.4.5.1.4: Indian publication contribution related to “National Mission for Sustaining the Himalayan Ecosystem” in top 30 research areas before and after the adoption of the mission.

4.4.5.1.5. The quantitative evolution and exchange of keywords of Indian publication related to “National Mission for Sustaining the Himalayan Ecosystem”

The quantitative evolution and exchange of keywords from the before mission to the after mission are represented in Figure for total Indian publications on National Mission for Sustaining the Himalayan Ecosystem. Each circle contains the number of keywords during that period which is indicated below the circle. The arrow containing the number of keywords coming towards the circle indicates newly arisen keywords. On the other hand, the arrow going outside indicates the number of keywords that are not used at successive period. The arrow pointing from the previous to successive period represents the number of keywords exchanged (integer value) and the fraction of overlap (i.e., Similarity Index) in parentheses.

The higher value of the similarity index indicates the core themes of Indian publications on National Mission for Sustaining the Himalayan Ecosystem research remain more or less continuous, whereas, the quantity of newly evolved keywords indicates the advancement of the core theme in different subthemes. The number of keywords did increase from 756 during the before the mission to 1234 during the after mission with a growth rate of 63.23%. Indian publications on National Mission for Sustaining the Himalayan Ecosystem publications research after setting of the mission incorporated more than 50% keyword from research perform during before mission.

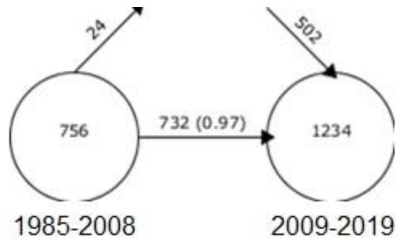


Figure4.4.5.1.5: Overlapping map of keyword's quantitative perspective during successive periods of Indian Publications on "National Mission for Sustaining the Himalayan Ecosystem"

4.4.5.1.6. Quantitative and qualitative development of themes at successive periods of Indian publication related to "National Mission for Sustaining the Himalayan Ecosystem"

Thematic evolution was represented through strategic diagrams at successive periods. Themes were plotted as circles denoting different theme clusters according to centrality and density in strategic diagrams. The size of the circle is proportional to the number of documents and referred to as document frequency (DF) in which it's linked or related keywords are present. The strategic diagrams are divided into four quadrants and they can be interpreted as follows: the top-right quadrant represents "motor themes", the top-left quadrant represents "highly developed and isolated themes", the bottom-left quadrant represents "emerging or declining themes", the bottom-right quadrant represents "basic and transversal themes".

During 1985-2008 a total of only 756 keywords during the before mission were observed among the total 1895 publications. The initial period has registered six themes with DF. During this period "FOREST" was found to be the most active theme having a DF of 73 followed by “RIVER” with a DF of 51 (Figure, Table). The theme “FOREST” received maximum document citations (1,739) followed by “RIVER” (1581). The theme “FOREST” was positioned in the top-right quadrant with the highest centrality value (18.57) indicating itself as the most important and well-connected theme with other keywords vis-à-vis themes followed by “RIVER” (16.64). The theme “PROVENANCE”, “STABLE-ISOTOPES” and “CONFLICTS” was positioned in the top-left quadrant with no centrality, thereby assigning it as an isolated theme. The themes “WATER” and “PLANTS” were found to come under emerging focus, as they were positioned in the bottom-left quadrant and also appeared in the bottom-right quadrant as basic and transversal themes. The theme “CLIMATE” appeared in the bottom-right quadrant as basic and transversal themes with highest document citations of 1947 and also “SYSTEM” appeared in the bottom-right quadrant as basic and transversal themes with highest centrality value of 24.62.

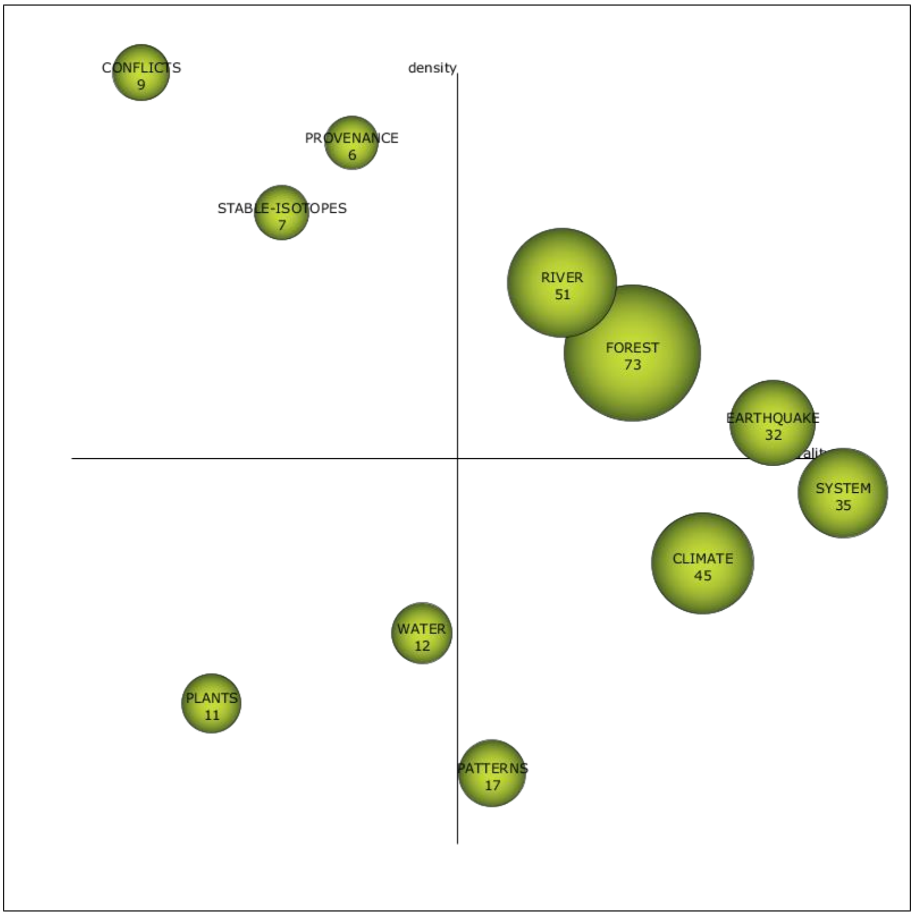


Figure4.4.5.1.6: Strategic diagram of themes during 1985-2008 of Indian publications related to “National Mission for Sustaining the Himalayan Ecosystem”.

Table4.4.5.1.2: Quantitative and qualitative performance measures of themes during 1985-2008 of Indian publications related to "National Mission for Sustaining the Himalayan Ecosystem".

Name	Centrality	Density	Core Documents Count	Core Documents sum Citations	Secondary Documents Count	Secondary Documents sum Citations
Forest	18.57	6.42	73	1,739	333	8,366
Climate	21.51	2.62	45	1,947	149	5,412
River	16.64	6.49	51	1,581	195	7,171
Earthquake	21.9	4.25	32	1,187	127	4,170
System	24.62	2.78	35	1,095	186	5,246
Patterns	14.46	1.67	17	410	150	3,281
Water	12.25	1.76	12	205	90	2,268
Conflicts	1.55	18.35	9	608	22	908
Plants	4.29	1.73	11	180	77	1,396
Provenance	8.67	11.3	6	286	36	1,672
Stable-Isotopes	5.57	7.01	7	383	22	861

During 2009-2019 total keywords have increased to 1234 during the after mission with a growth rate of 63.23% among the total 5396 publications (increased by more than 50%). The number of themes did also increase to seventeen after the mission with comparatively more DF. During this period "CLIMATE-CHANGE" was found to be the most active theme having a DF of 508 followed by "ACTIVE-TECTONICS" with a DF of 123 (Figure, Table). The theme "CLIMATE-CHANGE" received maximum document citations (7,525) followed by "ACTIVE-TECTONICS" (1,323). The theme "CLIMATE-CHANGE" was positioned in the top-right quadrant with the highest centrality value (28.34) indicating itself as the most important and well-connected theme with other keywords vis-à-vis themes followed by "ACTIVE-TECTONICS" (25.08). The theme "ANTIOXIDANT", "KASHMIR-HIMALAYA", "STABLE-ISOTOPES" and "YIELD" was positioned in the top-left quadrant with no centrality, thereby assigning it as an isolated theme. The themes "PLANTS", "POPULATIONS" and "DISTRICT" were found to come under emerging focus, as they were positioned in the bottom-left quadrant. The themes

"FOREST", "MODEL" and "BASIN" appeared in the bottom-right quadrant as basic and transversal themes.

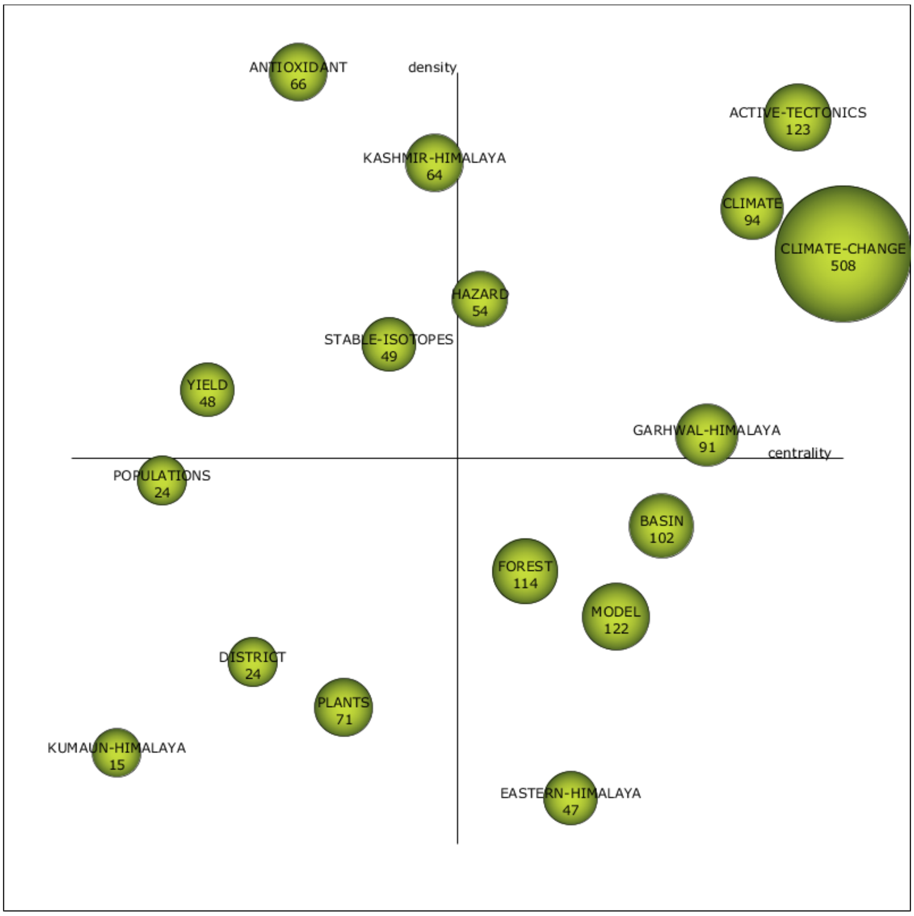


Figure4.4.5.1.7: Strategic diagram of themes during 2009-2019 of Indian publications related to "National Mission for Sustaining the Himalayan Ecosystem".

Table4.4.5.1.3: Quantitative and qualitative performance measures of themes during 2009-2019 of Indian publications related to "National Mission for Sustaining the Himalayan Ecosystem".

Name	Centrality	Density	Core Documents Count	Core Documents Sum Citations	Secondary Documents Count	Secondary Documents Sum Citations
Climate-Change	28.34	4.76	508	7,525	1,460	14,480
Active-Tectonics	25.08	5.44	123	1,323	338	3,271
Antioxidant	7.83	9.56	66	613	155	1,091
Garhwal-Himalaya	14.77	2.4	91	1,117	402	4,393
Hazard	11.62	4.35	54	594	217	3,609

Forest	**11.64**	**2.05**	**114**	**685**	**454**	**3,471**
Climate	**16.63**	**4.92**	**94**	**1,312**	**398**	**4,528**
Basin	**14.22**	**2.09**	**102**	**892**	**503**	**4,856**
Plants	**7.88**	**1.1**	**71**	**482**	**479**	**3,473**
Model	**13.13**	**1.76**	**122**	**1,335**	**569**	**5,828**
Stable-Isotopes	**10**	**3.11**	**49**	**501**	**253**	**3,285**
Kashmir-Himalaya	**11.03**	**4.99**	**64**	**554**	**245**	**2,306**
Eastern-Himalaya	**11.95**	**0.76**	**47**	**378**	**501**	**4,106**
Yield	**5.93**	**2.87**	**48**	**451**	**220**	**1,885**
District	**6.41**	**1.17**	**24**	**260**	**214**	**1,838**
Populations	**3.86**	**2.25**	**24**	**125**	**173**	**1,282**
Kumaun-Himalaya	**3.44**	**1.05**	**15**	**53**	**176**	**1,513**

4.4.5.2. Analysis of Scopus publication data related to "National Mission for Sustaining the Himalayan Ecosystem"

4.4.5.2.1. Number of publications by top 30 countries related to "National Mission for Sustaining the Himalayan Ecosystem"

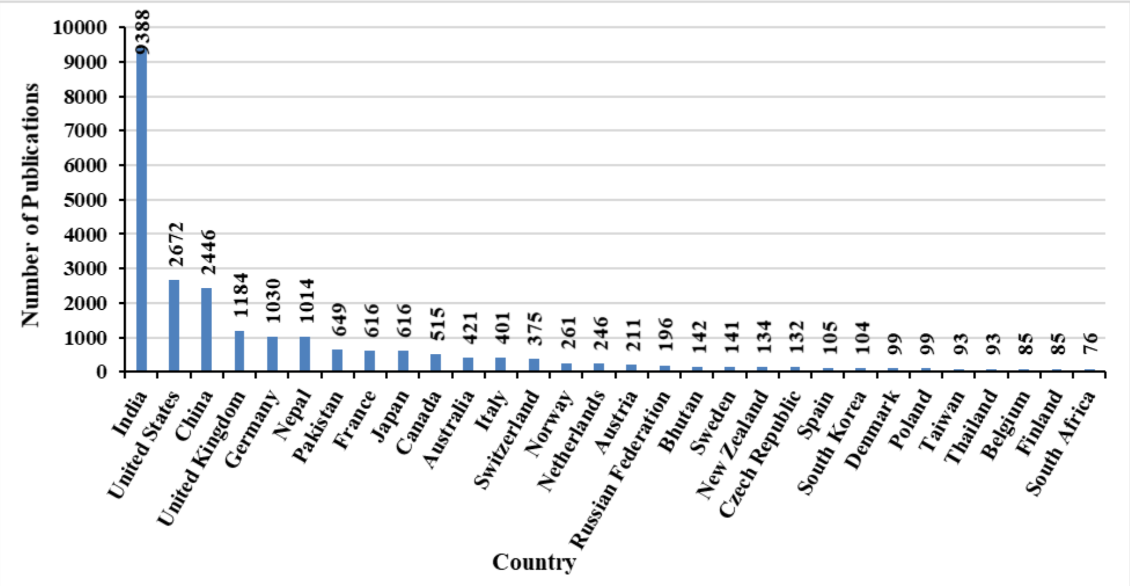


Figure 4.4.5.2.1: Total number of publications related to "National Mission for Sustaining the Himalayan Ecosystem" of top 30 countries.

A total of 18,181 publications were retrieved from the Scopus database using the final search string. Figure 4.4.5.2.1shows the publication contributions by the top 30 countries. India is the leading country and contributed 9388 publications in the publications related to the "National Mission for Sustaining the Himalayan Ecosystem".

4.4.5.2.2. Year-wise Growth of global and Indian publications related to "National Mission for Sustaining the Himalayan Ecosystem"

Figure 4.4.5.2.2 shows the year-wise growth of the number of total global and Indian publications related to the "National Mission for Sustaining the Himalayan Ecosystem". The compound annual growth rate (10.35%) of Indian publications is higher than the total global publications during 1987-2019 (Table 4.4.5.2.1). The CAGR (9.73%) of Indian publications was higher than the total global publications up to 2008 i.e. the year of the setting of the "National Mission for Sustaining the Himalayan Ecosystem". It is very interesting to see that the CAGR (11.67%) of Indian publications is also higher than the global total publications after the introduction of the mission. Therefore, it may conclude that the "National Mission for Sustaining the Himalayan Ecosystem" of India instigates the R&D activities on various objectives of solar mission thereby the growth of publications accelerated.

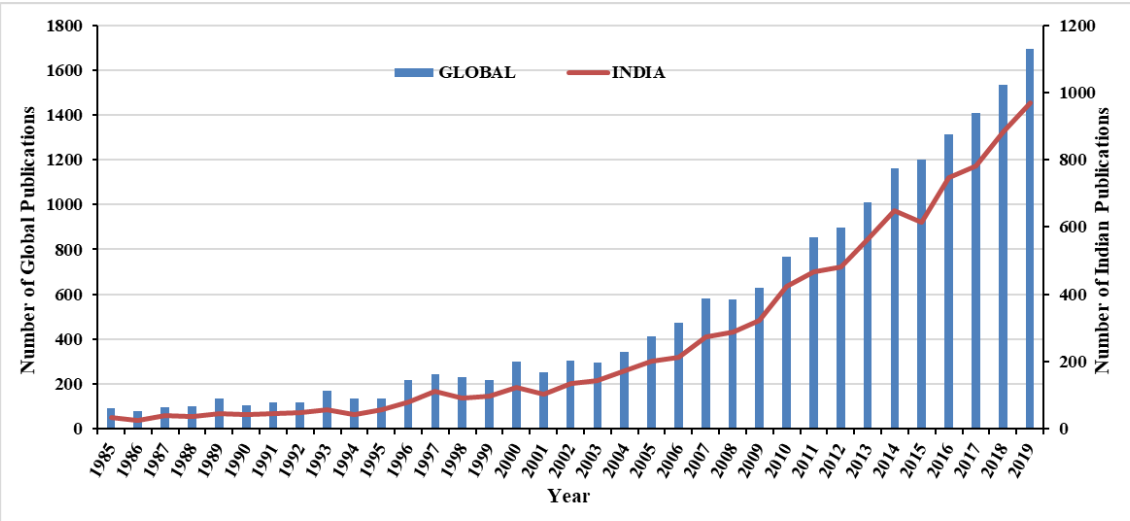


Figure 4.4.5.2.2: Year-wise global and Indian number of publications related to the "National Mission for Sustaining the Himalayan Ecosystem".

Table 4.4.5.2.1: Global and Indian total publications, Global and Indian compound annual growth rate of publications related to the "National Mission for Sustaining the Himalayan Ecosystem" during 1987-2019, 1987-2008 and 2008-2019.

	Number of publications	CAGR of all years	CAGR before setting of the mission	CAGR after setting of the mission
Global Publication	**18181**	**9.01%**	**8.4%**	**10.3%**
Indian Publication	**9388**	**10.35%**	**9.73%**	**11.67%**

4.4.5.2.3. Total Global and Indian comparative contribution in different subject areas:

Total global researches related to the Indian "National Mission for Sustaining the Himalayan Ecosystem" have been performed in 28 subject areas. The top 10 subject areas of total global researches related to the mission have contributed 90.05% cumulatively (normalised). India has contributed in 28 subject areas during total periods. The top 10 subject areas of total Indian research on climate change have also contributed 87.88% cumulatively (normalised). India has contributed at a higher proportion than the global in some research areas namely: Agricultural and Biological Sciences, Environmental Science, Biochemistry, Genetics and Molecular, Biology, Engineering, Medicine, Multidisciplinary, Pharmacology, Toxicology and Pharmaceutics, Computer Science, Immunology and Microbiology, Chemistry, Physics and Astronomy, Veterinary, Mathematics, Materials Science, Health Professions etc. India has contributed at a lower proportion than the global in some research areas namely: Earth and Planetary Sciences, Social Sciences, Arts and Humanities, Energy, Business, Management and Accounting, Economics, Econometrics and Finance, Chemical Engineering, Decision Sciences, Neuroscience, etc. (Figure 4.4.5.2.3).

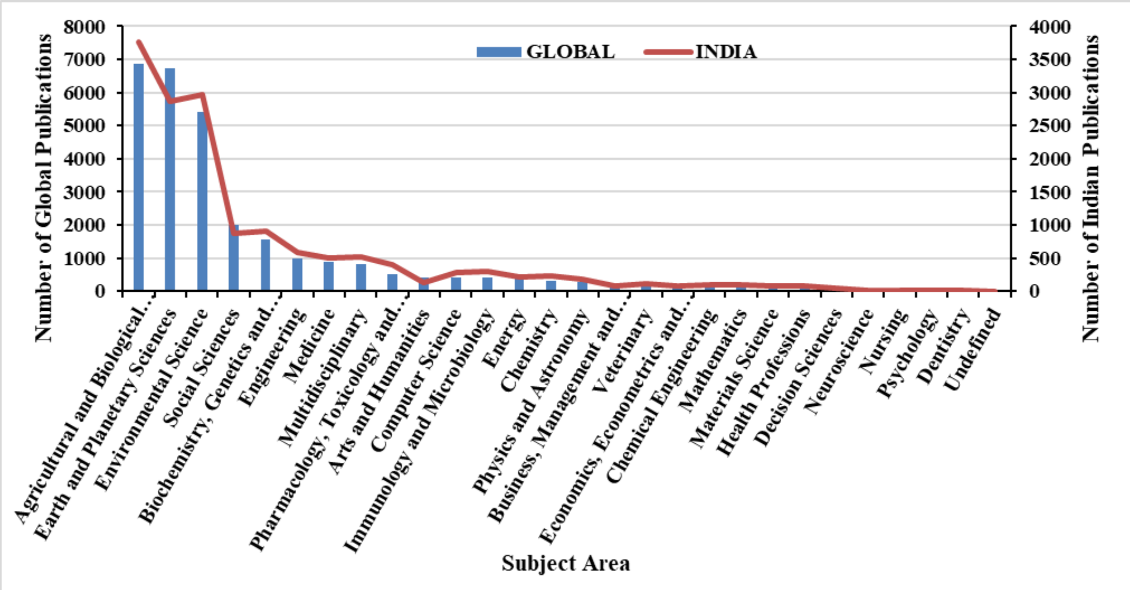


Table 4.4.5.2.3.: Global and Indian publication contribution related to “National Mission for Sustaining the Himalayan Ecosystem” in different subject areas

4.4.5.2.4 Indian publication contribution related to “National Mission for Sustaining the Himalayan Ecosystem” in different research areas before and after the introduction of the mission

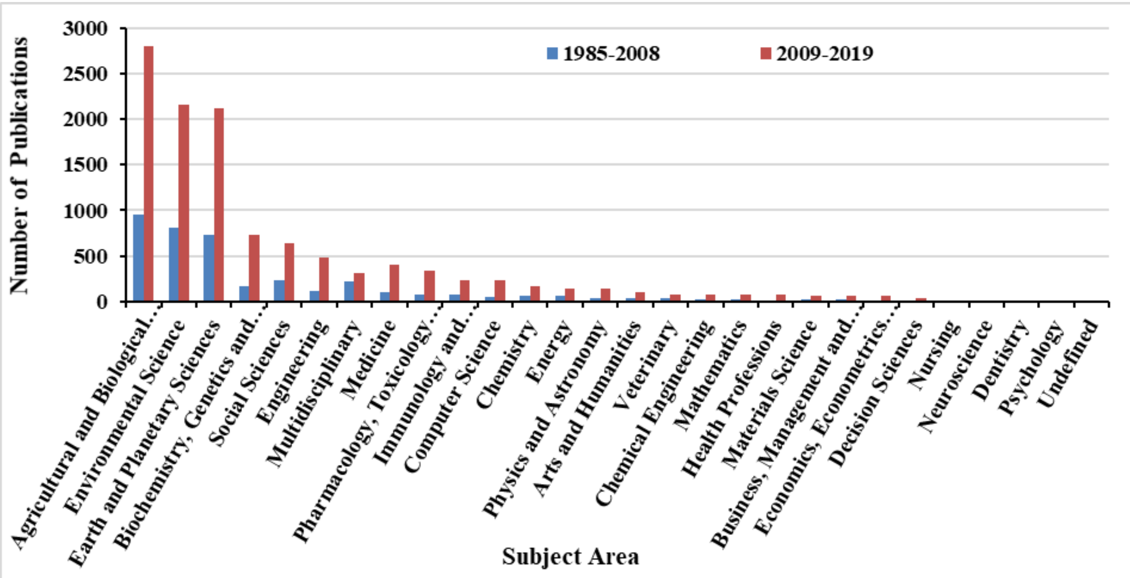


Figure 4.4.5.2.4: Indian publication contribution related to “National Mission for Sustaining the Himalayan Ecosystem”in different subject areas before and after the adoption of the mission.

Figure 4.4.1.2.4 shows the comparative contribution of different subject areas of Indian publications before and after the introduction of the mission. Following research areas namely, Agricultural and Biological Sciences, Environmental Science, Earth and Planetary Sciences, Biochemistry, Genetics and

Molecular Biology, Social Sciences, Engineering Multidisciplinary were the most important research areas before the introduction of the "National Solar Mission" by contributing more than 200 publications. After the introduction of the mission, the following research areas Agricultural and Biological Sciences, Environmental Science, Earth and Planetary Sciences, Biochemistry, Genetics and Molecular Biology, Social Sciences were the most important and contributed more than 600 publications.

4.4.5.3. Analysis of Indian Citation Index data related to "National Mission for Sustaining the Himalayan Ecosystem"

4.4.5.3.1. Year-wise Growth of global and Indian publications related to "National Mission for Sustaining the Himalayan Ecosystem"

Figure 4.4.5.3.1 shows the year-wise growth of the number of global and Indian publications related to "National Mission for Sustaining the Himalayan Ecosystem". The compound annual growth rate of Indian publications is slightly lower than the total global publications during 2005-2019. The CAGR of Indian publications was quite lower than the total global publications before 2008 i.e. the year of the introduction of the "National Mission for Sustaining the Himalayan Ecosystem". The CAGR of Indian publications from 2009 to 2019 is also lower than the global total publications (Table 4.4.1.3.1). Therefore, it may infer that the "National Mission for Sustaining the Himalayan Ecosystem" of India does not instigate R&D activities on various objectives of solar mission thereby the growth of publications decreased.

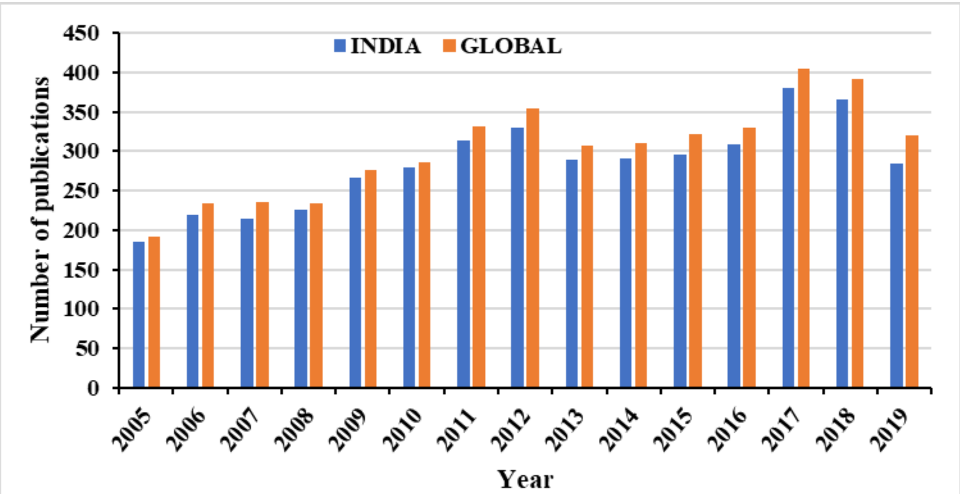


Figure 4.4.5.3.1. Year-wise global and Indian number of publications related to "National Mission for Sustaining the Himalayan Ecosystem"

Table 4.4.5.3.1: Global and Indian total publications, Global and Indian compound annual growth rate of publications related to the "National Mission for Sustaining the Himalayan Ecosystem" during 2005-2019, 2004-2008 and 2008-2019

	Number of publications	CAGR of all years	CAGR before setting of the mission	CAGR after setting of the mission
Global Publication	4524	3.75 %	7.00 %	3.18 %
Indian Publication	4247	3.13 %	6.74 %	2.39 %

4.4.5.3.2. Total Global and Indian comparative contribution in different subject areas:

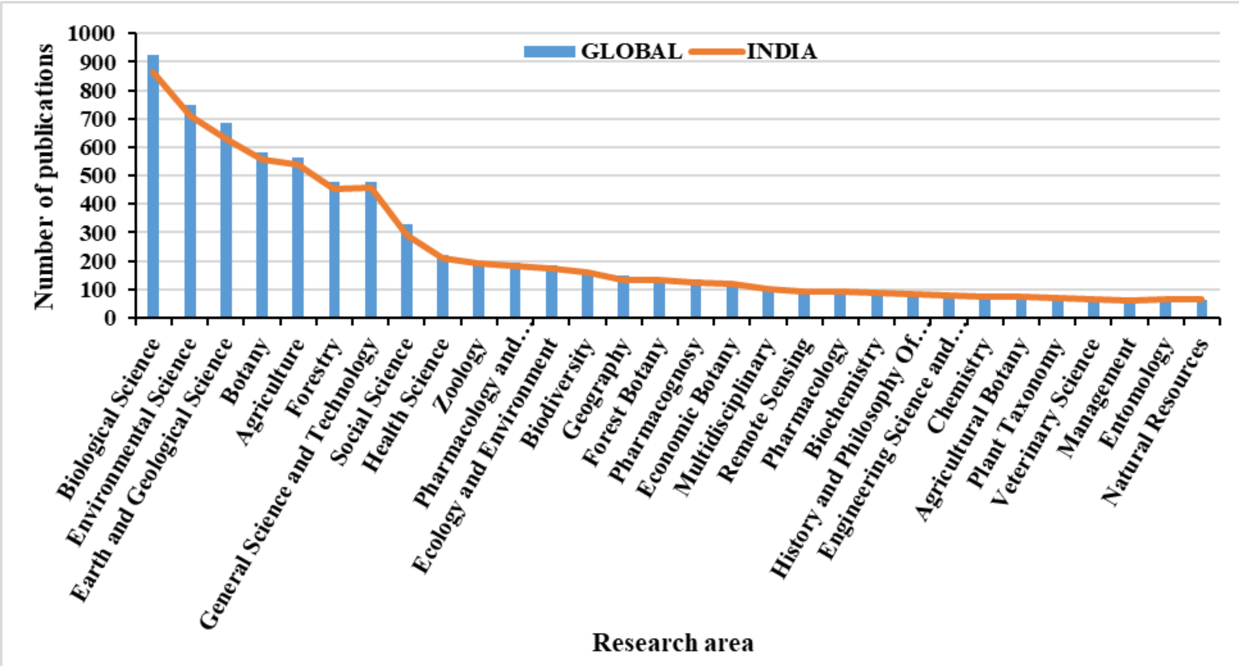


Figure 4.4.5.3.2: Global and Indian publication contribution related to "National Mission for Sustaining the Himalayan Ecosystem" in top 30 research areas

Total global research on the Indian "National Mission for Sustaining the Himalayan Ecosystem" related topic has been performed in 323 research areas. The top 30 research areas of total global research on the Indian "National Mission for Sustaining the Himalayan Ecosystem" related topic have contributed 75.19% cumulatively (normalised). India has contributed to 322 research areas during total periods. The top 30 research areas of total Indian research on climate change have contributed 75.82% cumulatively (normalised). India has contributed at a higher proportion than the global in some subject areas namely: Environmental Science, Botany, Agriculture, Forestry, General Science And Technology, Health

Science, Zoology, Pharmacology and Pharmaceutical Science, Biodiversity, Forest Botany, Economic Botany, Multidisciplinary, Pharmacology, Biochemistry, History and Philosophy Of Science and Knowledge, Engineering Science and Technology, Plant Taxonomy, Veterinary Science, Entomology, Natural Resources which are mainly deal with the Himalayan Ecosystem related study. India has contributed at a lower proportion than the global in some subject areas namely: Biological Science, Earth And Geological Science, Social Science, Ecology And Environment, Geography, Pharmacognosy, Remote Sensing, Chemistry, Agricultural Botany, Management (Figure 4.4.1.3.2).

4.4.5.3.3: Indian publication contribution in top 30 research areas before and after the adoption of the mission

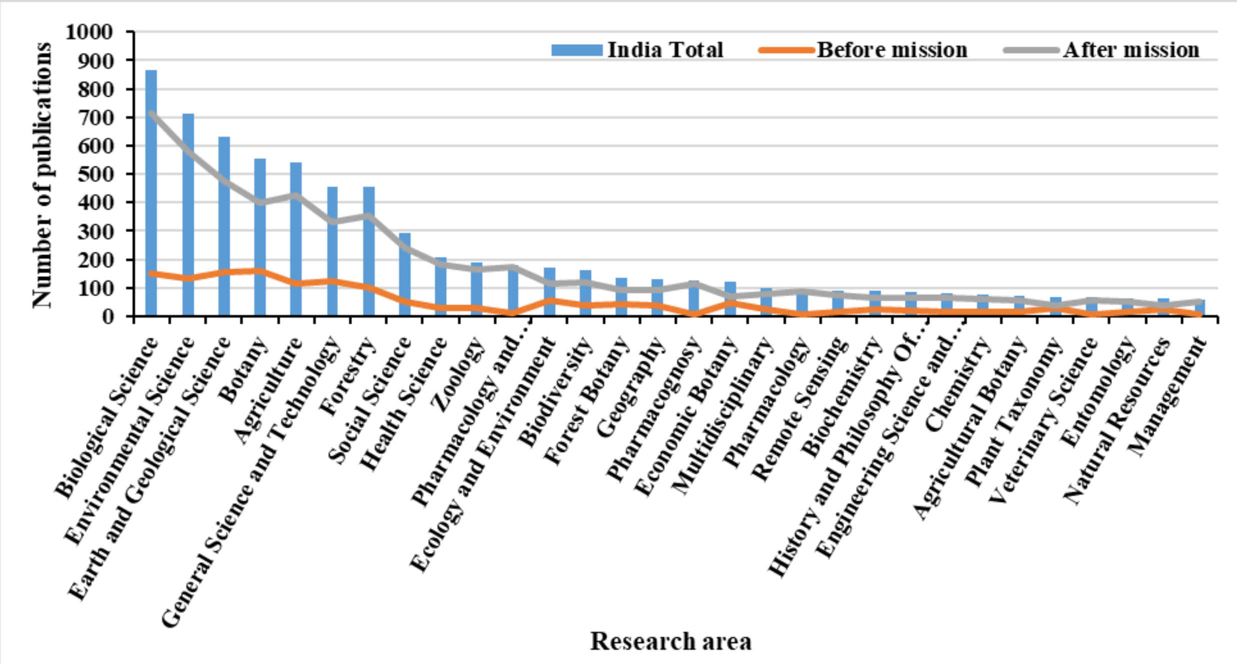


Figure 4.4.5.3.3: Indian publication contribution related to "National Mission for Sustaining the Himalayan Ecosystem"in top 30 research areas before and after the adoption of the mission.

Figure 4.4.1.3.3 shows the comparative contribution of the top 30 research areas of Indian publications before and after the introduction of the mission. Following research areas namely: Biological Science, Environmental Science, Earth And Geological Science, Botany, Agriculture, General Science And Technology, Forestry were the most important research areas before the introduction of the "National Mission for Sustaining the Himalayan Ecosystem" by contributing more than 100 publications. After the introduction of the mission, the following research areas Biological Science, Environmental Science, Earth And Geological Science, Botany, Agriculture, General Science And Technology, Forestry, Social Science were the most important and contributed more than 200 publications.

4.4.6. National Mission for a Green India

The final search string to retrieved publication data from “Web of Science” and “Scopus” for “National Mission for a Green India” was as follows:

TS=((*forest* AND (ecosystem* OR fire* OR "land use*" OR carbon OR protecte* OR conserv* OR fragment* OR fauna OR flora OR biodivers*)) OR (wildlife AND (conserv* OR in-situ OR ex-situ OR protecte* OR "genetic diversity" OR biodivers*))OR "*forest* cover*" OR "*forest* densit*")

4.4.6.1. Analysis of Web of Science publication data related to the “National Mission for a Green India”

4.4.6.1.1 Number of publications related to the “National Mission for a Green India” by top 30 countries: “National Mission for a Green India”

A total of 206003 global and 5499 Indian publications were retrieved from the Web of Science database using the final search string of National Mission for a Green India. Figure 4.4.6.1.1shows the publication contributions related to “National Mission for a Green India” by the top 30 countries. The USA is the leading country and contributed 69213 publications. India has contributed 5499 publications and secured 13th rank globally based on the number of publications.

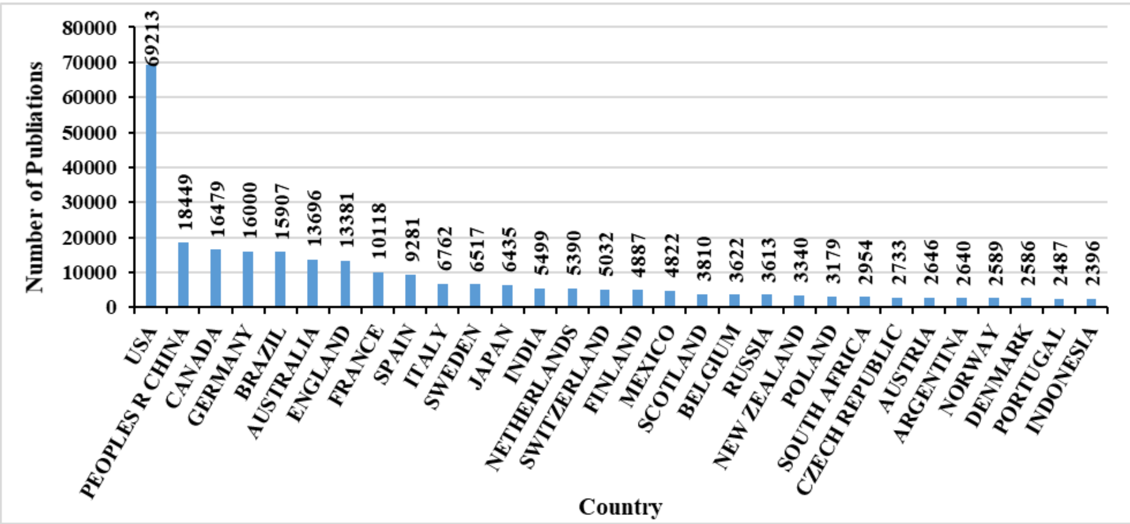


Figure 4.4.6.1.1 Total number of publications related to “National Mission for a Green India” of top 30 countries.

4.4.6.1.2. Year-wise Growth of global and Indian publications related to "National Mission for a Green India"

Figure 4.4.6.1.2 shows the year-wise growth of the number of total global and Indian publications related to "National Mission for a Green India". The compound annual growth rate of Indian publications is slightly lower than the total global publications during 1987-2019. The CAGR of Indian publications was lower than the total global publications before 2008 i.e. the year of the introduction of the "National Mission for a Green India". It is very interesting to see that the CAGR of Indian publications from 2009 to 2019 is fairly higher than the global total publications (Table 4.4.6.1.1). Therefore, it may infer that the "National Mission for a Green India" of India instigates R&D activities on various objectives of "National Mission for a Green India" thereby the growth of publications accelerated

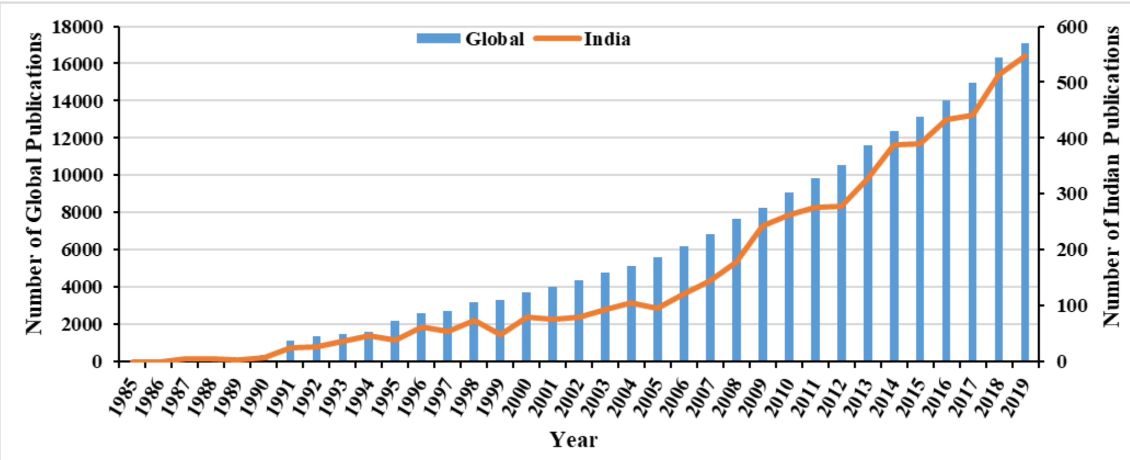


Figure 4.4.6.1.2: Year-wise global and Indian number of publications related to the "National Mission for a Green India"

Table 4.4.6.1.1: Global and Indian total publications, Global and Indian compound annual growth rate of publications related to the "National Mission for a Green India" during 1987-2019, 1987-2008 and 2008-2019

	Number of publications	CAGR of all years	CAGR before setting of the mission	CAGR after setting of the mission
Global Publication	206003	16.28	21.11	7.58
Indian Publication	5499	15.8	18.54	10.76

4.4.6.1.3. Total Global and Indian comparative contribution in top 30 research areas:

Total global research on the Indian "National Mission for a Green India" related topic has been performed in 226 research areas. The top 30 research areas of total global research on the Indian "National Mission for a Green India" related topic have contributed 87.26% cumulatively (normalised). India has contributed to 160 research areas during total periods. The top 30 research areas of total Indian research on climate change have contributed 89.99 % cumulatively (normalised). India has contributed at a higher proportion than the global in some research areas namely: Environmental Sciences, Multidisciplinary Sciences, Remote Sensing, Water Resources, Agronomy, Imaging Science Photographic Technology, Engineering Environmental, Agriculture Multidisciplinary, Energy Fuels, Engineering Electrical Electronic, Green Sustainable Science Technology. India has contributed at a lower proportion than the global in some research areas namely Ecology, Forestry, Biodiversity Conservation, Plant Sciences, Geosciences Multidisciplinary, Soil Science, Zoology, Meteorology Atmospheric Sciences, Geography Physical, Environmental Studies, Marine Freshwater Biology, Entomology, Evolutionary Biology, Biology, Ornithology, Economics, Genetics Heredity, Biochemistry Molecular Biology, Microbiology (Figure 4.4.6.1.3).

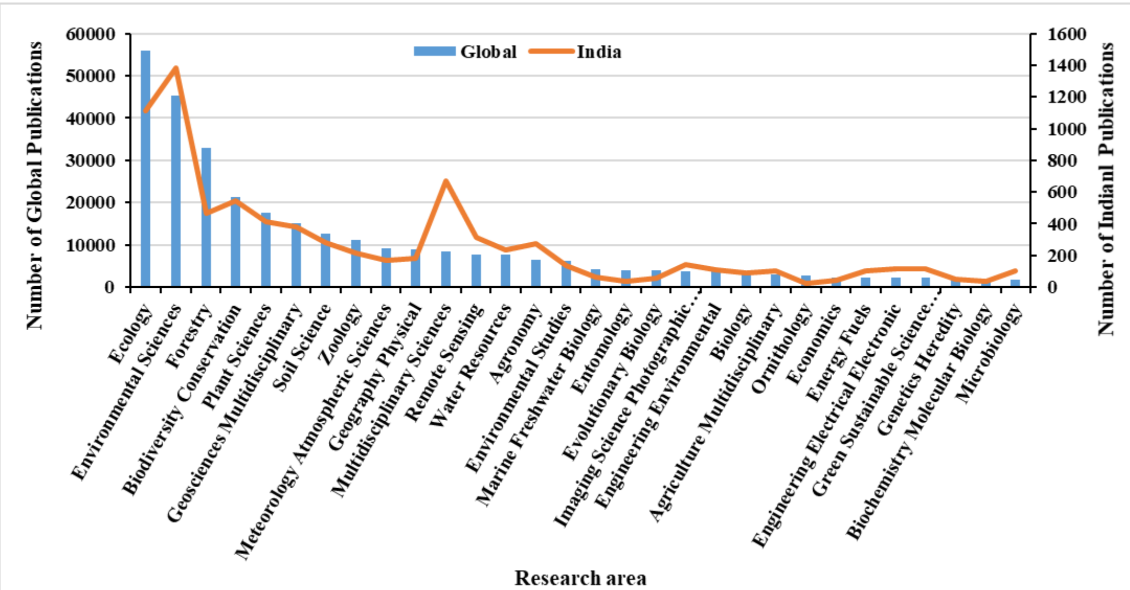


Figure 4.4.6.1.3. Global and Indian publication contribution related to "National Mission for a Green India"in top 30 research areas

4.4.6.1.4. Indian publication contribution in top 30 research areas before and after the adoption of the mission

Figure 4.4.1.1.4 shows the comparative contribution of the top 30 research areas of Indian publications before and after the introduction of the mission. Following research areas namely, Environmental Sciences, Ecology, Multidisciplinary Sciences, Biodiversity Conservation were the most important research areas before the introduction of the "National Mission for a Green India" by contributing more than 150 publications. After the introduction of the mission, the following research areas Environmental Sciences, Ecology, Multidisciplinary Sciences, Biodiversity Conservation, Forestry, Plant Sciences, Geosciences Multidisciplinary, Remote Sensing were the most important and contributed more than 250 publications.

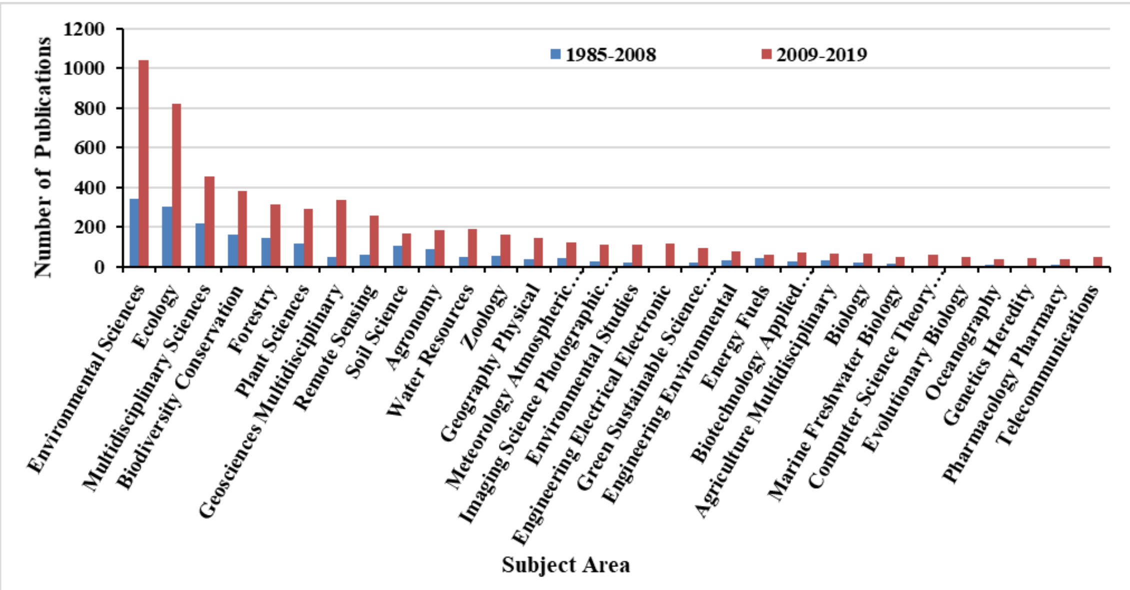


Figure 4.4.6.1.4: Indian publication contribution related to "National Mission for a Green India" in the top 30 research areas before and after the adoption of the mission.

4.4.6.1.5. The quantitative evolution and exchange of keywords of Indian publication related to "National Mission for a Green India":

The quantitative evolution and exchange of keywords from the before mission to the after mission are represented in Figure for total Indian publications on National Mission for a "Green India". Each circle contains the number of keywords during that period which is indicated below the circle. The arrow containing the number of keywords coming towards the circle indicates newly arisen keywords. On the other hand, the arrow going outside indicates the number of keywords that are not used at successive periods. The arrow pointing from the previous to successive period represents the number of keywords exchanged (integer value) and the fraction of overlap (i.e., Similarity Index) in parentheses.

The higher value of the similarity index indicates the core themes of Indian publications on National Mission for a "Green India" research remain more or less continuous, whereas, the quantity of newly evolved keywords indicates the advancement of the core theme in different subthemes. The number of keywords did increase from 651 before the mission to 1021 after the mission introduction with a growth rate of 56.84%. Indian publications on National Mission for a "Green India" publications research after setting of the mission incorporated more than 50% keyword from research perform during before mission.

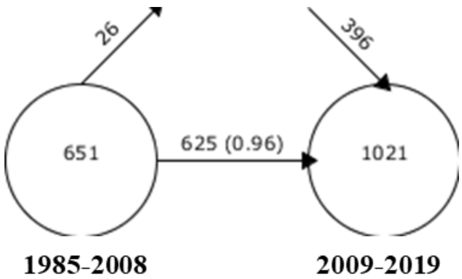


Figure4.4.6.1.5: Overlapping map of keyword's quantitative perspective during successive periods of Indian Publications on "National Mission for a Green India".

4.4.6.1.6. Quantitative and qualitative development of themes at successive periods of Indian publication related to "National Mission for a Green India"

Thematic evolution was represented through strategic diagrams at successive periods. Themes were plotted as circles denoting different theme clusters according to centrality and density in strategic diagrams. The size of the circle is proportional to the number of documents and referred to as document frequency (DF) in which it's linked or related keywords are present. The strategic diagrams are divided into four quadrants and they can be interpreted as follows: the top-right quadrant represents "motor themes", the top-left quadrant represents "highly developed and isolated themes", the bottom-left quadrant represents "emerging or declining themes", the bottom-right quadrant represents "basic and transversal themes".

During 1985-2008 a total of only 651 keywords during the before mission were observed among the total 1400 publications. The initial period has registered eleven themes with DF. During this period

“WESTERN-GHATS” was found to be the most active theme having a DF of 82 followed by “POPULATION” with a DF of 28 (Figure, Table). The theme “WESTERN-GHATS” received maximum document citations (2,678) followed by “POPULATION” (1,777). The theme “WESTERN-GHATS” was positioned in the top-right quadrant with the highest centrality value (23.68) indicating itself as the most important and well-connected theme with other keywords vis-à-vis themes followed by “POPULATION” (16.11). The theme “FOREST-FIRE” and “TREES” was positioned in the top-left quadrant with no centrality, thereby assigning it as an isolated theme. The themes “CARBON” and “PLANTATIONS” were found to come under emerging focus, as they were positioned in the bottom-left quadrant. The theme “ECOSYSTEMS”, “SYSTEMS” and “COMMUNITIES” appeared in the bottom-right quadrant as basic and transversal themes.

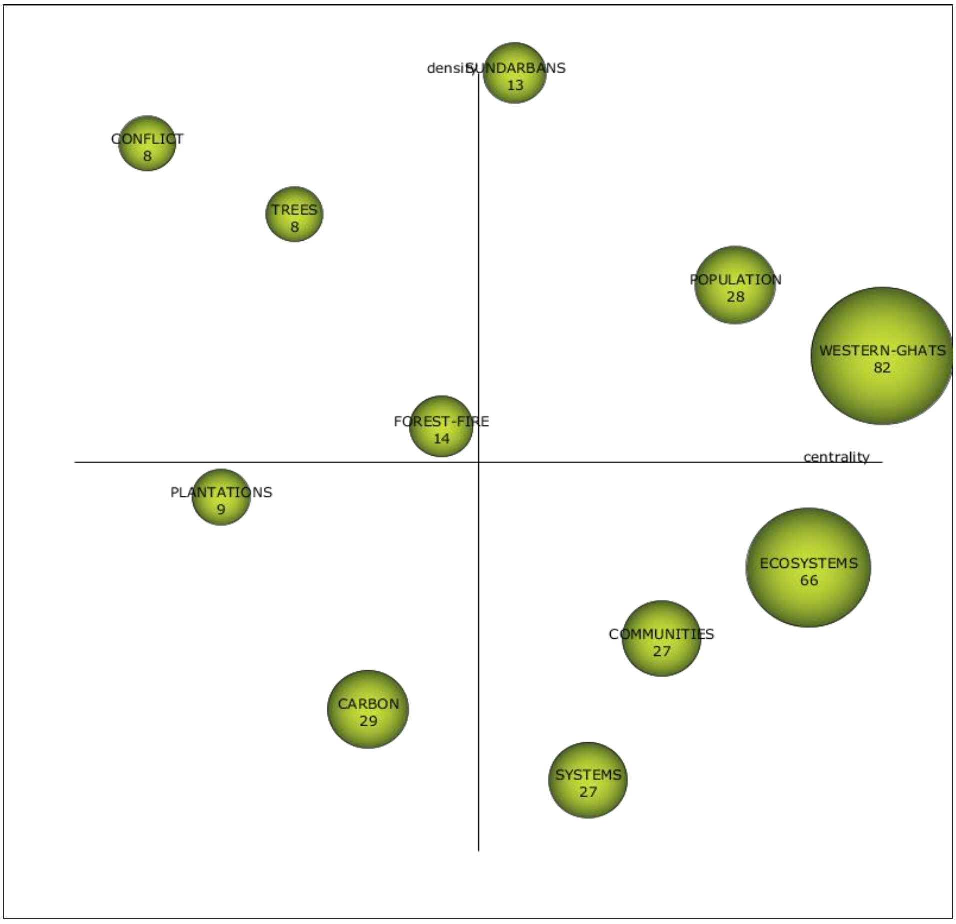


Figure 4.4.6.1.6: Strategic diagram of themes during 1985-2008 of Indian publications related to “National Mission for a Green India”.

Table 4.4.6.1.2: Quantitative and qualitative performance measures of themes during 1985-2008 of Indian publications related to "National Mission for a Green India".

Name	Centrality	Density	Core Documents Count	Core Documents sum Citations	Secondary Documents Count	Secondary Documents sum Citations
Western-Ghats	23.68	7.71	82	2,678	212	8,032
Population	16.11	10.31	28	1,777	73	2,702
Ecosystems	16.73	3.28	66	1,896	236	9,269
Carbon	6.1	2.36	29	1,134	81	2,337
Communities	15.62	2.62	27	762	129	4,190
Systems	15.41	2.33	27	1,419	144	5,639
Forest-Fire	8.83	5.86	14	207	58	2,441
Plantations	4.1	4.89	9	207	44	1,204
Sundarbans	9.24	12.14	13	811	29	1,281
Trees	6.04	11.39	8	318	44	1,446
Conflict	3.65	11.62	8	603	12	491

During 2009-2019 total keywords have increased to 1021 during the after mission with a growth rate of 56.84% among the total 4130 publications (increased by more than 50%). The number of themes did also increase to thirteen after mission introduction with comparatively more DF. During this period "WESTERN-GHATS" was found to be the most active theme having a DF of 329 followed by "NATIONAL-PARK" with a DF of 113 (Figure 4.4.6.1.7, Table Table4.4.6.1.3). The theme "WESTERN-GHATS" received maximum document citations (3,318) followed by "NATIONAL-PARK" (1,116). The theme "POPULATION" was positioned in the top-right quadrant with the highest centrality value (22.89) indicating itself as the most important and well-connected theme with other keywords vis-à-vis themes followed by "WESTERN-GHATS" (22.37). The theme "CLASSIFICATION", "BIOLOGICAL-INVASIONS" and "RECORD" was positioned in the top-left quadrant with no centrality, thereby assigning it as an isolated theme. The themes "PLANTS", "AREA" and "SUNDARBANS" were found to come under emerging focus, as they were positioned in the bottom-left quadrant. The theme "ECOSYSTEMS" appeared in the bottom-right quadrant as basic and transversal themes with the highest document citation of 3442 (DF 237) followed by "IMPACT" with document citation of 1753 (DF 112).

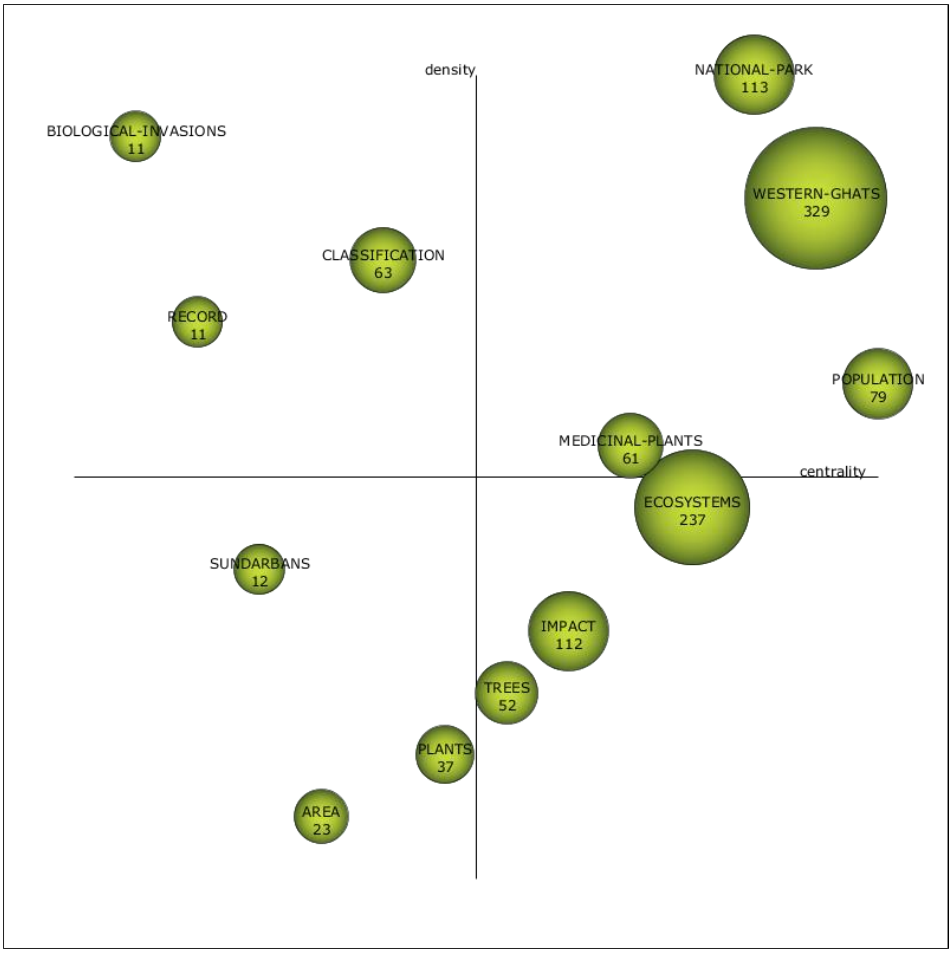


Figure 4.4.6.1.7: Strategic diagram of themes during 2009-2019 of Indian publications related to "National Mission for a Green India".

Table4.4.6.1.3: Quantitative and qualitative performance measures of themes during 2009-2019 of Indian publications related to "National Mission for a Green India".

Name	Centrality	Density	Core Documents Count	Core Documents sum Citations	Secondary Documents Count	Secondary Documents sum Citations
National-Park	**17.32**	**8.17**	**113**	**1,116**	**269**	**3,374**
Western-Ghats	**22.37**	**5.31**	**329**	**3,318**	**1,052**	**14,197**
Ecosystems	**15.97**	**2.62**	**237**	**3,442**	**812**	**10,910**
Population	**22.89**	**2.71**	**79**	**1,012**	**279**	**3,068**
Classification	**6.43**	**4.06**	**63**	**837**	**225**	**2,893**

Medicinal-Plants	**10.11**	**2.68**	**61**	**574**	**415**	**3,787**
Impact	**9.53**	**1.3**	**112**	**1,753**	**552**	**9,344**
Trees	**9.43**	**0.79**	**52**	**399**	**399**	**4,232**
Plants	**7.11**	**0.5**	**37**	**314**	**370**	**4,183**
Area	**5.92**	**0.26**	**23**	**373**	**370**	**4,838**
Sundarbans	**2.15**	**2.44**	**12**	**134**	**69**	**971**
Biological-Invasions	**0.9**	**6.3**	**11**	**340**	**47**	**478**
Record	**1.68**	**2.85**	**11**	**110**	**49**	**650**

4.4.6.2. Analysis of Scopus publication data related to "National Mission for a Green India"

4.4.6.2.1. Number of publications by top 30 countries related to "National Mission for a Green India"

A total of 2,54,822publications were retrieved from the Scopus database using the final search string. Figure 4.4.6.2.1shows the publication contributions by the top 30 countries. The USA is the leading country and contributed 74372 publications. India has contributed 8936 publications and secured 10th rank globally in the publications related to the "National Mission for a Green India".

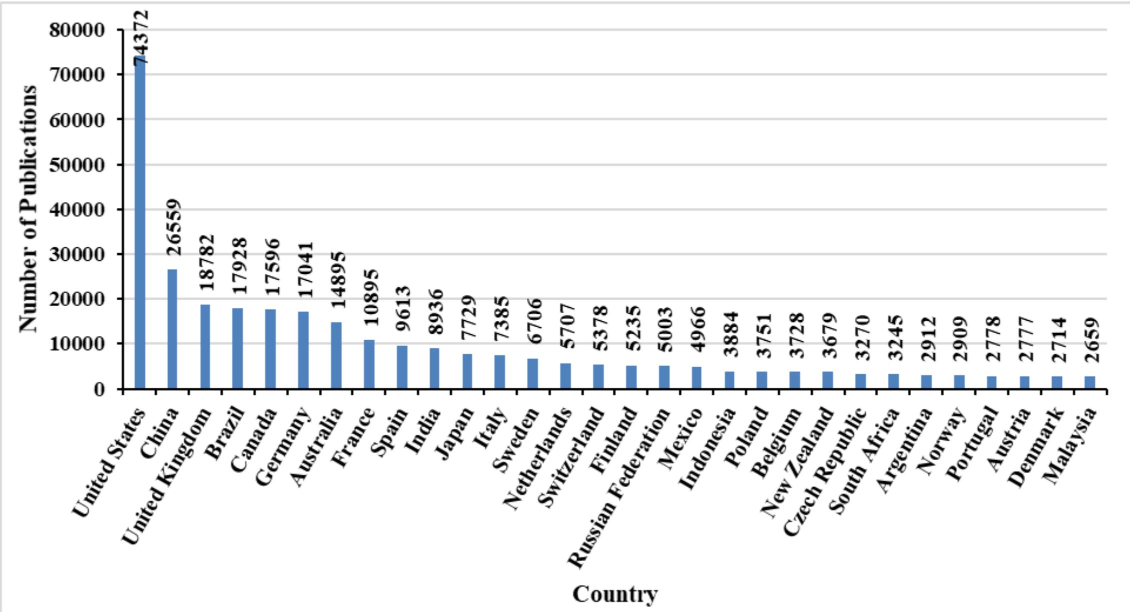


Figure 4.4.6.2.1.: The total number of publications related to "National Mission for a Green India".

of top 30 countries

4.4.6.2.2. Year-wise Growth of global and Indian publications related to "National Mission for a Green India".

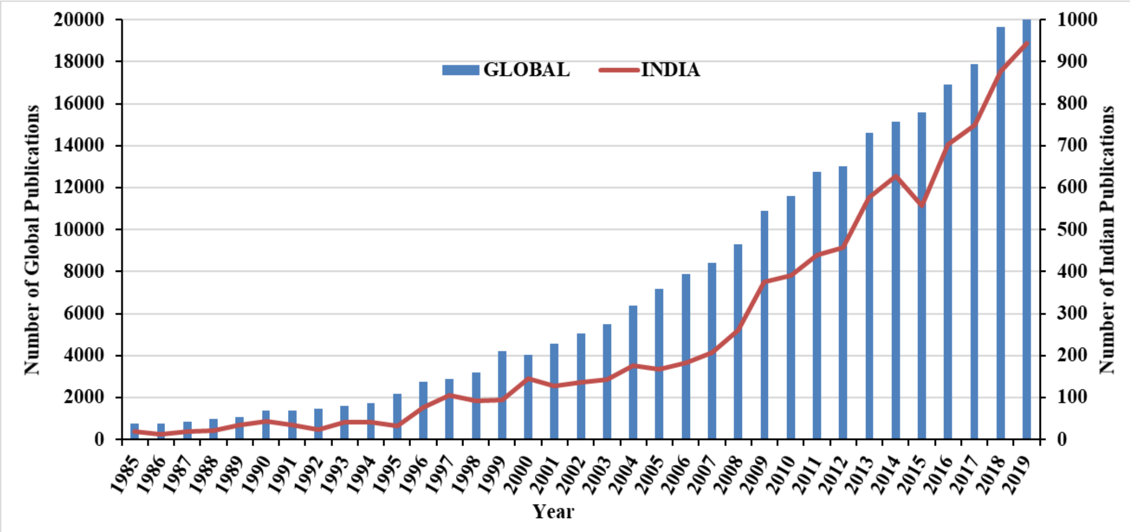


Figure 4.4.6.2.2.: Year-wise global and Indian number of publications related to "National Mission for a Green India".

Figure 4.4.6.2.2 shows the year-wise growth of the number of total global and Indian publications related to the "National Mission for a Green India". The compound annual growth rate (12.04%) of Indian publications is higher than the total global publications during 1987-2019 (Table 4.4.6.2.1). The CAGR (12.43%) of Indian publications was higher than the total global publications up to 2008 i.e. the year of the setting of the "National Mission for a Green India". It is very inspiring to see that the CAGR (12.17%) of Indian publications is also higher than the global total publications. Therefore, it may conclude that the "National Mission for a Green India" of India instigates the R&D activities on various objectives of solar mission thereby the growth of publications accelerated.

Table 4.4.6.2.1 Global and Indian total publications related to "National Mission for a Green India" Global and Indian compound annual growth rate of publications during 1987-2019, 1987-2008 and 2008-2019

	Number of publications	CAGR of all years	CAGR before the setting of the mission	CAGR after the setting of the mission
Global Publication	254822	11.49%	7.75%	10.26%
Indian Publication	8936	12.04%	12.43%	12.17%

4.4.6.2.3. Total Global and Indian comparative contribution in different subject areas

Total global researches related to the Indian "National Mission for a Green India" have been performed in 28 subject areas. The top 10 subject areas of total global researches related to the mission have contributed 90.24 % cumulatively (normalised). India has contributed in 27 subject areas during total periods. The top 10 subject areas of total Indian research on climate change have also contributed 87.04 % cumulatively (normalised).

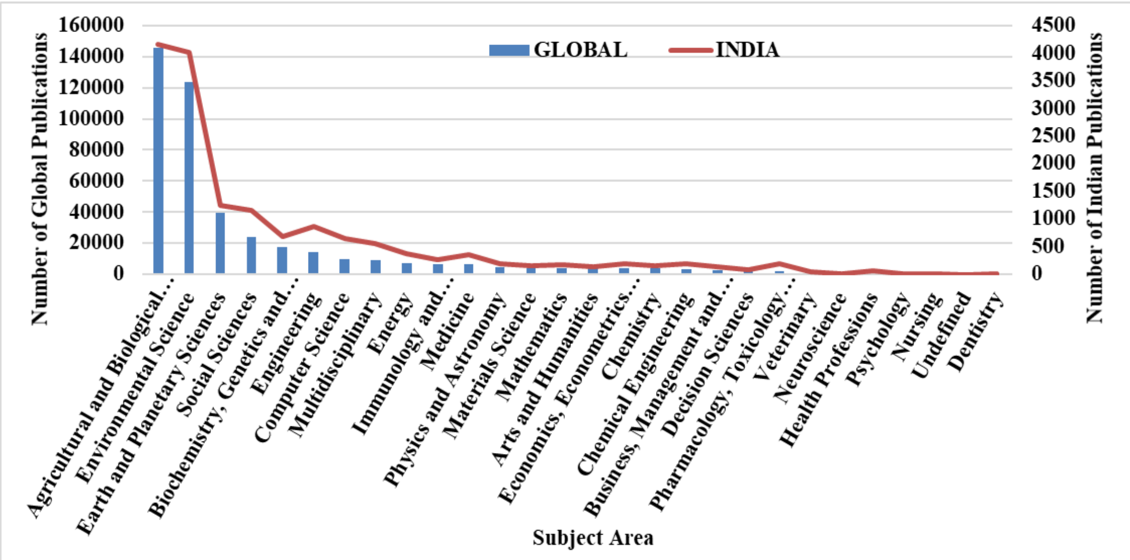


Figure 4.4.6.2.3: Global and Indian publication contribution related to "National Mission for a Green India" in different subject areas

India has contributed at a higher proportion than the global in some research areas namely: Social Sciences, Biochemistry, Genetics and Molecular Biology, Engineering, Computer Science, Multidisciplinary, Energy, Immunology and Microbiology, Medicine, Physics and Astronomy, Materials Science, Mathematics, Economics, Econometrics and Finance, Chemistry, Chemical Engineering, Business, Management and Accounting, Decision Sciences, Pharmacology, Toxicology and Pharmaceutics, Health Professions, Nursing etc. India has contributed at a lower proportion than the global in some research areas namely: Agricultural and Biological Sciences, Environmental Science, Earth and Planetary Sciences, Arts and Humanities, Veterinary, Neuroscience, Psychology, Undefined, Dentistry, etc. (Figure 4.4.6.2.3).

4.4.6.2.4: Indian publication contribution related to "National Mission for a Green India" in different research areas before and after the introduction of the mission:

Figure 4.4.6.2.4 shows the comparative contribution of different subject areas of Indian publications before and after the introduction of the mission. Following research areas namely, Agricultural and Biological Sciences, Environmental Science, Earth and Planetary Sciences, Social Sciences were the most important research areas before the introduction of the "National Mission for a Green India" by contributing more than 200 publications. After the introduction of the mission, the following research areas Agricultural and Biological Sciences, Environmental Science, Earth and Planetary Sciences, Social Sciences, Engineering, Biochemistry, Genetics and Molecular Biology, Computer Science were the most important and contributed more than 500 publications.

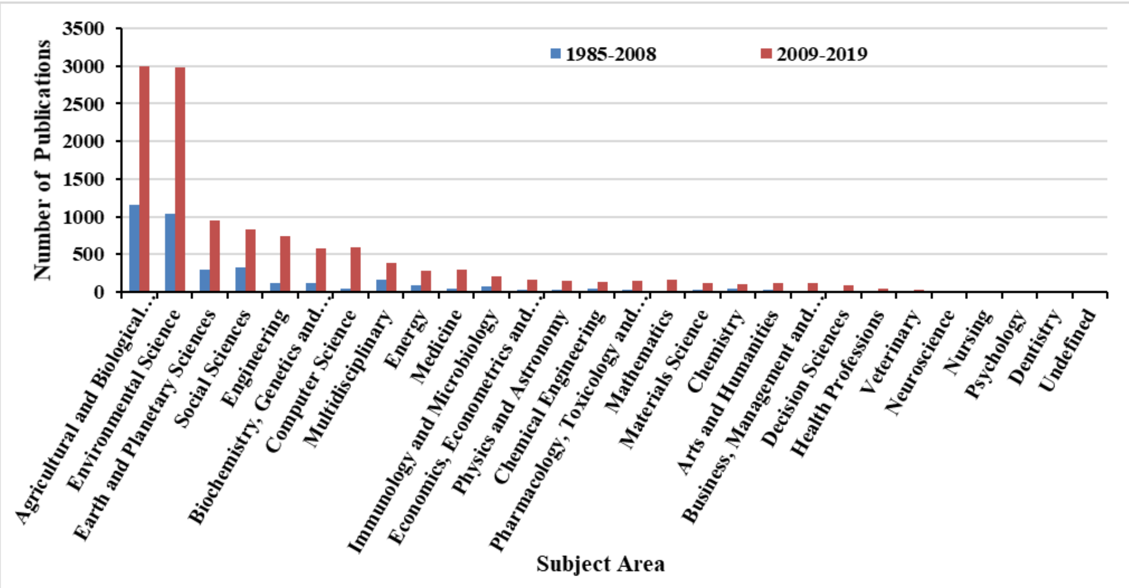


Figure 4.4.6.2.4: Indian publication contribution related to "National Mission for a Green India" in different subject areas before and after the adoption of the mission.

4.4.6.3. Analysis of Indian Citation Index data related to "National Mission for a Green India"

4.4.6.3.1. Year-wise Growth of global and Indian publications related to "National Mission for a Green India"

Figure 4.4.6.3.1 shows the year-wise growth of the number of global and Indian publications related to "National Mission for a Green India". The compound annual growth rate of Indian publications is lower than the total global publications during 2005-2019. The CAGR of Indian publications was slightly higher than the total global publications before 2008 i.e. the year of the introduction of the "National Mission for a Green India". While the CAGR of Indian publications from 2009 to 2019 is lower than the global total publications (Table 4.4.6.3.1). Therefore, it may infer that the "National Mission for a Green India" of India does not instigate R&D activities on various objectives of solar mission thereby the growth of publications decreased.

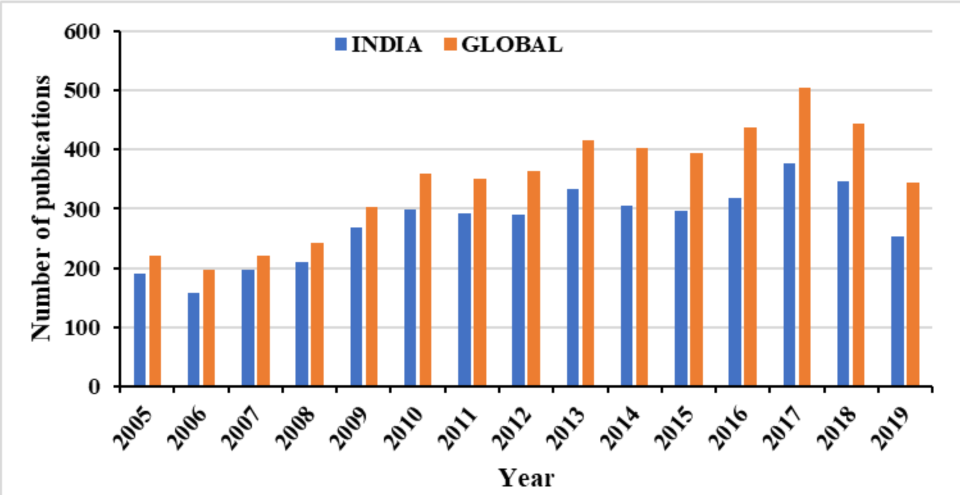


Figure 4.4.6.3.1: Year-wise global and Indian number of publications related to "National Mission for a Green India".

Table 4.4.6.3.1: Global and Indian total publications, Global and Indian compound annual growth rate of publications related to the "National Mission for a Green India" during 2005-2019, 2004-2008 and 2008-2019.

	Number of publications	CAGR of all years	CAGR before setting of the mission	CAGR after setting of the mission
Global Publication	5199	3.21	3.21	3.54
Indian Publication	4132	2.10	3.23	1.97

4.4.6.3.2. Total Global and Indian comparative contribution in different subject areas:

Total global research on the Indian "National Mission for a Green India" related topic has been performed in 304 research areas. The top 30 research areas of total global research on the Indian "National Solar Mission" related topic have contributed 79.19% cumulatively (normalised). India has contributed to 287 research areas during total periods. The top 30 research areas of total Indian research on climate change have contributed 78.33% cumulatively (normalised).

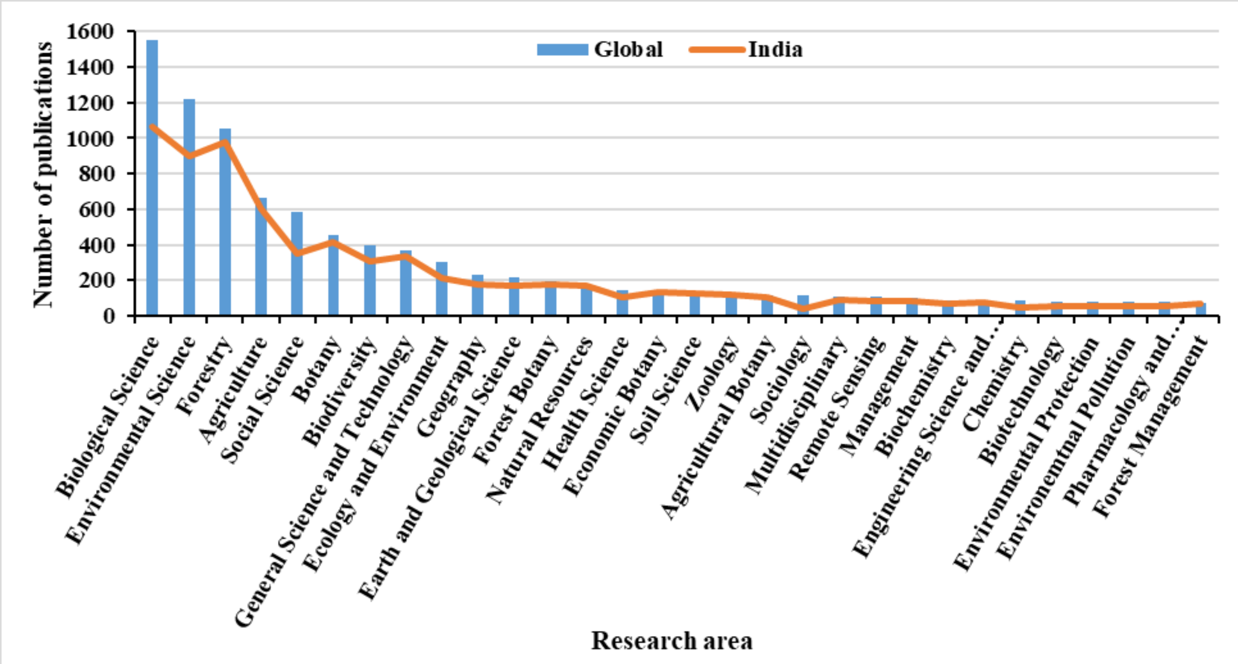


Figure 4.4.6.3.2: Global and Indian publication contribution related to "National Mission for a Green India"in top 30 research areas.

India has contributed at a higher proportion than the global in some research areas namely: Forestry, Agriculture, Botany, General Science And Technology, Earth And Geological Science, Forest Botany, Natural Resources, Economic Botany, Soil Science, Zoology, Agricultural Botany, Multidisciplinary, Engineering Science And Technology, Forest Management, Management, Remote Sensing which are mainly deal with the forest and environment-related research. India has contributed at a lower proportion than the global in some research areas namely: Biological Science, Environmental Science, Social Science, Biodiversity, Ecology and Environment, Geography, Health Science, Sociology, Biochemistry, Chemistry, Biotechnology, Environmental Protection, Environmental Pollution, Pharmacology And Pharmaceutical Science (Figure 4.4.6.3.2).

4.4.6.3.3. Indian publication contribution in top 30 research areas before and after the adoption of the mission

Figure 4.4.6.3.3 shows the comparative contribution of the top 30 research areas of Indian publications before and after the introduction of the mission. Following research areas namely: Biological Science, Forestry, Environmental Science, Agriculture were the most important research areas before the introduction of the "National Mission for a Green India"by contributing more than 100 publications. After the introduction of the mission, the following research areas Biological Science, Forestry, Environmental Science, Agriculture, Botany, Social Science, General Science and Technology, Biodiversity was the most important and contributed more than 200 publications.

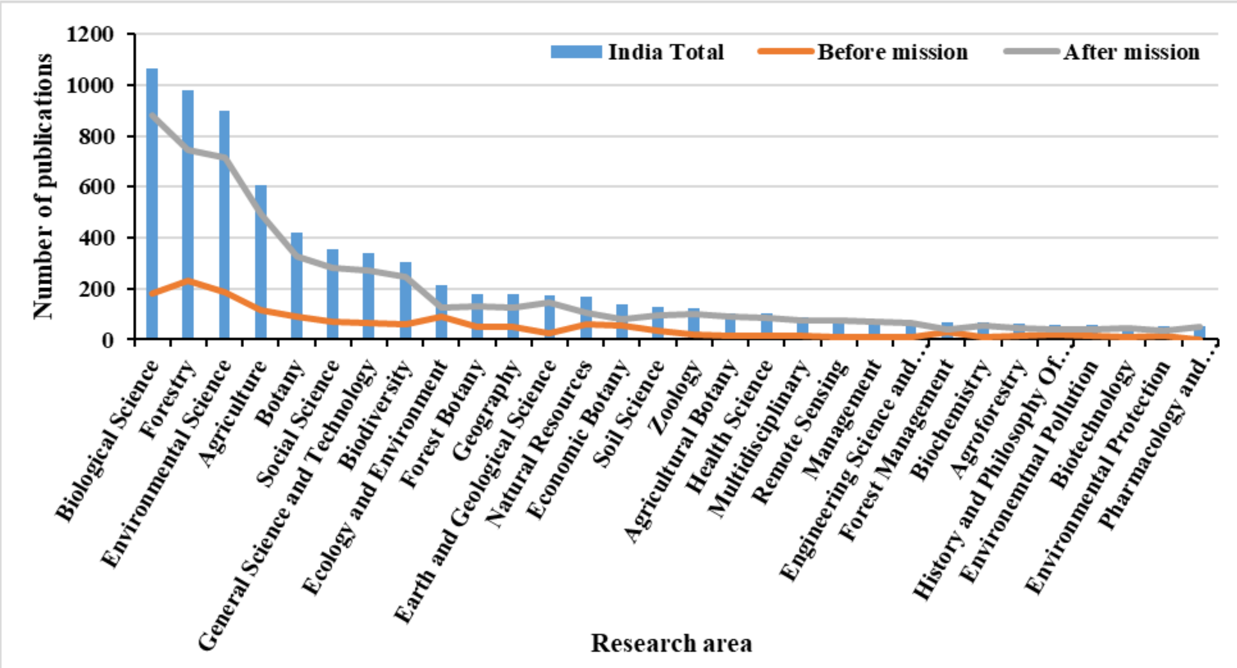


Figure 4.4.6.3.3: Indian publication contribution in top 30 research areas before and after the adoption of the mission

4.4.7. National Mission for Sustainable Agriculture

The final search string to retrieved publication data from "Web of Science" and "Scopus" for "National Mission for Sustainable Agriculture" was as follows:

TS=((agricult* AND ("land use" OR GHG OR "greenhouse gas*" OR environment* OR *forest* OR "food security" OR biodiversity OR CO2 OR carbon OR NO2 OR nitrogen OR "weather forecast*" OR *compost* OR GDP OR dairy OR climat* OR livelihood OR weather OR mountain* OR ecosystem OR (resistance AND (pest* OR disease)) OR (tolerance AND (drought OR salinity OR submergence OR heat)) OR "soil erosion" OR bio-control OR pesticide OR fertiliz* OR "organic farming" OR livestock OR(zone AND ("dry land" OR rain-fed)) OR sustainab* OR conserv* OR cultivation OR biotechnolog* OR technol* OR "water resource*" OR yield OR product* OR "medicinal plant" OR econom* OR intensif* OR (crop AND (rotation* OR improve* OR variety OR season OR hybrid OR greenhouse OR C-3 OR C-4)))) OR "agricult* manage*")

4.4.7.1. Analysis of Web of Science publication data related to the "National Mission for Sustainable Agriculture"

4.4.7.1.1. Number of publications related to the "National Mission for Sustainable Agriculture" by top 30 countries:

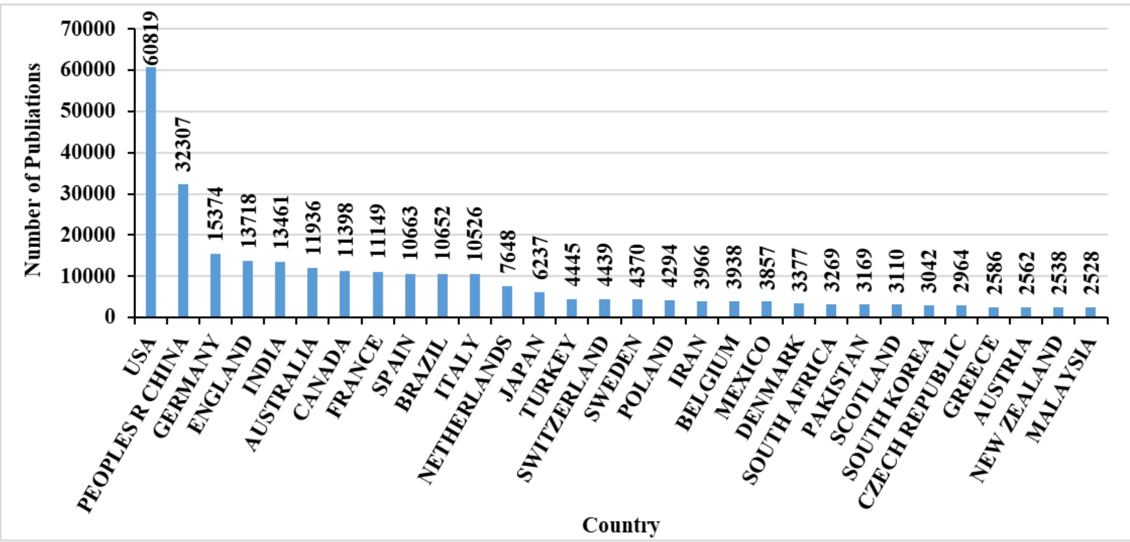


Figure 4.4.7.1.1: Total number of publications related to "National Mission for Sustainable Agriculture" of top 30 countries.

A total of 2,48,369 global and 13461 Indian publications were retrieved from the Web of Science database using the final search string of "National Mission for Sustainable Agriculture". Figure 4.4.7.1.1shows the publication contributions related to the "National Mission for Sustainable Agriculture"by the top 30 countries. The USA is the leading country and contributed 60819 publications. India has contributed 13461 publications and secured 5th rank globally based on the number of publications.

4.4.7.1.2. Year-wise Growth of global and Indian publications related to "National Mission for Sustainable Agriculture"

Figure 4.4.7.1.2 shows the year-wise growth of the number of total global and Indian publications related to the "National Mission for Sustainable Agriculture". The CAGR of Indian publications is slightly lower than the total global publications during 1987-2019. The CAGR of Indian publications was lower than the total global publications before 2008 i.e. the year of the introduction of the "National Mission for Sustainable Agriculture". It is very interesting to see that the CAGR of Indian publications from 2009 to 2019 is fairly higher than the global total publications (Table 4.4.7.1.1). Therefore, it may infer that the "National Mission for Sustainable Agriculture"of India instigates R&D activities on various objectives of solar mission thereby the growth of publications accelerated.

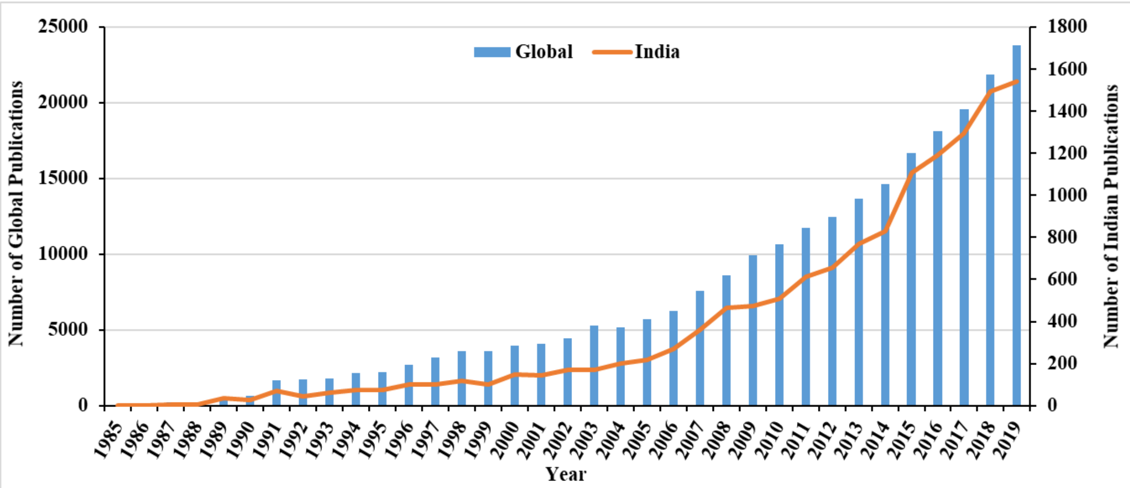


Figure 4.4.7.1.2: Year-wise global and Indian number of publications related to the "National mission for Sustainable Agriculture"

Table 4.4.7.1.1: Global and Indian total publications, Global and Indian compound annual growth rate of publications related to the "National mission for Sustainable Agriculture"during 1987-2019, 1987-2008 and 2008-2019

	Number of publications	CAGR of all years	CAGR before the setting of the mission	CAGR after the setting of the mission
Global Publication	224931	15.79%	19.11%	9.7%
Indian Publication	11918	18.93%	23.04%	11.47%

4.4.7.1.3. Total Global and Indian comparative contribution in top 30 research areas:

Total global research on the Indian "National Mission for Sustainable Agriculture" related topic has been performed in 244 research areas. The top 30 research areas of total global research on the Indian "National Mission for Sustainable Agriculture"related topic have contributed 74.61% cumulatively (normalised). India has contributed to 193 research areas during total periods. The top 30 research areas of total Indian research on climate change have contributed 72.61% cumulatively (normalised).

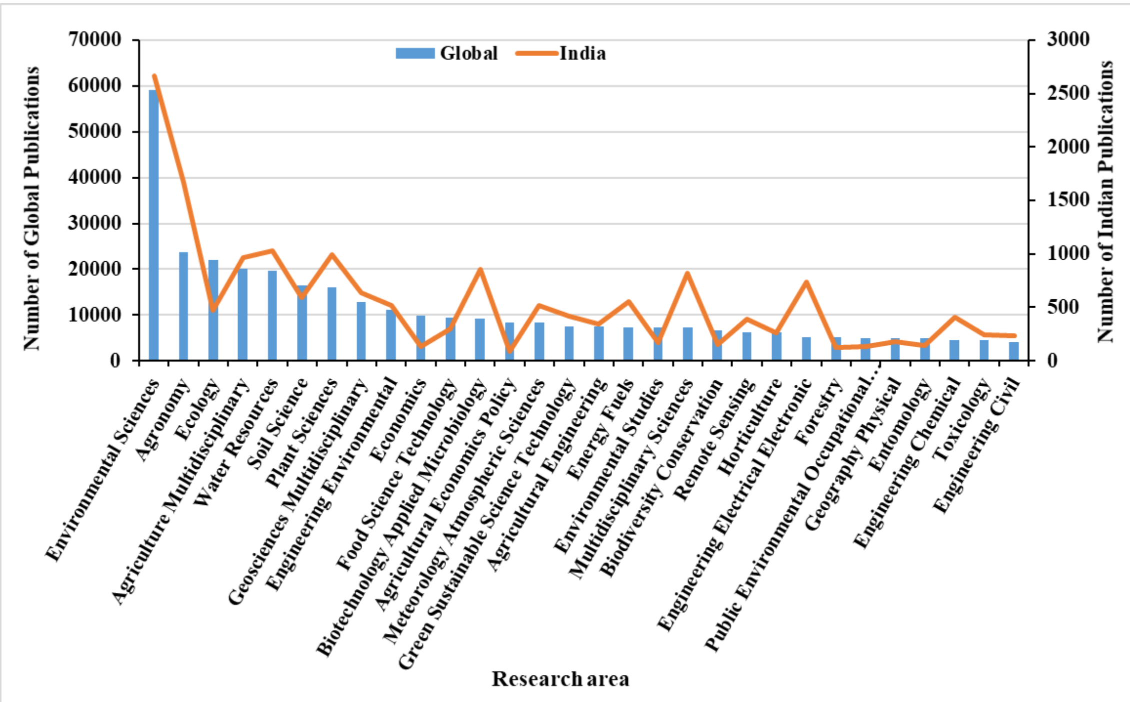


Figure 4.4.7.1.3: Global and Indian publication contribution related to "National Mission for Sustainable Agriculture" in top 30 research areas.

India has contributed at a higher proportion than the global in some research areas namely: Agronomy, Water Resources, Plant Sciences, Biotechnology Applied Microbiology, Meteorology Atmospheric Sciences, Green Sustainable Science Technology, Energy Fuels, Multidisciplinary Sciences, Remote Sensing, Engineering Electrical Electronic, Engineering Chemical, Toxicology, Engineering Civil which are mainly deal with the Sustainable Agriculture development-related research. India has contributed at a lower proportion than the global in some research areas namely: Environmental Sciences, Ecology, Agriculture Multidisciplinary, Soil Science, Geosciences Multidisciplinary, Engineering Environmental, Economics, Food Science Technology, Agricultural Economics Policy, Agricultural Engineering, Environmental Studies, Biodiversity Conservation, Horticulture, Forestry, Public Environmental Occupational Health, Geography Physical, Entomology (Figure 4.4.7.1.3).

4.4.7.1.4: Indian publication contribution in top 30 research areas before and after the adoption of the mission

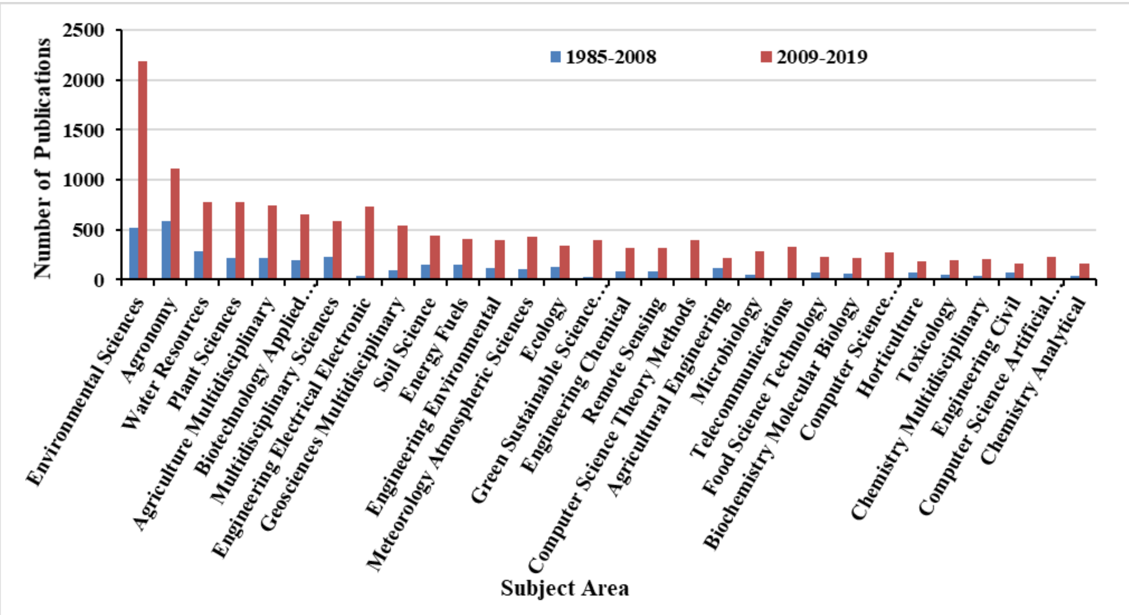


Figure 4.4.7.1.4: Indian publication contribution related to "National Mission for Sustainable Agriculture" in top 30 research areas before and after the adoption of the mission.

Figure 4.4.7.1.4 shows the comparative contribution of the top 30 research areas of Indian publications before and after the introduction of the mission. Following research areas namely, Environmental Sciences, Agronomy, Water Resources, Plant Sciences, Agriculture Multidisciplinary, Multidisciplinary Sciences were the most important research areas before the introduction of the "National Mission for

Sustainable Agriculture" by contributing more than 200 publications. After the introduction of the mission, the following research areas Environmental Sciences, Agronomy, Water Resources, Plant Sciences, Agriculture Multidisciplinary, Multidisciplinary Sciences, Biotechnology Applied Microbiology, Multidisciplinary Sciences, Engineering Electrical Electronic, Geosciences Multidisciplinary were the most important and contributed more than 500 publications.

4.4.7.1.5: The quantitative evolution and exchange of keywords of Indian publication related to "National Mission for Sustainable Agriculture"

The quantitative evolution and exchange of keywords from the before mission to the after mission are represented in Figure for total Indian publications on National Mission for Sustainable Agriculture. Each circle contains the number of keywords during that period which is indicated below the circle. The arrow containing the number of keywords coming towards the circle indicates newly arisen keywords. On the other hand, the arrow going outside indicates the number of keywords that are not used at successive periods. The arrow pointing from the previous to successive period represents the number of keywords exchanged (integer value) and the fraction of overlap (i.e., Similarity Index) in parentheses.

The higher value of the similarity index indicates the core themes of Indian publications on the "National Mission for Sustainable Agriculture" research remain more or less continuous, whereas, the quantity of newly evolved keywords indicates the advancement of the core theme in different subthemes. The number of keywords did increase from 1203 before the mission to 2069 after the introduction of the mission with a growth rate of 71.99%. Indian publications on the "National Mission for Sustainable Agriculture" publications research after setting of the mission incorporated more than 50% keyword from research perform during before mission.

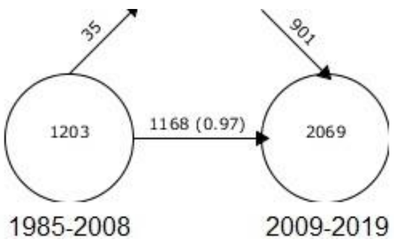


Figure 4.4.7.1.5: Overlapping map of keyword's quantitative perspective during successive periods of Indian Publications on "National Mission for Sustainable Agriculture".

4.4.7.1.6: Quantitative and qualitative development of themes at successive periods of Indian publication related to "National Mission for Sustainable Agriculture"

Thematic evolution was represented through strategic diagrams at successive periods. Themes were plotted as circles denoting different theme clusters according to centrality and density in strategic diagrams. The size of the circle is proportional to the number of documents and referred to as document frequency (DF) in which it's linked or related keywords are present. The strategic diagrams are divided into four quadrants and they can be interpreted as follows: the top-right quadrant represents "motor themes", the top-left quadrant represents "highly developed and isolated themes", the bottom-left quadrant represents "emerging or declining themes", the bottom-right quadrant represents "basic and transversal themes".

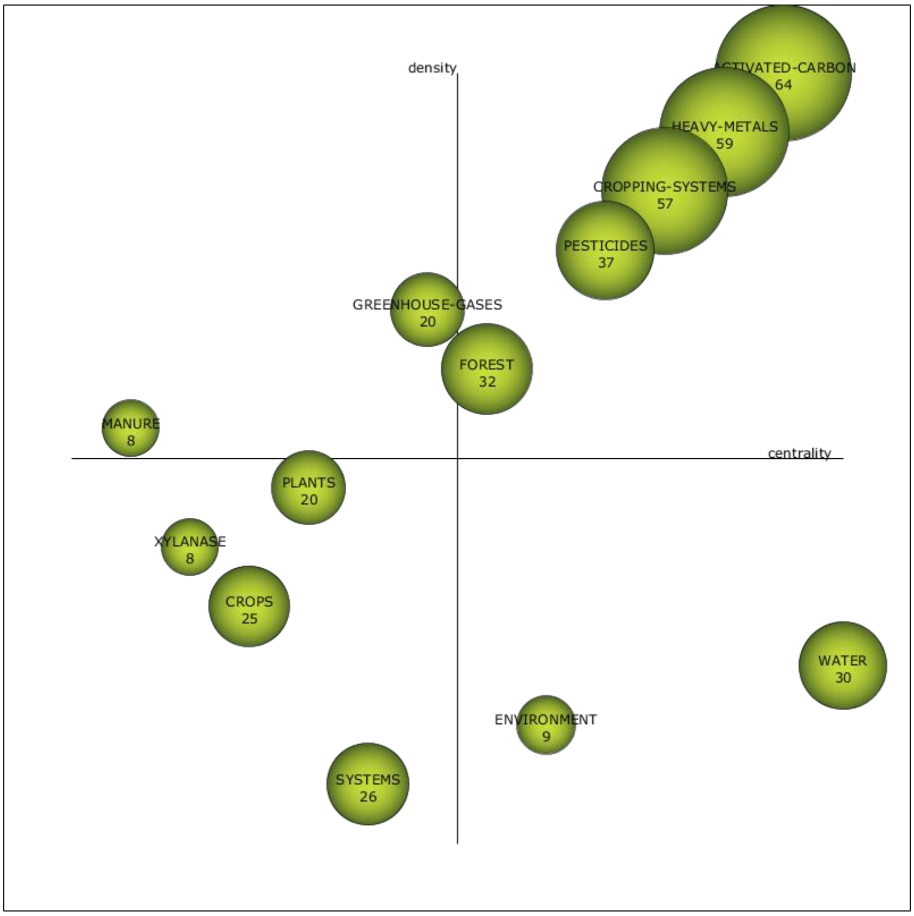


Figure 4.4.7.1.6: Strategic diagram of themes during 1985-2008 "National Mission for Sustainable Agriculture".

During 1985-2008 a total of only 1203 keywords during the before mission were observed among the total 2957 publications. The initial period has registered thirteen themes with DF. During this period

"ACTIVATED-CARBON" was found to be the most active theme having a DF of 64 followed by "HEAVY-METALS" with a DF of 59, "CROPPING-SYSTEMS" with a DF of 57 and "PESTICIDES" with a DF of 37 (Figure, Table). The theme "ACTIVATED-CARBON" received maximum document citations (15,372) followed by "HEAVY-METALS" (6,557), "WATER" (4,799), "GREENHOUSE-GASES" (3,037). The theme "ACTIVATED-CARBON" was positioned in the top-right quadrant with the highest centrality value (35.14) indicating itself as the most important and well-connected theme with other keywords vis-à-vis themes followed by "HEAVY-METALS" (29.72). The theme "FOREST" and "GREENHOUSE-GASES" was positioned in the top-left quadrant with no centrality, thereby assigning it as an isolated theme. The themes "SYSTEMS", "CROPS" and "PLANTS" were found to come under emerging focus, as they were positioned in the bottom-left quadrant. The theme "WATER" and "ENVIRONMENT" appeared in the bottom-right quadrant as basic and transversal themes.

Table 4.4.7.1.2: Quantitative and qualitative performance measures of themes during 1985-2008 of Indian publications related to "National Mission for Sustainable Agriculture"

Name	Centrality	Density	Core Documents Count	Core Documents Sum Citations	Secondary Documents Count	Secondary Documents Sum Citations
Activated-Carbon	35.14	17.38	64	15,372	71	11,130
Heavy-Metals	29.72	8.72	59	6,557	225	15,911
Cropping-Systems	18.24	7.56	57	1,285	224	8,719
Forest	10.55	4.84	32	1,192	135	6,675
Water	38.71	2.08	30	4,799	135	8,637
Crops	6.69	2.16	25	557	162	5,349
Systems	9.31	1.24	26	925	145	10,582
Pesticides	18.11	6.28	37	1,060	131	5,537
Plants	8.04	4.5	20	617	146	6,460
Greenhouse-Gases	9.56	5.36	20	3,037	79	6,062
Xylanase	4.55	4.03	8	384	66	3,152
Manure	1.79	4.51	8	384	56	1,137
Environment	12.5	1.43	9	310	93	4,843

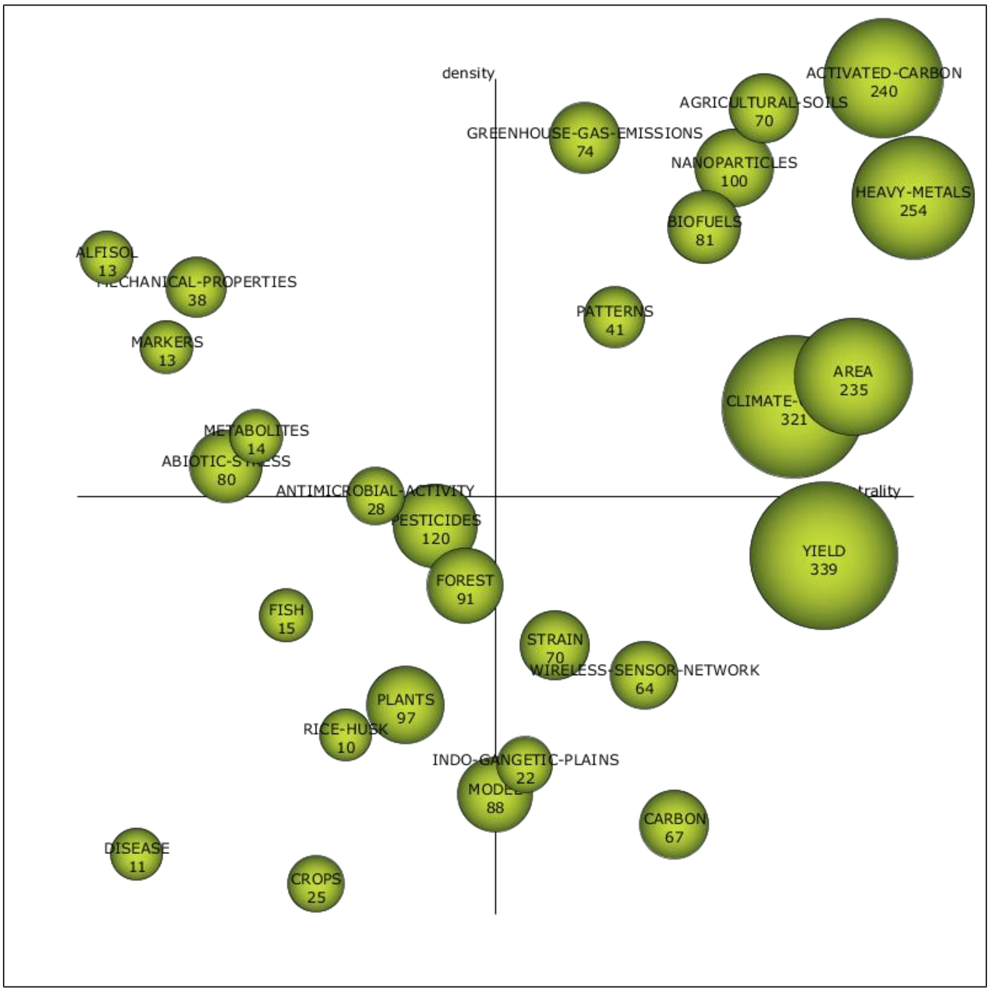


Figure 4.4.7.1.7: Strategic diagram of themes during 2009-2019 of Indian publications related to "National Mission for Sustainable Agriculture"

During 2009-2019 total keywords have increased to 2069 during the after mission with a growth rate of 71.99% among the total 10639 publications (increased by 50%). The number of themes did also increase to 28 after the mission with comparatively more DF. During this period "CLIMATE-CHANGE" was found to be the most active theme having a DF of 321 followed by "HEAVY-METALS" with a DF of 254, "ACTIVATED-CARBON" with a DF of 240 and "AREA" with a DF of 235 (Figure 4.4.7.1.7, Table 4.4.7.1.3). The theme "ACTIVATED-CARBON" received maximum document citations (13,856) followed by "HEAVY-METALS" (8,117), "CLIMATE-CHANGE" (6,125), "YIELD" (5,236) and "NANOPARTICLES" (4,449). The theme "HEAVY-METALS" was positioned in the top-right quadrant with the highest centrality value (23.21) indicating itself as the most important and well-connected theme with other keywords vis-à-vis themes followed by "ACTIVATED-CARBON" (18.95). The theme

"ABIOTIC-STRESS" and "MECHANICAL-PROPERTIES" was positioned in the top-left quadrant with no centrality, thereby assigning it as an isolated theme. The themes "PESTICIDES", "PLANTS" and "FOREST" were found to come under emerging focus, as they were positioned in the bottom-left quadrant. The theme "YIELD" appeared in the bottom-right quadrant as basic and transversal themes with the highest DF of 339.

Table 4.4.7.1.3: Quantitative and qualitative performance measures of themes during 2009-2019 of Indian publications related to "National Mission for Sustainable Agriculture"

Name	Centrality	Density	Core Documents Count	Core Documents Sum Citations	Secondary Documents Count	Secondary Documents Sum Citations
Activated-Carbon	18.95	17.23	240	13,856	256	12,254
Heavy-Metals	23.21	5.37	254	8,117	931	20,337
Greenhouse-Gas-Emissions	6.75	9.54	74	2,034	243	5,845
Climate-Change	10.79	3.22	321	6,125	988	22,466
Nanoparticles	8.76	5.67	100	4,449	236	7,757
Agricultural-Soils	10.69	15.9	70	2,107	195	5,741
Area	12.43	3.35	235	4,187	950	18,429
Abiotic-Stress	2.34	2.91	80	3,312	342	11,251
Pesticides	5.1	2.06	120	2,847	444	8,041
Forest	5.83	1.96	91	1,569	461	8,153
Yield	12.07	2.04	339	5,236	1,117	17,084
Plants	5.07	1.04	97	1,636	537	13,068
Strain	6.5	1.25	70	1,166	369	7,275
Model	5.88	0.83	88	1,588	537	9,551
Biofuels	8.28	5.25	81	2,573	336	8,423
Carbon	8.15	0.81	67	971	449	9,513
Wireless-Sensor-Network	7.49	1.22	64	718	477	5,760
Patterns	7.08	3.7	41	673	448	7,956
Mechanical-Properties	2.03	4.22	38	730	165	3,267
Antimicrobial-Activity	4.06	2.45	28	1,571	249	5,256
Indo-Gangetic-	6.22	0.84	22	599	190	4,418

Plains						
Crops	3.38	0.29	25	1,036	367	6,842
Metabolites	2.46	3.06	14	339	109	3,582
Fish	2.63	1.65	15	192	144	3,591
Alfisol	0.53	5.13	13	67	53	546
Markers	2	3.62	13	116	79	1,011
Disease	1.58	0.39	11	129	173	3,214
Rice-Husk	3.83	0.85	10	294	157	5,385

4.4.7.2. Analysis of Scopus publication data related to the "National Mission for Sustainable Agriculture"

4.4.7.2.1. Number of publications by top 30 countries related to the "National Mission for Sustainable Agriculture"

A total of 5,06,446publications were retrieved from the Scopus database using the final search string. Figure 4.4.7.2.1shows the publication contributions by the top 30 countries. The USA is the leading country and contributed 112543 publications. India has contributed 36033 publications and secured 3rd rank globally in the publications related to the "National Mission for Sustainable Agriculture".

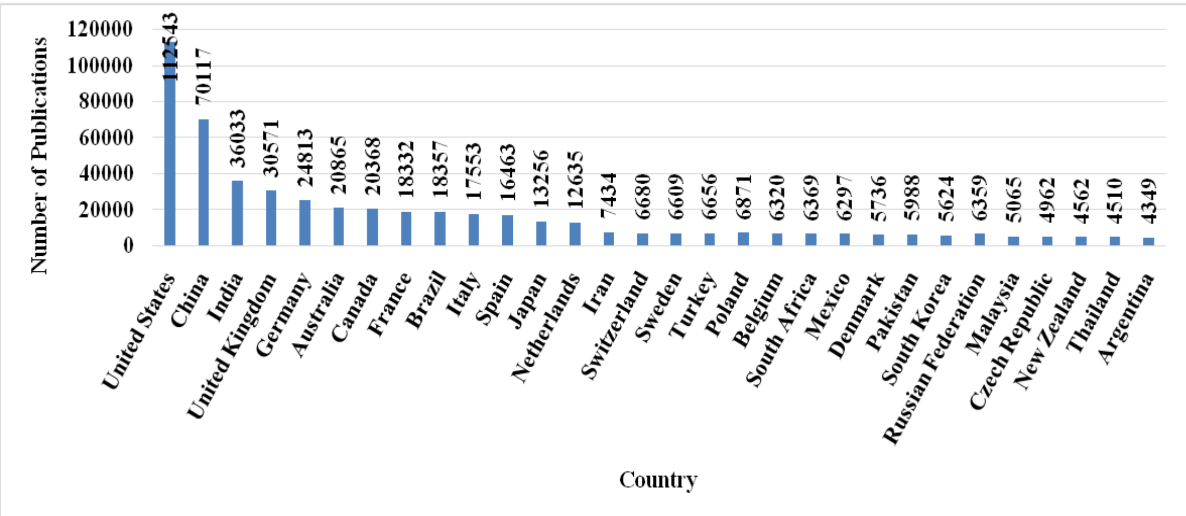


Figure 4.4.7.2.1: Total number of publications related to "National mission for Sustainable Agriculture".

4.4.7.2.2. Year-wise Growth of global and Indian publications related to the "National mission for Sustainable Agriculture"

Figure 4.4.7.2.2 shows the year-wise growth of the number of total global and Indian publications related to the "National Mission for Sustainable Agriculture". The compound annual growth rate (12.26%) of Indian publications is higher than the total global publications during 1987-2019 (Table 4.4.7.2.1). The CAGR (11.5%) of Indian publications was higher than the total global publications up to 2008 i.e. the year of the setting of the "National Mission for Sustainable Agriculture". It is very interesting to see that the CAGR (13.87%) of Indian publications is also higher than the global total publications after the introduction of the mission. Therefore, it may conclude that the "National Solar Mission" of India instigates the R&D activities on various objectives of "National mission for Sustainable Agriculture" thereby the growth of publications accelerated

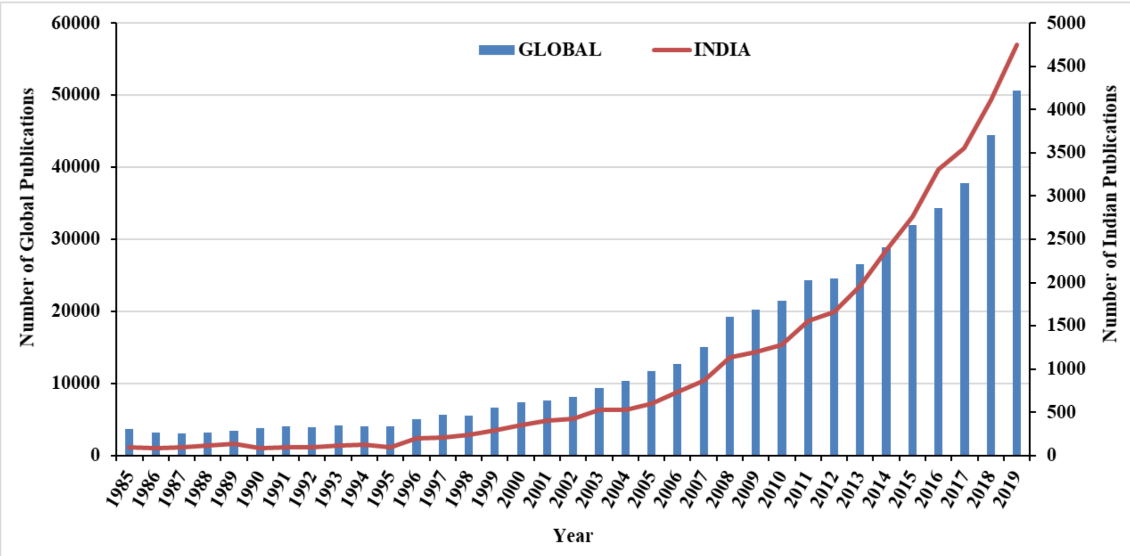


Figure 4.4.7.2.2: Year-wise global and Indian number of publications related to "National mission for Sustainable Agriculture"

Table 4.4.7.2.1: Global and Indian total publications related to "National mission for Sustainable Agriculture"Global and Indian compound annual growth rate of publications during 1987-2019, 1987-2008 and 2008-2019

	Number of publications	CAGR of all years	CAGR before setting of the mission	CAGR after setting of the mission
Global Publication	509884	8.05%	7.5%	9.2%
Indian Publication	36169	12.26%	11.5%	13.87%

4.4.7.2.3. Total Global and Indian comparative contribution in different subject areas:

Total global researches related to the Indian "National Mission for Sustainable Agriculture" have been performed in 28 subject areas. The top 10 subject areas of total global researches related to the mission have contributed 81.60% cumulatively (normalised). India has contributed in 28 subject areas during total periods. The top 10 subject areas of total Indian research on climate change have also contributed 77.88% cumulatively (normalised). India has contributed at a higher proportion than the global in some research areas namely: Agricultural and Biological Sciences, Engineering, Biochemistry, Genetics and Molecular Biology, Computer Science, Energy, Chemical Engineering, Immunology and Microbiology, Business, Management and Accounting, Materials Science, Multidisciplinary, Physics and Astronomy, Pharmacology, Toxicology and Pharmaceutics, Veterinary, Mathematics, Health Professions,etc. India has contributed at a lower proportion than the global in some research areas namely: Environmental Science, Social Sciences, Earth and Planetary Sciences, Medicine, Economics, Econometrics and Finance, Chemistry, Arts and Humanities, Decision Sciences, etc. (Figure 4.4.7.2.3).

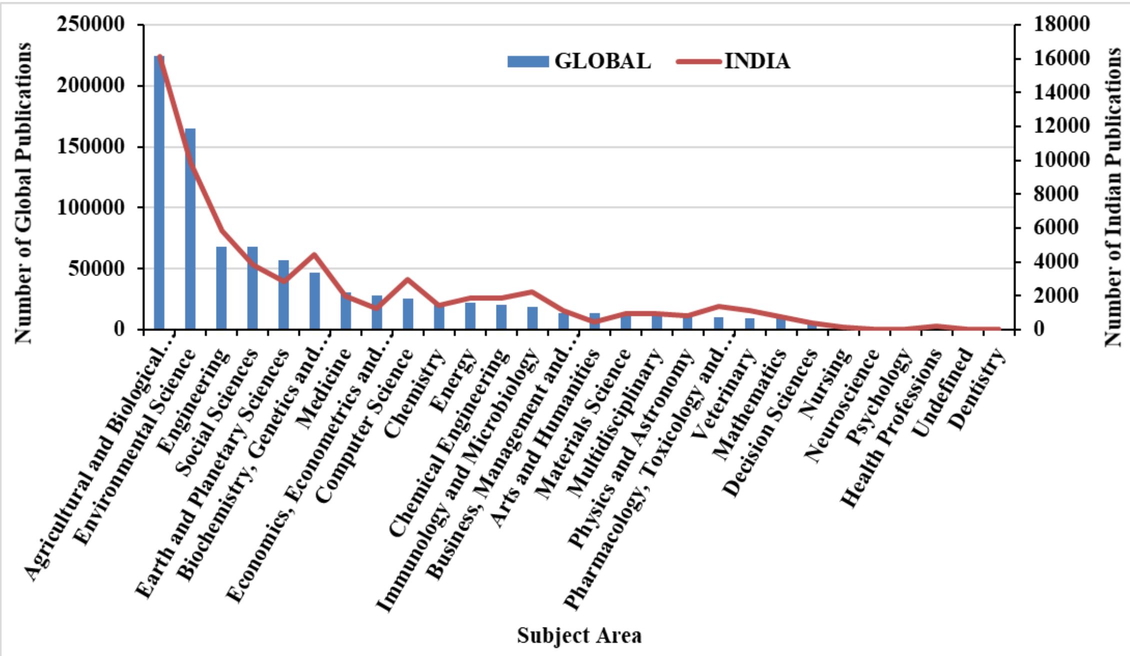


Figure 4.4.7.2.3: Global and Indian publication contribution related to "National mission for Sustainable Agriculture"in different subject areas.

4.4.7.2.4: Indian publication contribution related to the "National Mission for Sustainable Agriculture" in different research areas before and after the introduction of the mission

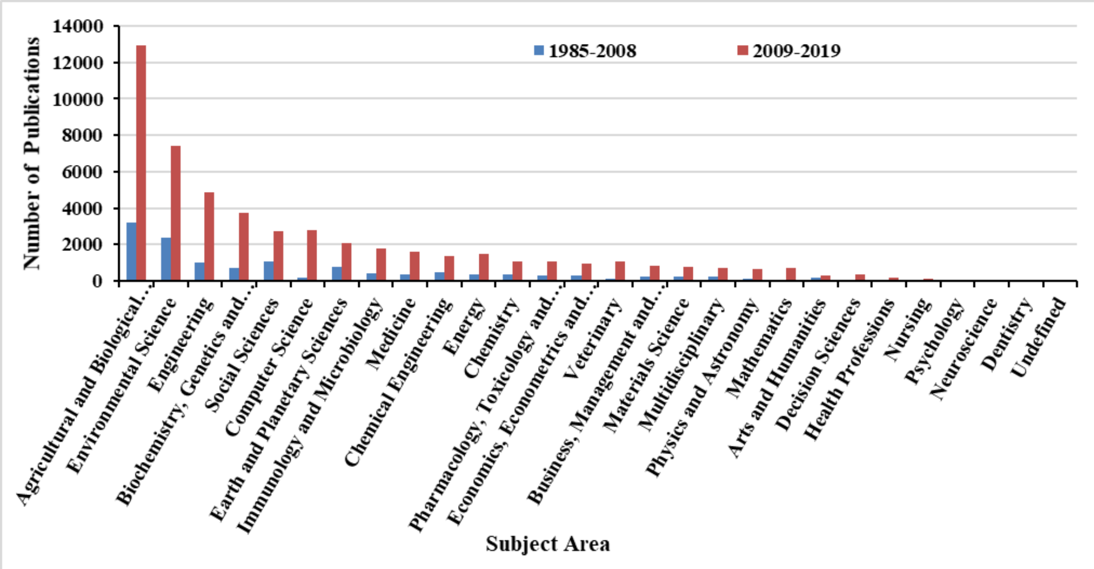


Figure 4.4.7.2.4: Indian publication contribution related to the "National Mission for Sustainable Agriculture"in different subject areas before and after the adoption of the mission.

Figure 4.4.1.2.4 shows the comparative contribution of different subject areas of Indian publications before and after the introduction of the mission. Following research areas namely: Agricultural and Biological Sciences, Environmental Science, Engineering, Biochemistry, Genetics and Molecular Biology, Social Sciences were the most important research areas before the introduction of the "National Mission for Sustainable Agriculture" by contributing more than 1000 publications. After the introduction of the mission, the following research areas Agricultural and Biological Sciences, Environmental Science, Engineering, Biochemistry, Genetics and Molecular Biology, Social Sciences, Biochemistry, Genetics and Molecular Biology, Computer Science, Earth and Planetary Sciences, Immunology and Microbiology, Medicine were the most important and contributed more than 1500 publications.

4.4.7.3. Analysis of Indian Citation Index data related to "National Mission for Sustainable Agriculture"

4.4.7.3.1. Year-wise Growth of global and Indian publications related to "National Mission for Sustainable Agriculture"

Figure 4.4.1.3.1 shows the year-wise growth of the number of global and Indian publications related to "National Mission for Sustainable Agriculture". The compound annual growth rate of Indian publications is lower than the total global publications during 2005-2019. The CAGR of Indian publications was quite lower than the total global publications before 2008 i.e. the year of the introduction of the "National

Mission for Sustainable Agriculture". While the CAGR of Indian publications from 2009 to 2019 is also lower than the global total publications (Table 4.4.7.3.1). Therefore, it may infer that the "National Mission for Sustainable Agriculture"of India does not instigate R&D activities on various objectives of "National Mission for Sustainable Agriculture" thereby the growth of publications decreased.

Table 4.4.7.3.1: Global and Indian total publications, Global and Indian compound annual growth rate of publications related to the "National Mission for Sustainable Agriculture"during 2005-2019, 2004-2008 and 2008-2019

	Number of publications	CAGR of all years	CAGR before setting of the mission	CAGR after setting of the mission
Global Publication	29652	5.98	8.05	5.98
Indian Publication	24863	4.95	8.01	4.55

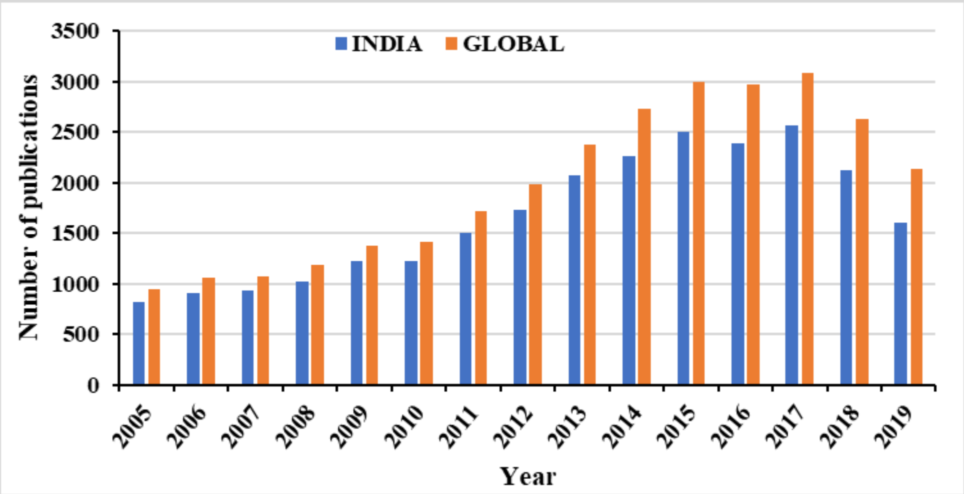


Figure 4.4.7.3.1: Year-wise global and Indian number of publications related to "National mission for Sustainable Agriculture"

4.4.7.3.2. Total Global and Indian comparative contribution in different subject areas:

Total global research on the Indian "National Mission for Sustainable Agriculture" related topic has been performed in 575 research areas. The top 30 research areas of total global research on the Indian "National Mission for Sustainable Agriculture"related topic have contributed 71.33% cumulatively (normalised). India has contributed to 545 research areas during total periods. The top 30 research areas of total Indian research on climate change have contributed 71.84% cumulatively (normalised).

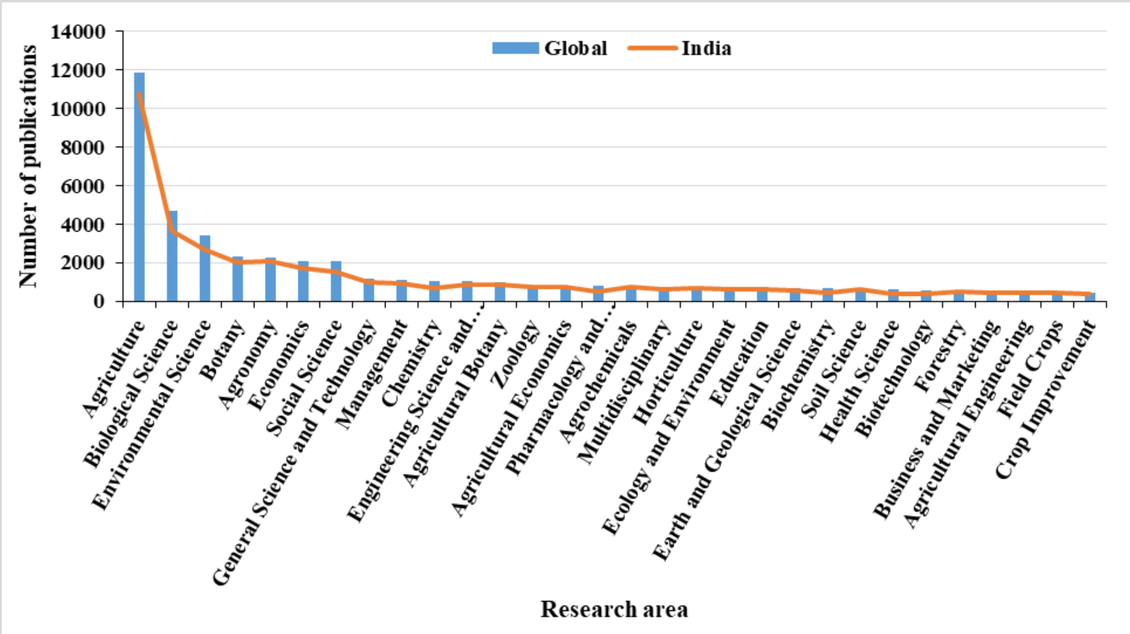


Figure 4.4.7.3.2: Global and Indian publication contribution related to "National Mission for Sustainable Agriculture"in top 30 research areas.

India has contributed at a higher proportion than the global in some research areas namely: Agriculture, General Science And Technology, Management, Botany, Agronomy, Agricultural Botany, Agricultural Economics, Agrochemicals, Horticulture, Education, Soil Science, Forestry, Agricultural Engineering, Field Crops, Crop Improvement,Zoology, Earth And Geological Science. India has contributed at a lower proportion than the global in some research areas namely: Biological Science, Environmental Science, Economics, Chemistry, Engineering Science and Technology, Pharmacology and Pharmaceutical Science, Ecology and Environment, Biochemistry, Biotechnology, (Figure 4.4.7.3.2).

4.4.7.3.3: Indian publication contribution in top 30 research areas before and after the adoption of the mission

Figure 4.4.7.3.3 shows the comparative contribution of the top 30 research areas of Indian publications before and after the introduction of the mission. Following research areas namely: Agriculture, Biological Science, Environmental Science, Agronomy, Botany, Agrochemicalswere the most important research areas before the introduction of the "National Mission for Sustainable Agriculture" by contributing more than 200 publications. After the introduction of the mission, the following research areas Agriculture, Biological Science, Environmental Science, Agronomy, Botany, Economics, Social Science, General

Science And Technology, Management, Agricultural Botany, Zoology, Agricultural Economics were the most important and contributed more than 600 publications.

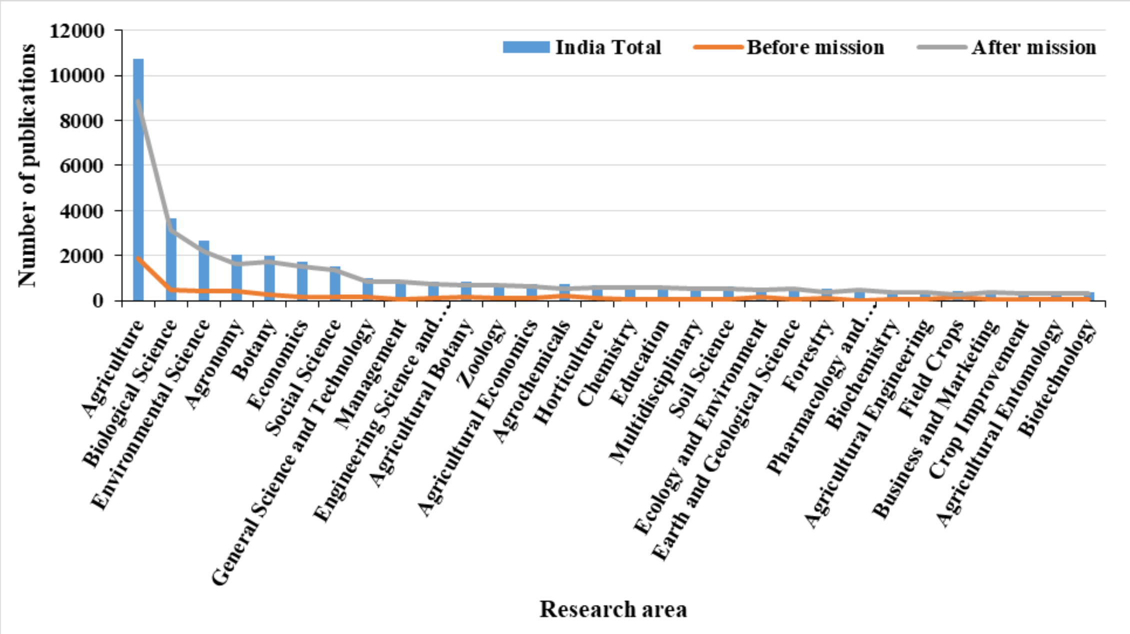


Figure 4.4.7.3.3: Indian publication contribution related to "National Mission for Sustainable Agriculture"in top 30 research areas before and after the adoption of the mission.

4.4.8. National Mission for Strategic Knowledge for Climate Change

The final search string to retrieved publication data from “Web of Science” and “Scopus” for “National Mission for Strategic Knowledge for Climate Change” was as follows:

TS=(“Climat* Chang*” AND ("monsoon dynamic*" OR "aerosol science" OR "ecosystem response*" OR projection* OR projected OR "hydrological cycle*" OR "observation network"OR (data AND (gather* OR assimialation* OR access* OR availab* OR resource*)) OR "research infrastruc*" OR compution* OR (model* AND (IPCC OR "Intergovernmental Panel on Climate Change" OR India* OR global OR "air ocean general circulation" OR AOGCM OR regional OR RCM OR "general circulation" OR GCM OR "regional model inter-comparion project" OR RMIP)) OR (database AND (Oceans OR "Sea surface temperature Salinity" OR "Sea level rise*" OR Cryosphere OR "Snow cover" OR "Glacial data" OR Meteorology OR Precipitation OR Humidity OR "Surface temperature" OR "Air temperature" OR "Evaporation data" OR "Land Surface" OR Topography OR Erosion OR Imagery OR "vegetation map" OR "Forest cover" OR Hydrological OR "Ground water" OR "water quality" OR "River water" OR "water utilization" OR Agriculture OR "Soil profile" OR cultivation OR Production OR yield OR Socio-Economic OR Demography OR "Economic status" OR Forest* OR "natural resource*" OR Plant* OR animal* OR species OR "Health Data")) OR "skil* develop*" OR training OR "human resource*" OR awareness))

4.4.8.1. Analysis of Web of Science publication data related to the “National Mission for Strategic Knowledge for Climate Change”

4.4.8.1.1. Number of publications related to the “National Mission for Strategic Knowledge for Climate Change” by top 30 countries

A total of 75456 global and 2442 Indian publications were retrieved from the Web of Science database using the final search string of “National Mission for Strategic Knowledge for Climate Change”. Figure 4.4.8.1.1 shows the publication contributions related to “National Mission for Strategic Knowledge for Climate Change” by the top 30 countries. The USA is the leading country and contributed 26513 publications. India has contributed 2442 publications and secured 13th rank globally based on the number of publications.

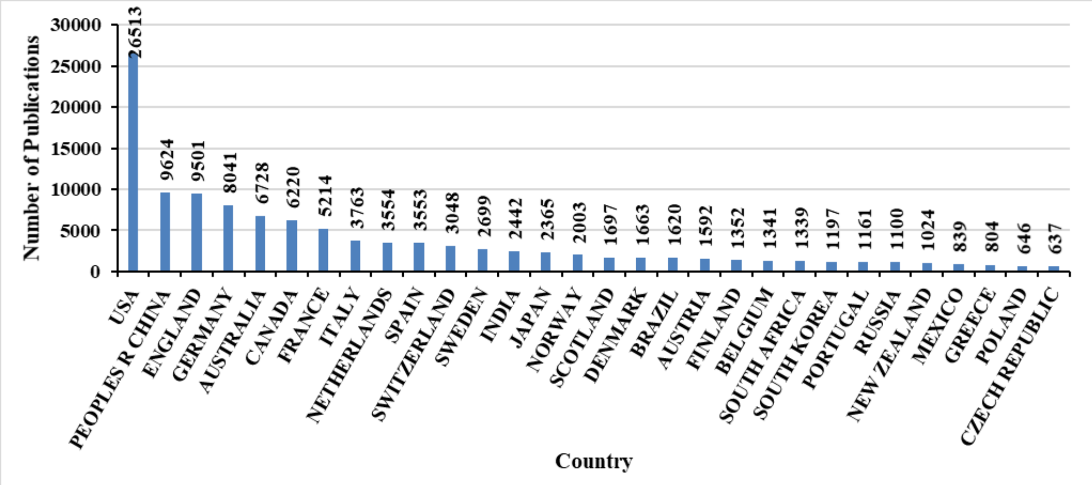


Figure 4.4.8.1.1: Total number of publications related to "National Mission for Strategic Knowledge for Climate Change" of top 30 countries.

4.4.8.1.2. Year-wise Growth of global and Indian publications related to "National Mission for Strategic Knowledge for Climate Change"

Figure 4.4.8.1.2 shows the year-wise growth of the number of total global and Indian publications related to "National Solar Mission". The compound annual growth rate of Indian publications is lower than the total global publications during 1987-2019. The CAGR of Indian publications was quite higher than the total global publications before 2008 i.e. the year of the introduction of the "National Solar Mission". The CAGR of Indian publications from 2009 to 2019 is also lower than the global total publications (Table 4.4.8.1.1).

Table 4.4.8.1.1: Global and Indian total publications, Global and Indian compound annual growth rate of publications related to the "National Mission for Strategic Knowledge for Climate Change" during 1987-2019, 1987-2008 and 2008-2019.

	Number of publications	CAGR of all years	CAGR before setting of the mission	CAGR after setting of the mission
Global Publication	75456	32.04%	14.64%	26.71%
Indian Publication	2442	23.46%	25.1%	25.1%

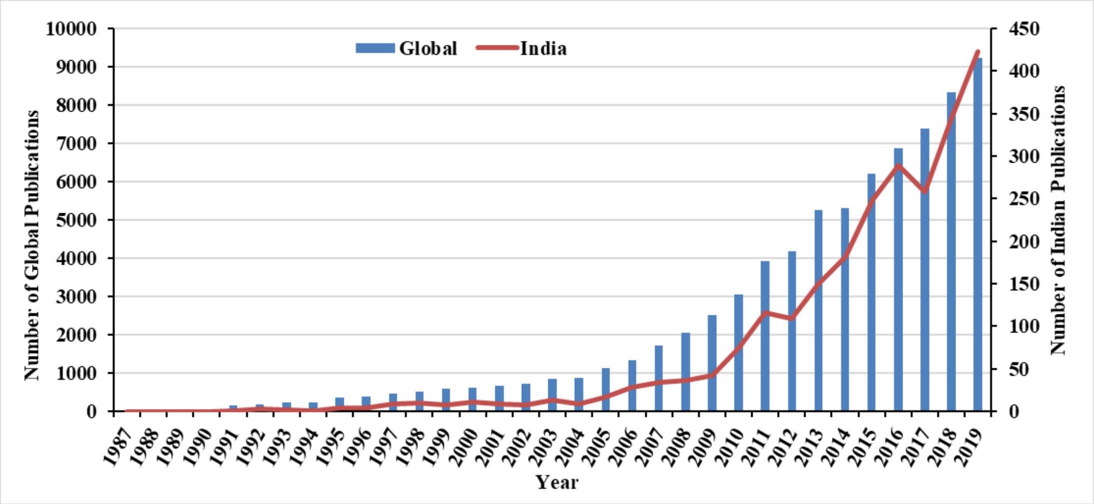


Figure 4.4.8.1.2: Year-wise global and Indian number of publications related to the "National Mission for Strategic Knowledge for Climate Change".

4.4.8.1.3. Total Global and Indian comparative contribution in top 30 research areas:

Total global research on the Indian "National Mission for Strategic Knowledge for Climate Change" related topic has been performed in 212 research areas. The top 30 research areas of total global research on the Indian "National Mission for Strategic Knowledge for Climate Change"related topic have contributed 86.33% cumulatively (normalised). India has contributed to 124 research areas during total periods. The top 30 research areas of total Indian research on climate change have contributed 85.62% cumulatively (normalised). India has contributed at a higher proportion than the global in some research areas namely: Meteorology Atmospheric Sciences, Geosciences Multidisciplinary, Water Resources, Multidisciplinary Sciences, Energy Fuels, Engineering Civil, Remote Sensing, Agronomy, Agriculture Multidisciplinary, Engineering Electrical Electronics. India has contributed at a lower proportion than the global in some research areas namely: Environmental Sciences, Ecology, Geography Physical, Environmental Studies, Biodiversity Conservation, Green Sustainable Science Technology, Forestry, Engineering Environmental, Oceanography, Marine Freshwater Biology, Plant Sciences, Economics, Evolutionary Biology, Public Environmental Occupational Health, Soil Science, Computer Science Interdisciplinary Applications, Limnology, Geochemistry Geophysics, Biology, Imaging Science Photographic Technologywhich are mainly deal with the causal factor identification and impact assessment of the climate change (Figure 4.4.8.1.3).

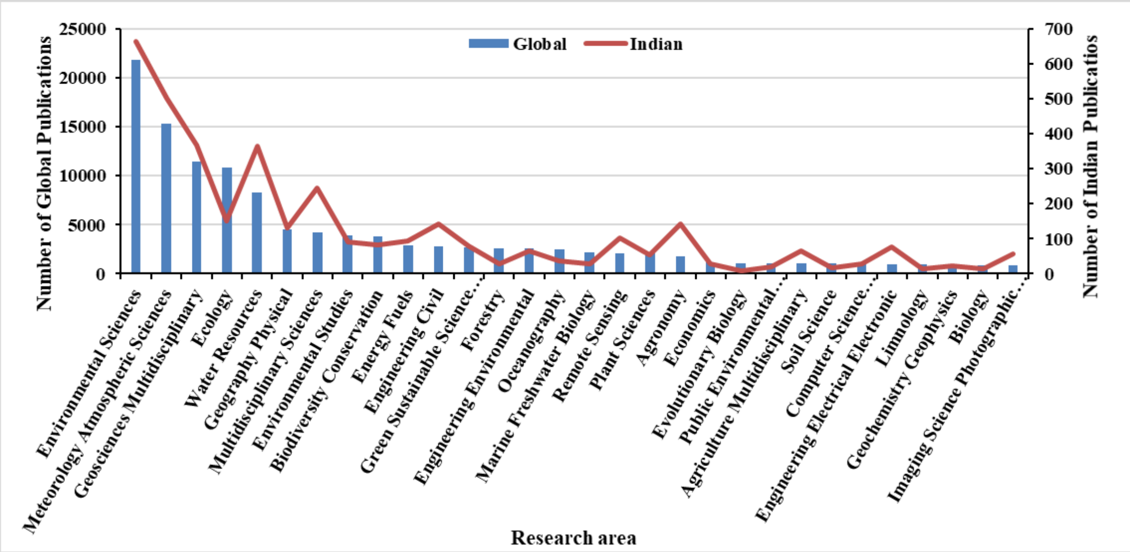


Figure 4.4.8.1.3: Global and Indian publication contribution related to "National Mission for Strategic Knowledge for Climate Change" in top 30 research areas

4.4.8.1.4: Indian publication contribution in top 30 research areas before and after the adoption of the mission

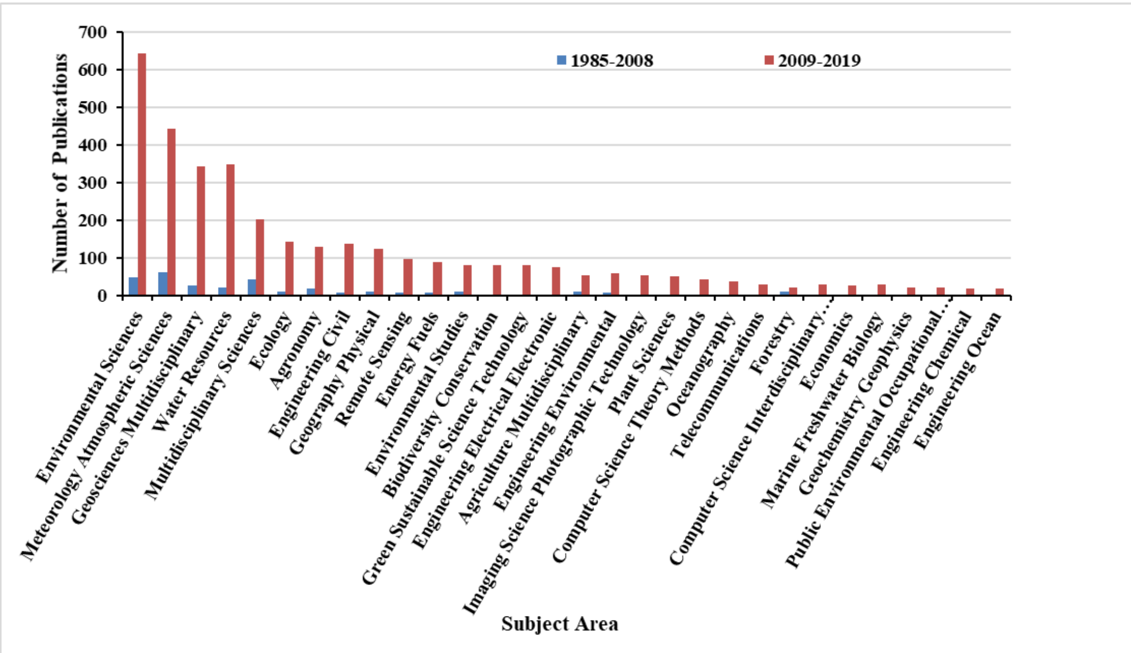


Figure 4.4.8.1.4: Indian publication contribution related to "National Mission for Strategic Knowledge for Climate Change" in top 30 research areas before and after the adoption of the mission.

Figure 4.4.8.1.4 shows the comparative contribution of the top 30 research areas of Indian publications before and after the introduction of the mission. Following research areas namely, Environmental Sciences, Meteorology Atmospheric Sciences, Geosciences Multidisciplinary, Water Resources, Multidisciplinary Sciences, Engineering Civil were the most important research areas before the introduction of the "National Mission for Strategic Knowledge for Climate Change" by contributing more than 15 publications. After the introduction of the mission, the following research areas Environmental Sciences, Meteorology Atmospheric Sciences, Geosciences Multidisciplinary, Water Resources, Multidisciplinary Sciences, Engineering Civil, Ecology, Agronomy, Engineering Civil, Geography Physical were the most important and contributed more than 100 publications.

4.4.8.1.5. The quantitative evolution and exchange of keywords "National Mission for Strategic Knowledge for Climate Change"

The quantitative evolution and exchange of keywords from the before mission to the after mission are represented in Figure for total Indian publications on National Mission on Strategic Knowledge for Climate Change. Each circle contains the number of keywords during that period which is indicated below the circle. The arrow containing the number of keywords coming towards the circle indicates newly arisen keywords. On the other hand, the arrow going outside indicates the number of keywords that are not used at successive periods. The arrow pointing from the previous to successive period represents the number of keywords exchanged (integer value) and the fraction of overlap (i.e., Similarity Index) in parentheses.

The higher value of the similarity index indicates the core themes of Indian publications on National Mission on Strategic Knowledge for Climate Change research remain more or less continuous, whereas, the quantity of newly evolved keywords indicates the advancement of the core theme in different subthemes. The number of keywords did increase from 160 before the mission to 500 after the introduction of the mission with a growth rate of 212.50%. Indian publications on National Mission on Strategic Knowledge for Climate Change publications research after setting of the mission incorporated maximum keyword from research perform during before mission.

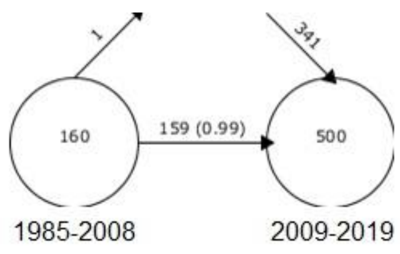


Figure 4.4.8.1.5: Overlapping map of keyword's quantitative perspective during successive periods of Indian Publications on National Mission on Strategic Knowledge for Climate Change

4.4.8.1.6. Quantitative and qualitative development of themes at successive periods of Indian publication related to "National Mission for Strategic Knowledge for Climate Change"

Thematic evolution was represented through strategic diagrams at successive periods. Themes were plotted as circles denoting different theme clusters according to centrality and density in strategic diagrams. The size of the circle is proportional to the number of documents and referred to as document frequency (DF) in which it's linked or related keywords are present. The strategic diagrams are divided into four quadrants and it can be interpreted as follows: the top-right quadrant represents "motor themes", the top-left quadrant represents "highly developed and isolated themes", the bottom-left quadrant represents "emerging or declining themes", the bottom-right quadrant represents "basic and transversal themes".

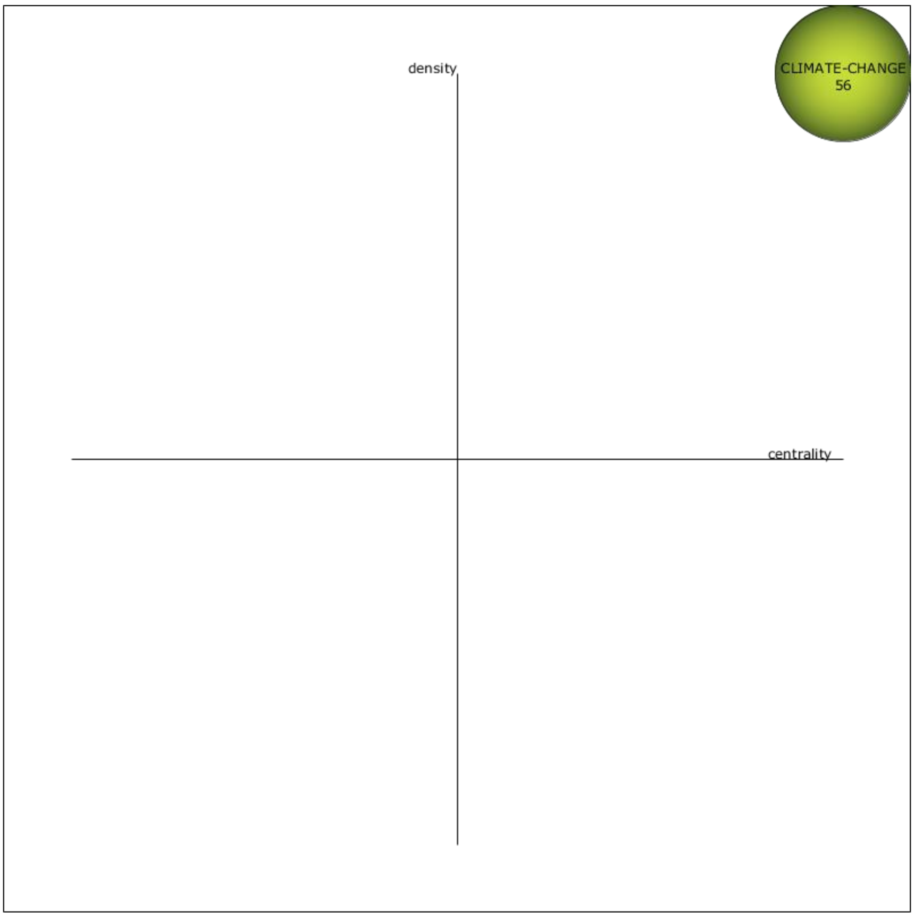


Figure 4.4.8.1.6: Strategic diagram of themes during 1985-2008 of Indian publications related to "National Mission for Strategic Knowledge for Climate Change"

During 1985-2008 a total of only 160 keywords during the before mission were observed among the total 206 publications. The initial period has registered only one theme with DF. During this period “CLIMATE-CHANGE” was found to be the most active theme having a DF of 56 with document citations (3968). The theme “CLIMATE-CHANGE” was positioned in the top-right quadrant with the highest centrality value (25.2) indicating itself as the most important and well-connected theme with other keywords vis-à-vis themes.

Table 4.4.8.1.2: Quantitative and qualitative performance measures of themes during 1985-2008 of Indian publications related to “National Mission for Strategic Knowledge for Climate Change”

Name	Centrality	Density	Core Documents Count	Core Documents sum Citations	Secondary Documents Count	Secondary Documents sum Citations
Climate-Change	25.2	14.36	56	3,968	78	5,540

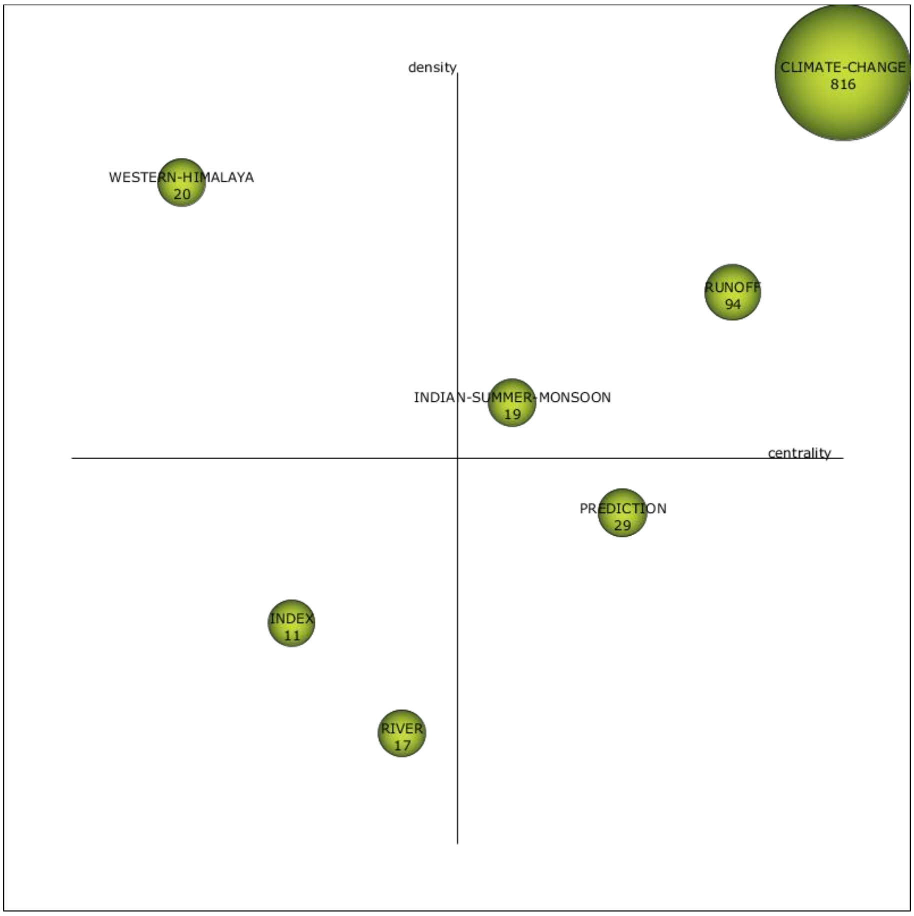


Figure 4.4.8.1.7: Strategic diagram of themes during 2009-2019 of Indian publications related to “National Mission for Strategic Knowledge for Climate Change”

During 2009-2019 total keywords have increased to 500 during the after mission with a growth rate of 212.50% among the total 2243 publications (increased by maximum). The number of themes did also increase to seven after the mission with comparatively more DF. During this period "CLIMATE-CHANGE" was found to be the most active theme having a DF of 816 followed by "RUNOFF" with a DF of 94 (Figure, Table). The theme "CLIMATE-CHANGE" received maximum document citations (19,923) followed by "RUNOFF" (1744). The theme "CLIMATE-CHANGE" was positioned in the top-right quadrant with the highest centrality value (43.46) indicating itself as the most important and well-connected theme with other keywords vis-à-vis themes followed by "RUNOFF" (16.11). The theme "WESTERN-HIMALAYA" was positioned in the top-left quadrant with no centrality, thereby assigning it as an isolated theme. The themes "RIVER" and "INDEX" were found to come under emerging focus, as they were positioned in the bottom-left quadrant. The theme "PREDICTION" appeared in the bottom-right quadrant as basic and transversal themes.

Table 4.4.8.1.3 Quantitative and qualitative performance measures of themes during 2009-2019 of Indian publications related to"National Mission for Strategic Knowledge for Climate Change"

Name	**Centrality**	**Density**	**Core Documents Count**	**Core Documents sum Citations**	**Secondary Documents Count**	**Secondary Documents sum Citations**
Climate-Change	43.46	10.86	816	19,923	1,020	24,023
Runoff	16.11	3.1	94	1,744	335	6,066
Prediction	9.55	1.8	29	286	273	4,812
Indian-Summer-Monsoon	8.99	2.02	19	400	128	2,892
River	5.2	1.62	17	240	144	3,571
Western-Himalaya	1.93	3.46	20	1,158	99	2,701
Index	3.73	1.74	11	124	142	3,149

4.4.8.2. Analysis of Scopus publication data related to "National Mission for Strategic Knowledge for Climate Change"

4.4.8.2.1. Number of publications by top 30 countries related to "National Mission for Strategic Knowledge for Climate Change"

A total of 83738 publications were retrieved from the Scopus database using the final search string. Figure 4.4.8.2.1shows the publication contributions by the top 30 countries. The USA is the leading country and contributed 28371 publications. India has contributed 3236 publications and secured 10th rank globally in the publications related to the "National Mission for Strategic Knowledge for Climate Change".

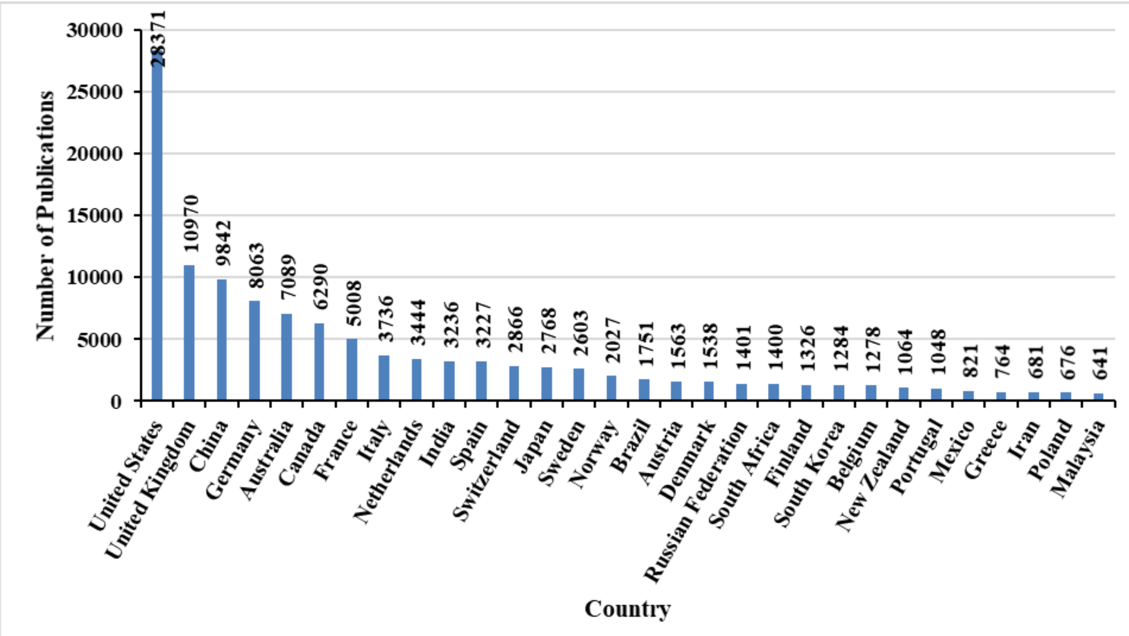


Figure 4.4.8.2.1.: Total number of publications related to "National Mission for Strategic Knowledge for Climate Change" of top 30 countries.

4.4.8.2.2. Year-wise Growth of global and Indian publications related to "National Mission for Strategic Knowledge for Climate Change"

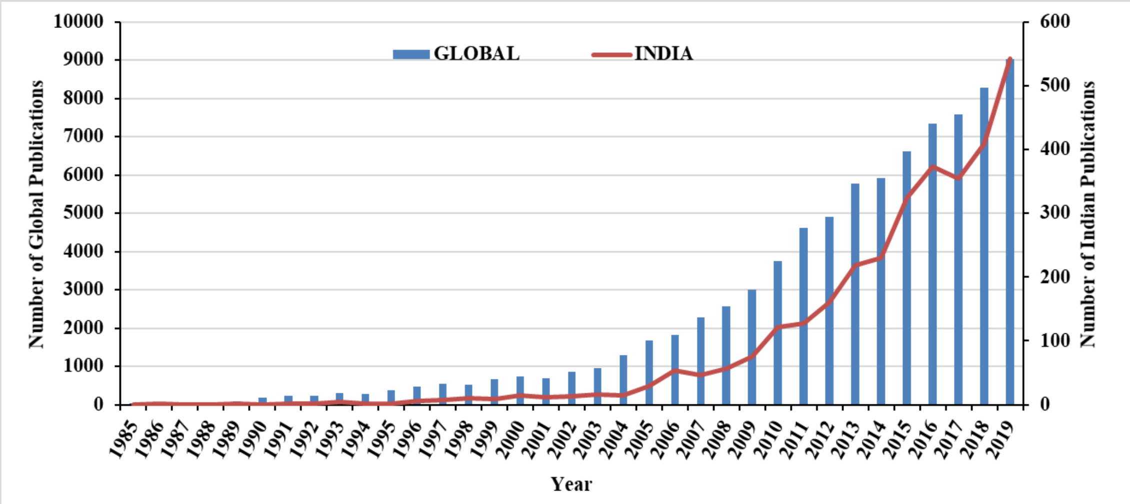


Figure 4.4.8.2.2: Year-wise global and Indian number of publications related to "National Mission for Strategic Knowledge for Climate Change".

Figure 4.4.8.2.2 shows the year-wise growth of the number of total global and Indian publications related to the "National Mission for Strategic Knowledge for Climate Change".The compound annual growth rate (21.02%) of Indian publications is higher than the total global publications during 1987-2019 (Table 4.4.8.2.1). The CAGR (20.07%) of Indian publications was lower than the total global publications up to 2008 i.e. the year of the setting of the "National Mission for Strategic Knowledge for Climate Change". It is very interesting to see that the CAGR (22.93%) of Indian publications is also higher than the global total publications after the introduction of the mission. Therefore, it may conclude that the "National Mission for Strategic Knowledge for "Climate Change"of India instigates the R&D activities on various objectives of "National Mission for Strategic Knowledge for Climate Change" thereby the growth of publications accelerated.

Table 4.4.8.2.1: Global and Indian total publications related to "National Mission for Strategic Knowledge for Climate Change" Global and Indian compound annual growth rate of publications during 1987-2019, 1987-2008 and 2008-2019

	Number of publications	CAGR of all years	CAGR before setting of the mission	CAGR after setting of the mission
Global Publication	83738	18.27%	21.32%	12.15%
Indian Publication	3236	21.02%	20.07%	22.93%

4.4.8.2.3. Total Global and Indian comparative contribution in different subject areas:

Total global researches related to the Indian "National Mission for Strategic Knowledge for Climate Change" have been performed in 28 subject areas. The top 10 subject areas of total global researches related to the mission have contributed 90.24% cumulatively (normalised). India has contributed in 27 subject areas during total periods. The top 10 subject areas of total Indian research on climate change have also contributed 89.51% cumulatively (normalised).

India has contributed at a higher proportion than the global in some research areas namely: Engineering, Multidisciplinary, Computer Science, Medicine, Economics, Econometrics and Finance, Physics and Astronomy, Business, Management and Accounting, Materials Science, Decision Sciences, Chemical Engineering, Pharmacology, Toxicology and Pharmaceutics, Veterinary, Health Professions, Undefined etc. India has contributed at a lower proportion than the global in some research areas namely: Environmental Science, Earth and Planetary Sciences, Agricultural and Biological Sciences, Social Sciences, Energy, Biochemistry, Genetics and Molecular Biology, Mathematics, Arts and Humanities, Chemistry, Immunology and Microbiology, Psychology,Neuroscience, Nursing, Dentistry etc. (Figure 4.4.8.2.3).

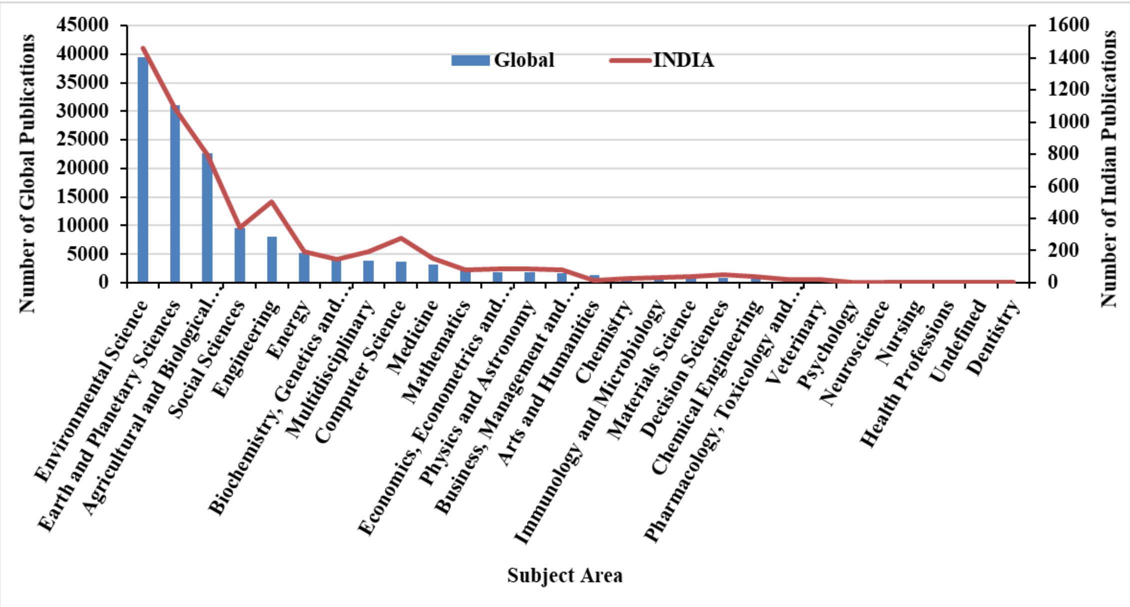


Figure 4.4.8.2.3: Global and Indian publication contribution in different subject areas "National Mission for Strategic Knowledge for Climate Change".

4.4.8.2.4: Indian publication contribution related to “National Mission for Strategic Knowledge for Climate Change” in different research areas before and after the introduction of the mission

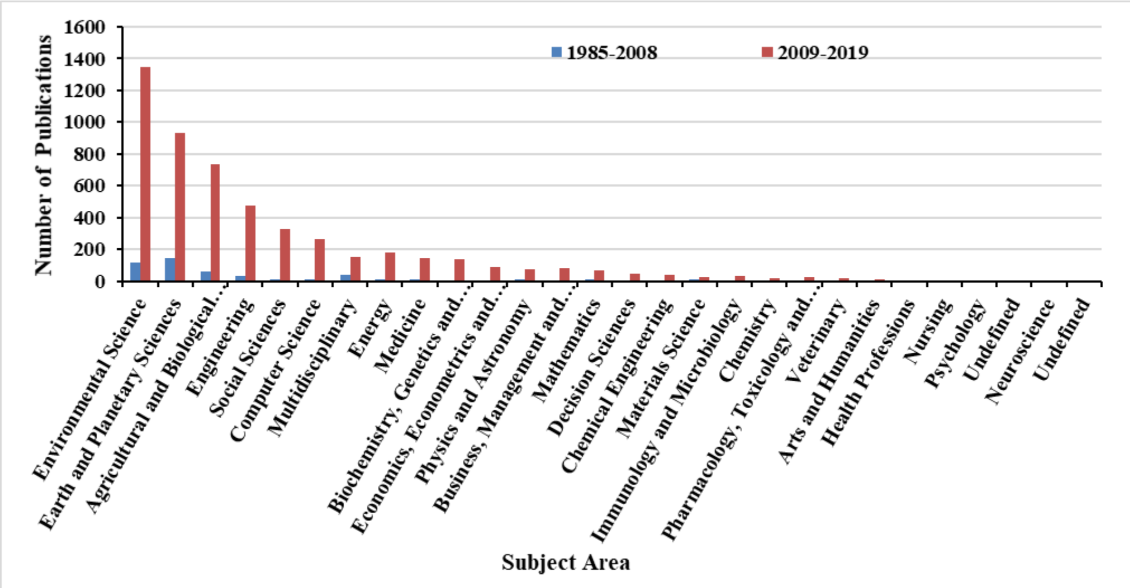


Figure 4.4.8.2.4: Indian publication contribution related to “National Mission for Strategic Knowledge for Climate Change”in different subject areas before and after the adoption of the mission.

Figure 4.4.8.2.4 shows the comparative contribution of different subject areas of Indian publications before and after the introduction of the mission. Following research areas namely, Environmental Science, Earth and Planetary Sciences, Agricultural and Biological Sciences were the most important research areas before the introduction of the “National Mission for Strategic Knowledge for Climate Change”by contributing more than 50 publications. After the introduction of the mission, the following research areas Environmental Science, Earth and Planetary Sciences, Agricultural and Biological Sciences, Engineering, Social Sciences, Computer Science, Multidisciplinary, Energy, Medicine, Biochemistry, Genetics and Molecular Biology were the most important and contributed more than 100 publications.

4.4.8.3. Analysis of Indian Citation Index data related to “National Mission for Strategic Knowledge for Climate Change”

4.4.8.3.1. Year-wise Growth of global and Indian publications related to “National Mission for Strategic Knowledge for Climate Change”

Figure 4.4.8.3.1 shows the year-wise growth of the number of global and Indian publications related to "National Mission for Strategic Knowledge for Climate Change". The compound annual growth rate of Indian publications is quite lower than the total global publications during 2005-2019. The CAGR of Indian publications was lower than the total global publications before 2008 i.e. the year of the introduction of the "National Mission for Strategic Knowledge for Climate Change"**.** While the CAGR of Indian publications from 2009 to 2019 is also lower than the global total publications (Table 4.4.8.3.1). Therefore, it may infer that the "National Mission for Strategic Knowledge for Climate Change"of India does not instigate R&D activities on various objectives of "National Mission for Strategic Knowledge for Climate Change"thereby the growth of publications decreased.

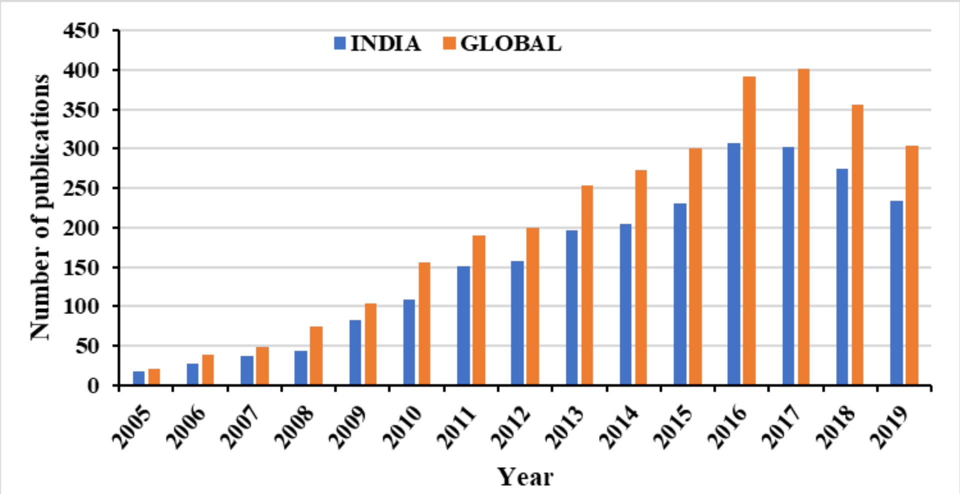


Figure 4.4.8.3.1: Year-wise global and Indian number of publications related to "National Mission for Strategic Knowledge for Climate Change".

Table 4.4.8.3.1: Global and Indian total publications, Global and Indian compound annual growth rate of publications related to the "National Mission for Strategic Knowledge for Climate Change" during 2005-2019, 2004-2008 and 2008-2019

	Number of publications	CAGR of all years	CAGR before setting of the mission	CAGR after setting of the mission
Global Publication	3106	21.43 %	54.67 %	15.14 %
Indian Publication	2375	20.56 %	37.30 %	18.14 %

4.4.8.3.2. Total Global and Indian comparative contribution in different subject areas:

Total global research on the Indian "National Mission for Strategic Knowledge for Climate Change" related topic has been performed in 304 research areas. The top 30 research areas of total global research on the Indian "National Mission for Strategic Knowledge for Climate Change"related topic have contributed 75.41% cumulatively (normalised). India has contributed to 270 research areas during total periods. The top 30 research areas of total Indian research on climate change have contributed 75.40% cumulatively (normalised).

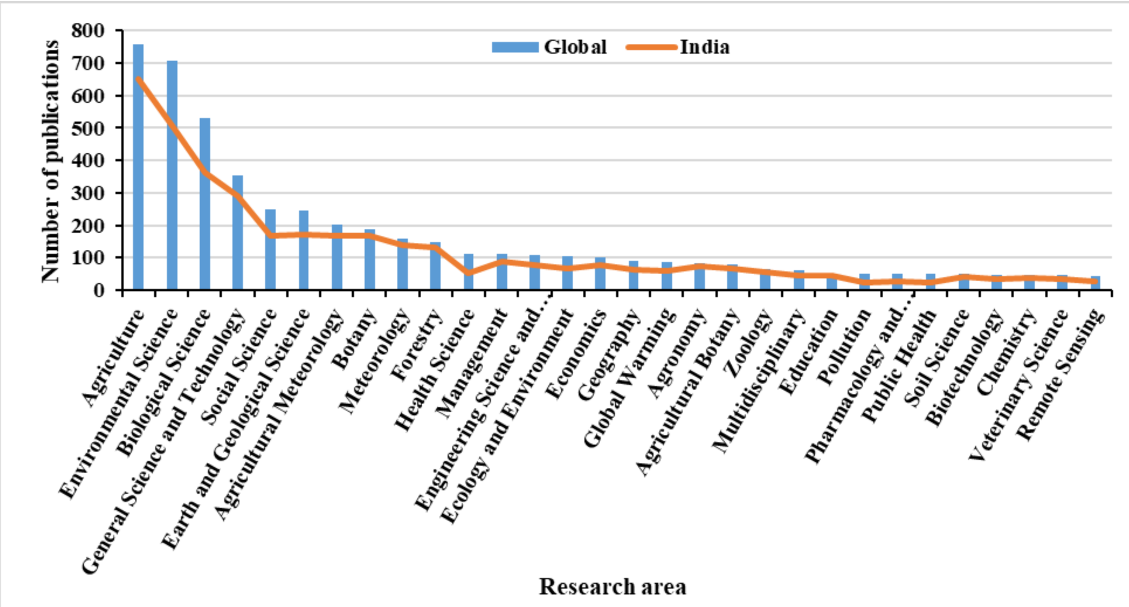


Figure 4.4.8.3.2: Global and Indian publication contribution related to "National Mission for Strategic Knowledge for Climate Change" in top 30 research areas in top 30 research areas

India has contributed at a higher proportion than the global in some research areas namely: Agriculture, General Science and Technology, Agricultural Meteorology, Botany, Meteorology, Forestry, Management, Economics, Agronomy, Agricultural Botany, Zoology, Education, Soil Science and Chemistry. India has contributed at a lower proportion than the global in some research areas namely: Environmental Science, Biological Science, Social Science, Earth And Geological Science, Health Science, Engineering Science And Technology, Ecology And Environment, Geography, Global Warming, Multidisciplinary, Pollution, Pharmacology And Pharmaceutical Science, Public Health, Biotechnology, Veterinary Science, Remote Sensing (Figure 4.4.8.3.2).

4.4.8.3.3: Indian publication contribution in top 30 research areas before and after adoption of the mission

Figure 4.4.8.3.3 shows the comparative contribution of the top 30 research areas of Indian publications before and after the introduction of the mission. Following research areas namely: Agriculture, Environmental Science, Biological Science, General Science And Technology, Earth And Geological Science, Agricultural Meteorology, Botany, Meteorology, Forestry were the most important research areas before the introduction of the "National Mission for Strategic Knowledge for Climate Change" by contributing more than 10publications. After the introduction of the mission, the following research areas Agriculture, Environmental Science, Biological Science, General Science And Technology, Earth And Geological Science, Agricultural Meteorology, Botany, Meteorology, Forestry, Social Science, Management were the most important and contributed more than 90 publications.

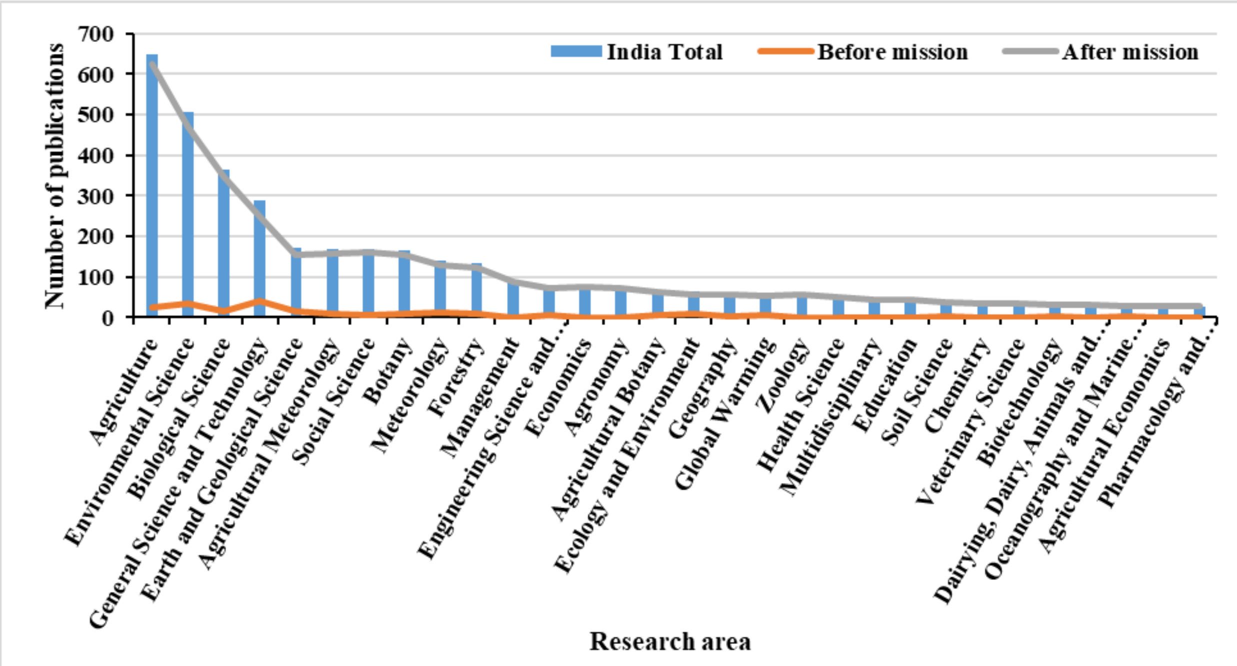


Figure 4.4.8.3.3: Indian publication contribution related to "National Mission for Strategic Knowledge for Climate Change" in top 30 research areas before and after the adoption of the mission.

4.5. Evaluation of the comparative evolving trends of the research area and research topic

4.5.1. Analysisfrom Web of Science database

4.5.1.1. Period-wise growth of the number of the research area of total global publications on "Climate Change":

Figure 4.5.1.1 shows the period-wise growth of the number of research areas at successive periods of the total global publications. The number of research areas was increased from 88 during the initial period (1985-1989) to 239 during the last period (2015-2019) with a compound period-wise growth rate of 18.12%. The major diversification in research areas of the total global research on climate change was accelerated during the second period (1990-1994) with a growth rate of 127.27 %.

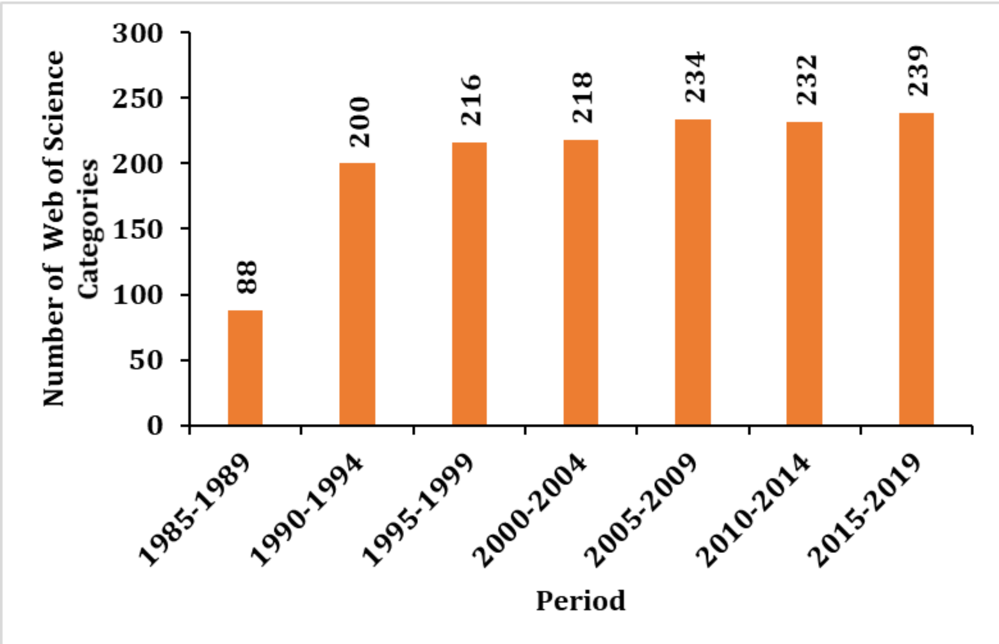


Figure 4.5.1.1: Global total number of research areas during different periods

4.5.1.2. Period-wise comparative growth of the number of research area among top 20 countries:

The average number of research areas of the top 20 countries increased at successive periods. The Group's average number of research areas was increased from 10.6 during the initial period (1985-1989) to 181.55 during the last period (2015-2019) with a CPGR of 60.54%. India's number of research areas was increased from 7 during the initial period (1985-1989) to 177 during the last period (2015-2019) with a CPGR of 71.32 %. Seven to ten countries have contributed to more research areas than the group average number of research areas during different periods. The major diversifications of research areas were observed during the second period for the USA, England, Germany, France and Canada (Figure

4.5.1.2) like that of total global total publications. The significant diversification of research areas of Indian publications was observed during 1990-1994, 1995-1999, 2005-2009 and 2010-2014. Total global research on climate change has been performed in 243 research areas. India contributed to 200 research areas during total periods and achieved 9th position during the last period by contributing to 177 research areas (Table 4.5.1.1).

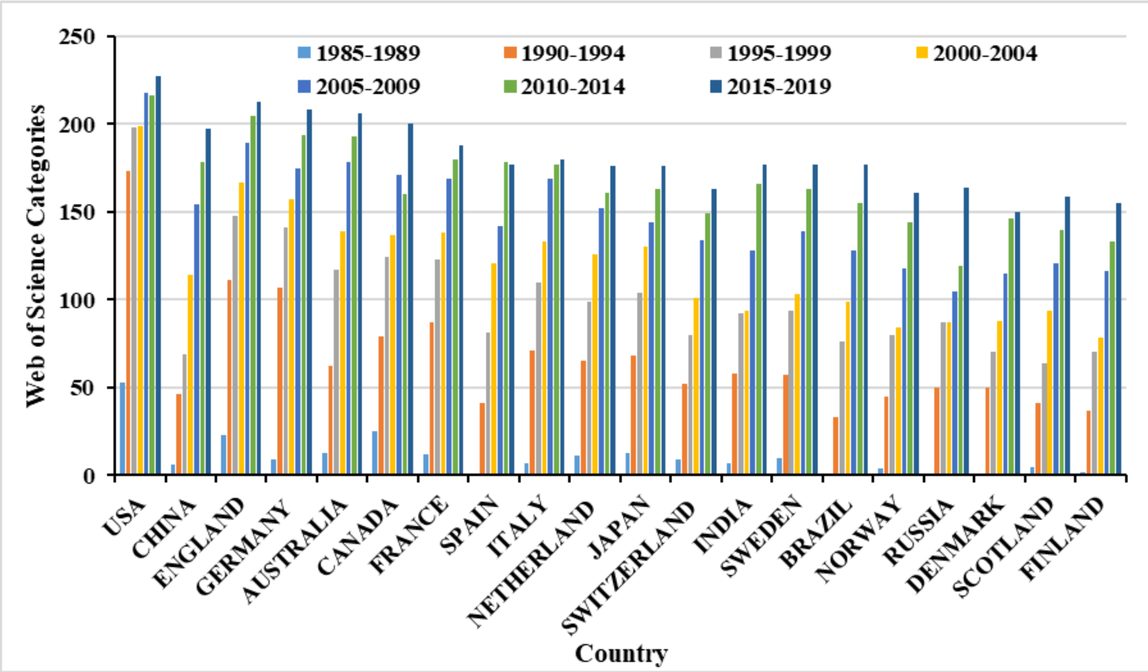


Figure 4.5.1.2: Number of research areas during different periods of top 20 countries

Table 4.5.1.1: Number of research areas of top 20 countries, number of countries having a greater number of research areas than the group's average number of research areas among the top 20 countries, India's rank based on the number of research areas and name of the top countries during different periods.

	1985-1989	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014	2015-2019
Group average number of research areas	10.6	66.65	101.35	119.45	148.25	166	181.55
Number of countries having a more research area than the group average	7	7	8	10	9	9	7
India's Rank	12	10	11	13	14	9	9
Group Top	USA	USA	USA	USA	USA	USA	USA

4.5.1.3. Total Global and Indian comparative contribution in top 30 research areas:

Total global research on Climate Change has been performed in 242 research areas. The top 30 research areas of total global research on climate change have contributed 79.09% cumulatively. India has contributed to 200 research areas during total periods. The top 30 research areas of total Indian research on climate change have contributed 79.26 % cumulatively. India has contributed at a higher proportion than the global in some research areas namely: Energy fuel, Water resource, Agronomy, Engineering Electrical Electronics, Green sustainable, Remote sensing those are mainly deal with the mitigation and adaptive measures of climate change. India has contributed a lower proportion than the global in some research areas namely: Ecology, Oceanography, Forestry, Environmental Studies, Geology, Zoology, Biodiversity and Evolution, Economics those are mainly deal with the causal factor identification and impact assessment of climate change (Figure 4.5.1.3).

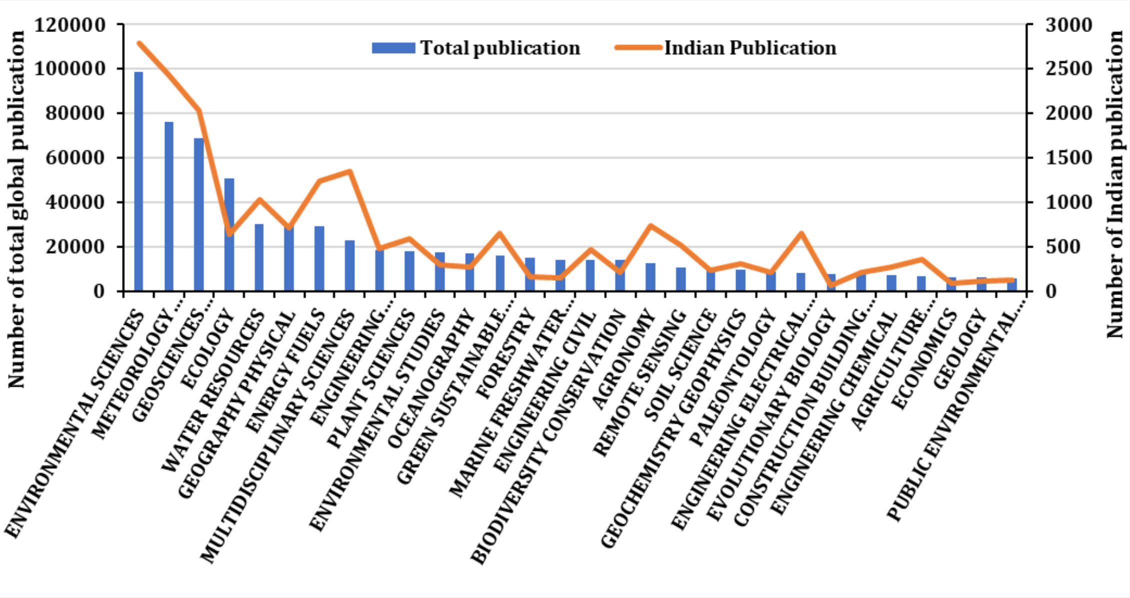


Figure 4.5.1.3: Global and Indian publication contribution in top 30 research areas.

4.5.1.4. Period-wise growth of top 30 research areas of global and total Indian publications:

Figure 4.5.1.4 and Figure 4.5.1.5 show the period-wise growth of the top 30 research areas of Global and Indian publications on climate change respectively. Figure 4.5.1.6 and Figure 4.5.1.7 show the CPGR of an individual research area of Global and Indian publications on climate change respectively. Some of the research areas of Global publications have contributed at higher CPGR than the average CPGR of total global publications (181.19 %) namely Remote Sensing (312.63 %), Evolutionary Biology

(293.65 %), Construction Building Technology (257.54 %), Engineering Electrical Electronic (255.91 %), Engineering Environmental (232.74 %), Marine Freshwater Biology (220.83 %), Environmental Studies (217.01 %), Biodiversity Conservation (212.65 %), Public Environmental Occupational Health (212.44 %), Energy Fuels (203.44 %), Ecology (197.89 %), Engineering Civil (196.90 %), Plant Sciences (194.69 %), Soil Science (183.96 %), Agriculture Multidisciplinary (182.49 %).

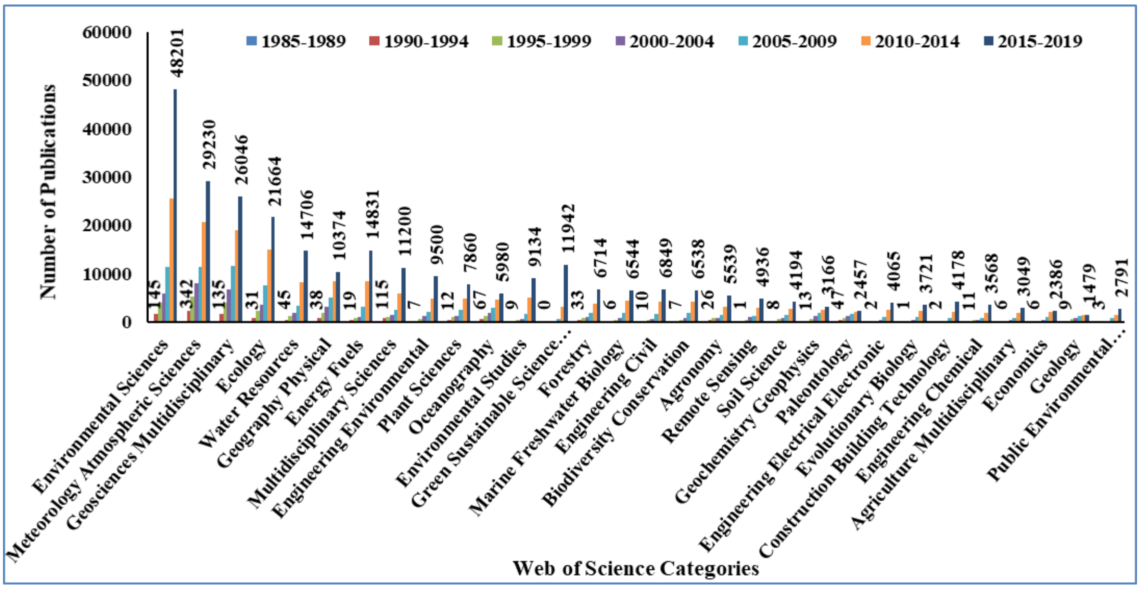


Figure 4.5.1.4: Period-wise evolving trends of top 30 research areas of global publications

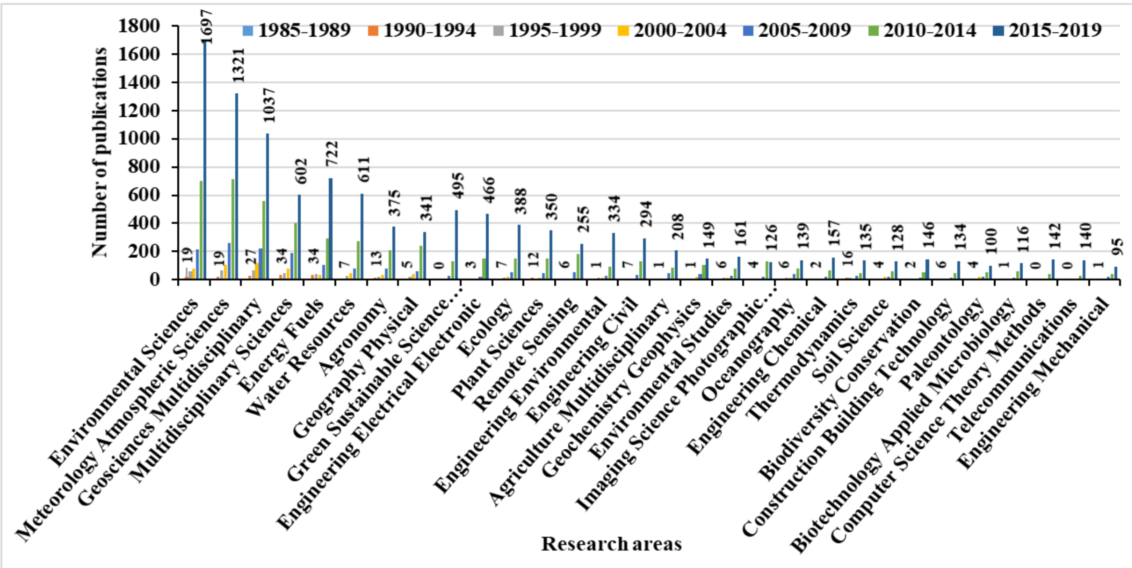


Figure 4.5.1.5: Period-wise evolving trends of top 30 research areas of Indian publications

Some of the research areas of Indian publications contributed at higher CPGR than the average CPGR of total Indian publications (136.56 %) namely Computer Science Theory Methods (421.71 %), Engineering Electrical Electronic (258.40), Engineering Civil (219.70), Agriculture Multidisciplinary (190.81), Ecology (174.32), Geochemistry Geophysics (172.04 %), Forestry (161.37), Biodiversity Conservation (158.76 %), Telecommunications (148.62 5), Environmental Sciences (145.58 %), Water Resources (144.45 %), Thermodynamics (139.32%). The following research areas of Indian publications have contributed with higher CPGR than the global CPGR namely: Agriculture Multidisciplinary, Computer Science Theory Methods, Engineering Electrical Electronic, Forestry, Geochemistry Geophysics, Meteorology Atmospheric Sciences, Paleontology.

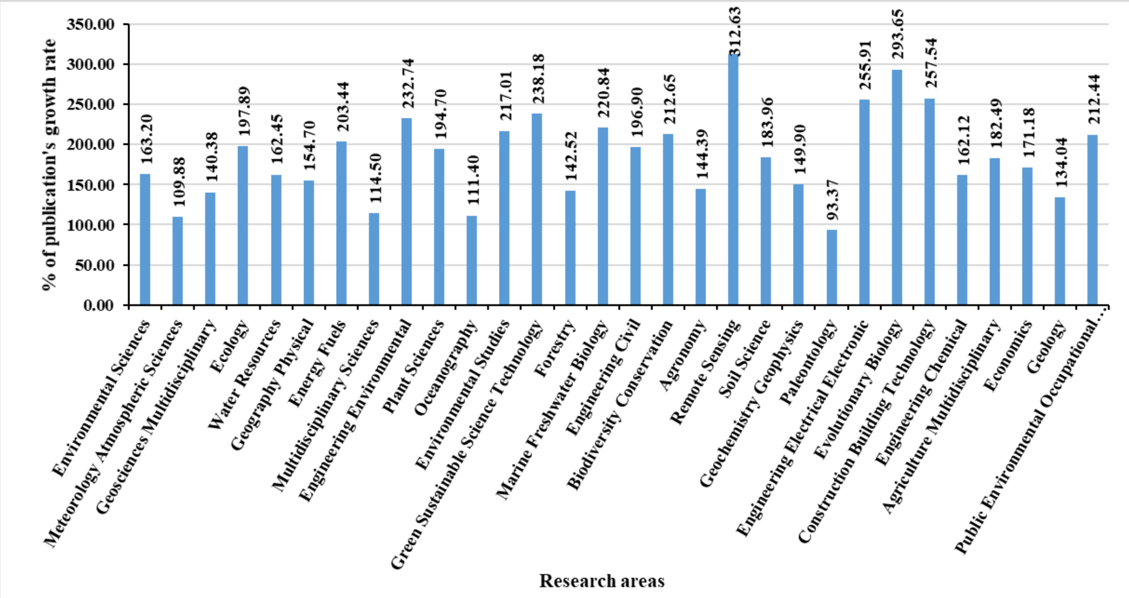


Figure 4.5.1.6: Period-wise growth rate of top 30 research areas of Global publications.

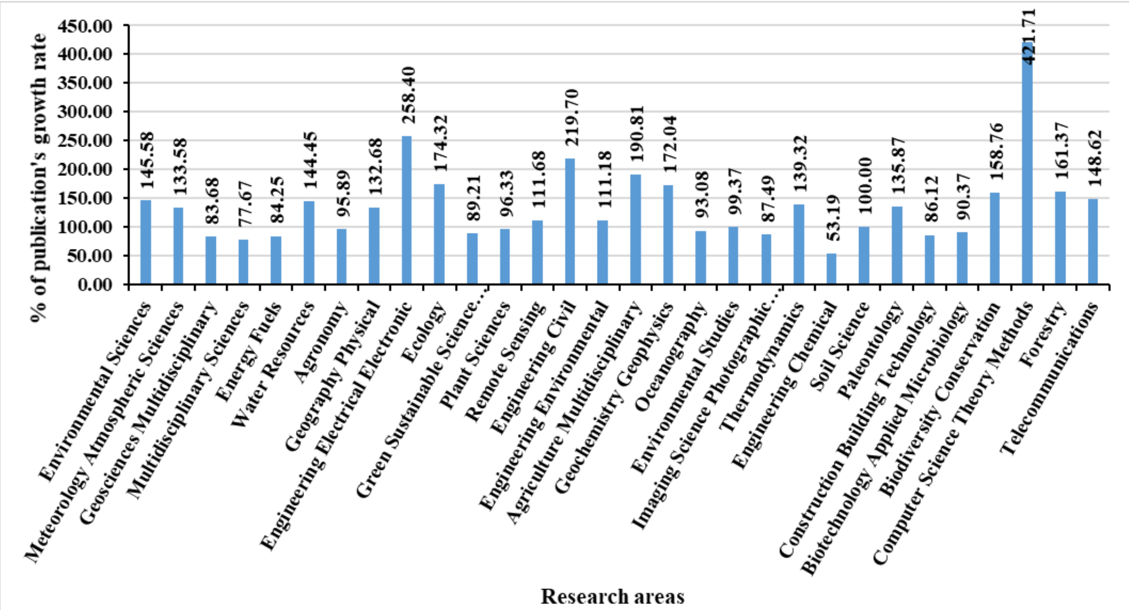


Figure 4.5.1.7: Period-wise growth rate of top 30 India's research areas

4.5.1.5. Comparative evolving trend of top 30 research areas among top 20 countries:

Table 4.5.1.2, Table 4.5.1.3, Table 4.5.1.4, Table 4.5.1.5, Table 4.5.1.6, Table 4.5.1.7, Table 4.5.1.8 and Table 4.5.1.9 show the number of publications contributed by top 20 individual countries in the top 30 individual research areas of total global climate change research and rank of India in the individual research area among top 20 countries during the total period (1985-2019), 1985-1989, 1990-1994, 1995-1999, 2000-2004, 2005-2009, 2010-2014 and 2015-2019 respectively. Throughout the periods in the following research areas namely Engineering Electrical Electronic (Rank-3), Multidisciplinary Sciences(Rank-8), Energy Fuels (Rank-9) and Remote Sensing (Rank-9) India cumulatively contributed more publications as compared with the top 20 countries. In the top ten research areas of global cumulative publications, India did not rank better except Multidisciplinary Sciences (Rank-8) and Energy Fuels (Rank-9). During the last period Meteorology Atmospheric Sciences, Water Resources and Energy Fuels ranked 9th and Geography Physical ranked 10th among top 20 countries and these research areas also positioned in the top ten research areas of global cumulative publications.

Table 4.5.1.2: Number of publications contributed by top 20 individual countries in top 30 individual research areas of total global climate change research during the total period (1985-2019) and rank of India in the individual research area among top 20 countries.

Research area	Global	USA	Peoples R China	England	Germany	Australia	Canada	France	Spain	Italy	Netherlands	Japan	Switzerland	Sweden	India	Brazil	Norway	Russia	Denmark	Scotland	Finland	India's rank
Environmental Sciences	98752	31722	14133	9887	9030	7309	7527	5074	4727	4750	4564	3068	3457	2793	3762	2257	2357	1290	2117	1867	2229	14
Meteorology Atmospheric Sciences	76237	32517	10905	8808	8459	4655	5003	5259	2443	2929	2683	3802	2917	2438	2131	1249	1876	1958	946	809	1209	13
Geosciences Multidisciplinary	68969	23515	9487	8971	9056	4144	5092	6431	2918	3155	3195	2447	3313	2029	2350	1108	2141	2018	1417	1550	1005	15
Ecology	50767	19972	3903	5573	4970	5671	4820	3852	3235	1779	2142	1206	2229	643	2206	1434	1624	903	1595	1563	1317	20
Water Resources	30280	8105	4645	2273	2195	2146	2340	1442	1205	1382	1417	816	776	1033	724	546	482	432	335	358	257	11
Geography Physical	29937	9026	3998	4229	3985	1925	2449	2712	1739	1492	1370	781	1609	711	1174	554	1047	881	806	794	530	18
Energy Fuels	29174	5106	3955	2341	1658	1343	1525	955	1265	1652	894	915	509	1233	907	638	517	113	476	392	463	9
Multidisciplinary Sciences	23050	9415	3532	3199	2359	2052	1536	1730	985	821	884	663	976	1351	798	638	614	364	564	528	365	8
Engineering Environmental	18735	4537	3249	1317	1006	1199	1151	624	792	854	768	658	447	483	889	419	463	131	604	181	366	14
Plant Sciences	18195	4367	1907	1433	2004	1648	1188	1187	1447	1059	589	628	722	588	569	648	392	244	356	428	329	14
Environmental Studies	17284	4844	1737	2408	1816	1451	1024	716	726	742	1172	460	574	297	749	330	455	118	340	341	336	19
Oceanography	17065	6534	1246	1742	1769	1603	1558	1494	788	555	567	784	219	279	459	212	776	871	383	357	160	17
Green Sustainable Science Technology	15929	2394	2684	1224	942	985	713	514	832	955	675	537	276	654	582	504	274	79	285	201	308	10
Forestry	14955	4428	1620	530	1424	861	1655	882	1120	692	339	397	561	162	594	469	257	214	204	239	639	20
Marine Freshwater Biology	14313	4587	660	1417	1194	1895	1441	1075	928	698	436	387	202	150	460	449	601	217	467	380	277	20
Engineering Civil	14120	3581	2248	1088	639	927	1025	529	526	693	409	408	235	472	330	187	253	83	192	144	133	10
Biodiversity Conservation	13885	5293	1072	1926	1399	1735	1327	1078	975	591	568	270	585	217	536	545	397	182	478	511	396	19
Agronomy	12826	2727	1543	636	1055	981	708	947	678	765	515	393	242	738	268	555	132	74	289	231	219	7
Remote Sensing	10712	3800	2563	545	916	343	621	701	417	605	368	567	197	512	118	200	135	182	97	83	139	9
Soil Science	10304	2354	1790	549	1124	754	820	562	724	489	411	337	256	242	268	404	104	402	234	282	140	17
Geochemistry Geophysics	9859	4081	1363	1293	1410	569	581	1194	346	460	390	410	455	308	214	153	233	436	143	200	101	14
Paleontology	8785	2784	938	1215	1469	441	513	932	538	530	400	276	362	207	230	207	203	384	138	186	45	15
Engineering Electrical Electronic	8287	1775	1403	320	403	257	355	308	260	373	127	491	103	648	72	131	59	78	97	74	83	3
Evolutionary Biology	7748	3363	646	1054	777	970	740	752	560	286	250	214	389	70	372	280	277	132	254	239	203	20
Construction Building Technology	7689	1231	1143	653	350	409	374	282	314	498	158	245	154	208	235	115	139	43	197	86	108	12
Engineering Chemical	7405	1314	1078	567	376	276	365	209	316	313	160	290	112	267	165	121	64	31	75	48	63	10
Agriculture Multidisciplinary	6871	1009	713	385	540	721	226	398	380	321	363	235	187	360	99	467	70	17	164	152	126	10
Economics	6495	1785	581	705	587	423	312	296	249	222	379	151	176	91	232	105	151	71	105	94	128	19
Geology	6101	1983	363	796	618	300	476	394	310	351	200	115	251	119	165	117	159	288	114	171	41	16
Public Environmental Occupational Health	5852	1847	673	647	269	657	419	205	213	240	178	140	146	125	282	140	97	48	117	71	79	15

Table 4.5.1.3: Number of publications contributed by top 20 individual countries in top 30 individual research areas of total global climate change research during 1985-1989 and rank of India in the individual research area among top 20 countries.

Research Area	Global	USA	P R China	England	Germany	Australia	Canada	France	Spain	Italy	Netherlands	Japan	Switzerland	Sweden	India	Brazil	Norway	Russia	Denmark	Scotland	Finland	India's Rank
Meteorology Atmospheric Sciences	342	198	4	18	6	10	19	4	0	1	0	4	1	5	9	0	0	0	1	0	0	7
Environmental Sciences	145	75	1	4	2	5	10	0	0	1	2	1	0	2	2	0	0	0	0	0	0	8
Geosciences Multidisciplinary	135	75	2	11	5	1	9	8	0	2	4	1	2	6	1	0	1	0	0	0	0	13
Multidisciplinary Sciences	115	43	2	11	0	2	4	8	0	0	0	1	0	0	1	2	1	0	0	0	0	9
Oceanography	67	43	0	2	4	1	1	7	0	1	2	0	1	4	0	0	1	0	0	0	0	15
Paleontology	47	33	0	3	4	1	2	5	0	1	1	0	1	4	0	0	1	0	0	0	0	15
Water Resources	45	9	0	2	1	0	2	0	0	0	1	1	1	0	0	0	0	0	0	0	0	14
Geography Physical	38	15	2	5	0	1	5	2	0	0	1	0	2	3	1	0	0	0	0	0	0	10
Forestry	33	10	0	1	2	1	2	0	0	0	1	0	0	1	0	0	0	0	0	1	1	16
Ecology	31	12	0	3	1	0	2	0	0	0	2	0	1	0	0	0	0	0	0	1	0	15
Agronomy	26	6	0	1	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	14
Energy Fuels	19	2	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	14
Medicine General Internal	16	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14
Geochemistry Geophysics	13	7	1	3	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14
Plant Sciences	12	4	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14
Chemistry Multidisciplinary	11	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14
Engineering Chemical	11	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14
Engineering Civil	10	3	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14
Engineering Multidisciplinary	10	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14
Environmental Studies	9	5	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	14
Geology	9	4	0	2	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	14
Soil Science	8	2	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	14
Agricultural Economics Policy	7	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14
Agriculture Dairy Animal Science	7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14
Biodiversity Conservation	7	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	15
Engineering Environmental	7	3	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14
Agriculture Multidisciplinary	6	1	0	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	14
Biology	6	2	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	14
Economics	6	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14
Engineering Industrial	6	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14

Table 4.5.1.4: Number of publications contributed by top 20 individual countries in top 30 individual research areas of total global climate change research during 1990-1994 and rank of India in the individual research area among top 20 countries.

Research Area	Global	USA	P R China	England	Germany	Australia	Canada	France	Spain	Italy	Netherlands	Japan	Switzerland	Sweden	India	Brazil	Norway	Russia	Denmark	Scotland	Finland	India's Rank
Meteorology Atmospheric Sciences	2452	1412	25	146	134	138	119	93	6	28	49	62	18	18	19	4	10	41	3	7	2	12
Environmental Sciences	1830	772	14	162	74	69	110	42	7	15	58	27	23	30	19	13	16	20	14	17	9	12
Geosciences Multidisciplinary	1735	704	41	134	99	76	136	181	20	26	64	29	34	41	27	10	31	17	19	25	10	13
Ecology	981	375	4	113	26	61	29	40	13	9	27	19	18	31	7	4	19	15	11	11	10	18
Geography Physical	896	321	26	68	40	53	94	87	11	13	36	14	21	48	5	4	16	10	19	21	5	18
Multidisciplinary Sciences	843	350	11	86	35	24	22	75	1	5	10	3	8	3	34	2	8	11	12	3	3	5
Oceanography	624	287	3	37	53	42	36	63	1	9	13	7	4	5	6	0	10	17	1	4	2	12
Energy Fuels	566	135	3	76	28	8	13	17	1	7	7	23	5	13	34	1	9	2	4	1	4	3
Water Resources	553	214	3	42	26	18	20	14	4	4	24	11	7	8	7	2	1	9	4	3	1	12
Plant Sciences	547	129	3	69	43	41	35	16	16	11	24	17	11	22	12	1	7	8	2	11	6	11
Agronomy	460	136	1	32	22	29	16	14	4	5	15	5	1	3	13	2	1	1	5	5	5	8
Forestry	438	178	1	20	21	17	33	14	5	3	10	6	5	10	5	1	2	2	0	3	8	13
Paleontology	429	183	14	37	25	23	42	58	10	11	12	11	10	6	4	2	2	5	4	3	3	15
Geology	276	119	2	24	10	12	13	14	4	6	4	3	11	14	4	4	2	8	5	3	0	14
Engineering Civil	252	90	1	22	8	6	7	7	3	1	8	15	1	4	7	1	1	1	1	1	1	8
Marine Freshwater Biology	248	55	1	28	14	22	25	17	4	0	14	0	5	5	0	1	7	0	2	7	3	19
Soil Science	248	67	2	13	24	18	3	16	3	4	10	8	1	4	4	1	1	6	2	2	0	11
Environmental Studies	216	82	1	51	5	3	9	5	0	1	5	2	1	4	6	2	6	0	5	1	2	4
Geochemistry Geophysics	213	122	5	15	11	9	12	29	2	4	3	4	6	2	1	3	3	6	0	5	2	19
Engineering Environmental	190	92	2	10	9	4	7	6	2	3	9	10	1	12	1	2	0	0	3	0	0	16
Geography	165	52	1	23	3	2	14	1	0	2	2	2	1	2	3	2	1	6	1	5	2	7
Economics	150	59	0	35	3	3	8	4	0	0	3	0	0	3	2	0	6	0	3	1	1	11
Thermodynamics	143	39	2	10	14	0	3	7	0	0	3	9	1	1	16	0	1	0	1	0	0	2
Zoology	142	61	0	10	7	15	4	6	2	5	1	3	0	2	0	0	1	2	1	3	3	19
Remote Sensing	139	71	2	13	4	1	23	21	1	4	0	4	0	0	6	2	0	8	0	0	0	6
Limnology	134	66	1	14	7	9	8	4	3	0	1	1	2	1	0	0	0	0	0	3	1	16
Biodiversity Conservation	130	52	1	27	2	3	3	3	1	2	2	1	7	5	2	0	3	1	2	2	1	12
Engineering Chemical	126	27	0	25	3	0	4	3	0	1	2	3	1	2	2	0	0	0	0	0	0	9
Agriculture Multidisciplinary	119	25	1	15	8	24	1	3	1	0	6	3	2	0	1	9	1	0	1	3	0	14
Biology	109	38	0	33	3	2	0	7	0	0	0	4	0	2	1	0	2	4	1	1	0	10

Table 4.5.1.5: Number of publications contributed by top 20 individual countries in top 30 individual research areas of total global climate change research during 1995-1999 and rank of India in the individual research area among top 20 countries.

Research Area	Global	USA	P R China	England	Germany	Australia	Canada	France	Spain	Italy	Netherlands	Japan	Switzerland	Sweden	India	Brazil	Norway	Russia	Denmark	Scotland	Finland	India's Rank
Meteorology Atmospheric Sciences	5361	2824	25	481	448	331	385	299	69	74	179	159	18	109	64	47	45	147	48	32	2	13
Geosciences Multidisciplinary	4023	1427	41	539	332	206	310	394	100	98	155	104	34	125	64	30	96	87	70	94	10	16
Environmental Sciences	3944	1530	14	395	256	144	330	137	80	94	199	97	23	122	59	34	62	74	47	2	9	14
Ecology	2265	867	4	251	120	126	148	111	65	38	96	47	18	94	16	24	54	38	37	34	10	18
Geography Physical	1884	593	26	275	119	109	176	157	58	45	84	30	21	95	21	10	60	52	50	60	5	18
Water Resources	1359	454	3	142		43	100	60	36	35	45	33	7	34	25	11	17	40	17	19	3	12
Oceanography	1269	560	3	94	137	55	123	121	28	26	37	43	4	24	16	5	27	74	22	13	2	15
Plant Sciences	1124	252	3	99	3	95	62	86	43	36	47	34	11	29	8	10	17	17	14	25	6	17
Multidisciplinary Sciences	1002	456	11	113	61	41	34	48	5	6	19	14	8	18	50	5	10	33	15	4	3	4
Agronomy	955	190	1	63	71	50	42	75	25	39	53	28	1	28	23	14	13	10	26	15	5	13
Energy Fuels	929	282	3	78	43	41	39	29	11	14	26	45	5	16	42	18	9	8	17	5	4	5
Paleontology	836	11	14	93	105	33	62	98	34	29	38	18	10	20	11	6	10	56	8	17	3	15
Forestry	833	273	1	42	67	53	80	45	25	18	22	16	5	42	13	14	14	12	10	3	8	14
Geology	711	257	2	81	46	42	60	39	21	20	17	10	11	22	8	4	15	51	16	20	0	17
Engineering Environmental	677	256	2	46	36	38	38	12	14	13	26	31	1	35	14	8	18	8	11	2	0	11
Geochemistry Geophysics	655	280	5	73	57	44	54	80	7	30	20	15	6	8	5	5	11	34	13	11	2	18
Soil Science	616	163	2	45	16	31	67	51	34	11	28	19	1	13	9	11	14	35	17	20	0	17
Engineering Civil	508	179	1	47	19	24	43	30	6	13	15	24	1	23	9	8	3	8	7	3	1	11
Environmental Studies	508	204	1	64	37	12	19	21	4	4	40	9	1	7	12	10	7	3	11	39	2	9
Marine Freshwater Biology	439	107	1	42	31	28	59	39	13	17	15	7	5	7	2	6	15	13	6	6	3	19
Remote Sensing	430	219	2	22	82	6	21	32	8	16	17	15	0	4	6	3	5	12	2	4	0	12
Engineering Chemical	379	83	0	21	10	5	12	4	2	7	6	25	1	2	7	0	0	5	0	0	0	7
Biodiversity Conservation	365	142	1	68	17	21	23	14	7	6	16	3	7	19	2	8	8	1	10	8	1	17
Limnology	324	177	1	29	16	14	48	11	5	12	6	9	2	8	1	2	4	1	2	2	1	18
Economics	300	153	0	28	13	11	11	14	2	1	20	6	0	8	6	8	4	1	4	1	1	11
Thermodynamics	257	47	2	21	61	12	12	14	2	2	6	31	1	6	17	1	5	1	2	1	0	5
Horticulture	254	26	1	15	21	12	9	23	5	20	14	7	1	1	3	2	8	0	6	3	0	13
Agriculture Multidisciplinary	250	29	1	19	22	43	11	18	3	2	14	10	2	4	8	13	5	0	2	7	0	10
Geography	219	58	1	45	14	4	25	8	1	4	21	9	1	2	3	0	3	8	2	9	2	12
Astronomy Astrophysics	212	100	1	23	25	4	5	32	3	7	7	14	1	0	5	5	1	13	1	0	0	10

Table 4.5.1.6: Number of publications contributed by top 20 individual countries in top 30 individual research areas of total global climate change research during 2000-2004 and rank of India in the individual research area among top 20 countries.

Research Area	Global	USA	P R China	England	Germany	Australia	Canada	France	Spain	Italy	Netherlands	Japan	Switzerland	Sweden	India	Brazil	Norway	Russia	Denmark	Scotland	Finland	India's Rank
Meteorology Atmospheric Sciences	5361	2824	25	481	448	331	385	299	69	74	179	159	18	109	64	47	45	147	48	32	2	13
Geosciences Multidisciplinary	4023	1427	41	539	332	206	310	394	100	98	155	104	34	125	64	30	96	87	70	94	10	16
Environmental Sciences	3944	1530	14	395	256	144	330	137	80	94	199	97	23	122	59	34	62	74	47	2	9	14
Ecology	2265	867	4	251	120	126	148	111	65	38	96	47	18	94	16	24	54	38	37	34	10	18
Geography Physical	1884	593	26	275	119	109	176	157	58	45	84	30	21	95	21	10	60	52	50	60	5	18
Water Resources	1359	454	3	142		43	100	60	36	35	45	33	7	34	25	11	17	40	17	19	3	12
Oceanography	1269	560	3	94	137	55	123	121	28	26	37	43	4	24	16	5	27	74	22	13	2	15
Plant Sciences	1124	252	3	99	3	95	62	86	43	36	47	34	11	29	8	10	17	17	14	25	6	17
Multidisciplinary Sciences	1002	456	11	113	61	41	34	48	5	6	19	14	8	18	50	5	10	33	15	4	3	4
Agronomy	955	190	1	63	71	50	42	75	25	39	53	28	1	28	23	14	13	10	26	15	5	13
Energy Fuels	929	282	3	78	43	41	39	29	11	14	26	45	5	16	42	18	9	8	17	5	4	5
Paleontology	836	11	14	93	105	33	62	98	34	29	38	18	10	20	11	6	10	56	8	17	3	15
Forestry	833	273	1	42	67	53	80	45	25	18	22	16	5	42	13	14	14	12	10	3	8	14
Geology	711	257	2	81	46	42	60	39	21	20	17	10	11	22	8	4	15	51	16	20	0	17
Engineering Environmental	677	256	2	46	36	38	38	12	14	13	26	31	1	35	14	8	18	8	11	2	0	11
Geochemistry Geophysics	655	280	5	73	57	44	54	80	7	30	20	15	6	8	5	5	11	34	13	11	2	18
Soil Science	616	163	2	45	16	31	67	51	34	11	28	19	1	13	9	11	14	35	17	20	0	17
Engineering Civil	508	179	1	47	19	24	43	30	6	13	15	24	1	23	9	8	3	8	7	3	1	11
Environmental Studies	508	204	1	64	37	12	19	21	4	4	40	9	1	7	12	10	7	3	11	39	2	9
Marine Freshwater Biology	439	107	1	42	31	28	59	39	13	17	15	7	5	7	2	6	15	13	6	6	3	19
Remote Sensing	430	219	2	22	82	6	21	32	8	16	17	15	0	4	6	3	5	12	2	4	0	12
Engineering Chemical	379	83	0	21	10	5	12	4	2	7	6	25	1	2	7	0	0	5	0	0	0	7
Biodiversity Conservation	365	142	1	68	17	21	23	14	7	6	16	3	7	19	2	8	8	1	10	8	1	17
Limnology	324	177	1	29	16	14	48	11	5	12	6	9	2	8	1	2	4	1	2	2	1	18
Economics	300	153	0	28	13	11	11	14	2	1	20	6	0	8	6	8	4	1	4	1	1	11
Thermodynamics	257	47	2	21	61	12	12	14	2	2	6	31	1	6	17	1	5	1	2	1	0	5
Horticulture	254	26	1	15	21	12	9	23	5	20	14	7	1	1	3	2	8	0	6	3	0	13
Agriculture Multidisciplinary	250	29	1	19	22	43	11	18	3	2	14	10	2	4	8	13	5	0	2	7	0	10
Geography	219	58	1	45	14	4	25	8	1	4	21	9	1	2	3	0	3	8	2	9	2	12
Astronomy Astrophysics	212	100	1	23	25	4	5	32	3	7	7	14	1	0	5	5	1	13	1	0	0	10

Table 4.5.1.7: Number of publications contributed by top 20 individual countries in top 30 individual research areas of total global climate change research during 2005-2009 and rank of India in the individual research area among top 20 countries.

Research Area	Global	USA	P R China	England	Germany	Australia	Canada	France	Spain	Italy	Netherlands	Japan	Switzerland	Sweden	India	Brazil	Norway	Russia	Denmark	Scotland	Finland	India's Rank
Geosciences Multidisciplinary	11700	4273	1129	1557	1405	602	930	1073	416	521	513	483	571	345	224	76	320	363	185	272	156	17
Meteorology Atmospheric Sciences	11422	5072	968	1336	1321	535	849	832	305	470	386	667	502	277	260	120	269	315	137	102	162	19
Environmental Sciences	11332	3872	748	1121	931	671	986	526	422	470	584	358	395	413	217	97	270	154	244	208	266	17
Ecology	7633	2908	317	881	693	724	675	568	516	259	334	206	249	270	55	76	239	148	237	263	216	20
Geography Physical	5174	1572	442	793	653	324	432	433	276	245	221	153	298	212	58	38	181	139	115	169	103	19
Water Resources	3462	971	269	294	238	201	306	203	123	145	178	140	86	80	80	34	61	42	39	33	18	14
Energy Fuels	3207	578	216	270	160	129	231	125	101	108	140	130	67	107	105	18	51	4	37	58	32	12
Oceanography	2943	1218	104	329	340	205	290	265	138	100	101	168	35	58	41	9	130	152	53	62	32	17
Multidisciplinary Sciences	2592	1063	299	378	250	187	119	158	66	50	106	44	87	55	191	13	50	30	46	47	31	5
Plant Sciences	2508	568	189	208	286	206	172	147	191	127	81	114	94	79	50	15	59	30	46	76	48	16
Engineering Environmental	2203	556	202	150	107	113	167	61	45	75	122	103	59	91	26	15	71	11	70	20	40	17
Marine Freshwater Biology	1988	621	19	246	169	216	209	155	115	97	68	56	26	51	13	9	69	32	67	73	34	19
Forestry	1947	550	129	53	167	86	277	97	137	71	56	75	74	62	19	15	33	28	17	32	93	18
Geochemistry Geophysics	1922	813	203	246	275	103	106	260	72	87	70	90	78	21	40	9	38	90	23	49	21	15
Biodiversity Conservation	1887	739	74	286	176	204	166	154	137	72	78	45	70	59	12	24	39	25	61	74	63	20
Paleontology	1783	541	140	254	324	75	108	186	102	137	89	71	77	49	20	19	38	64	25	34	17	18
Environmental Studies	1776	516	52	217	152	81	90	72	54	48	160	46	48	71	25	9	34	13	33	26	19	17
Engineering Civil	1705	405	194	158	76	75	137	81	51	78	66	80	28	42	32	12	33	1	21	28	13	14
Soil Science	1565	388	145	101	153	84	155	73	104	49	57	51	33	37	24	32	15	57	34	56	26	19
Agronomy	1542	315	114	60	121	98	115	130	82	65	67	65	28	25	78	31	15	11	28	25	13	8
Remote Sensing	1361	549	269	52	86	26	97	89	45	66	47	78	16	15	53	8	20	22	6	4	21	8
Geology	1330	427	83	172	154	56	113	82	72	101	48	38	57	44	37	15	37	48	33	44	11	16
Economics	1143	313	66	125	99	63	47	60	42	25	97	26	29	49	12	7	23	1	15	16	18	14
Evolutionary Biology	1084	473	36	188	104	121	86	97	66	44	29	32	38	46	8	6	37	22	35	45	29	19
Engineering Electrical Electronic	1024	254	142	44	41	21	48	38	29	50	25	109	11	4	22	7	10	5	8	20	17	11
Agriculture Multidisciplinary	953	154	53	51	89	110	29	75	48	34	64	29	43	12	50	23	7	2	19	27	32	8
Public Environmental Occupational Health	930	283	63	102	31	93	56	37	31	34	22	32	28	43	16	7	11	6	20	13	12	15
Engineering Chemical	869	128	49	42	28	27	47	25	26	19	18	36	9	16	20	5	5	3	3	7	4	10
Construction Building Technology	863	123	121	76	54	25	45	25	23	34	20	46	10	23	17	5	19	1	22	16	16	15
Horticulture	851	143	18	23	48	35	19	63	65	66	57	17	10	5	16	6	11	1	23	8	6	13

Table 4.5.1.8: Number of publications contributed by top 20 individual countries in top 30 individual research areas of total global climate change research during 2010-2014 and rank of India in the individual research area among top 20 countries.

Research Area	Global	USA	P R China	England	Germany	Australia	Canada	France	Spain	Italy	Netherlands	Japan	Switzerland	Sweden	India	Brazil	Norway	Russia	Denmark	Scotland	Finland	India's Rank
Environmental Sciences	25539	8154	3157	101	2209	2155	733	1234	1272	1210	1216	764	877	1010	701	493	606	256	580	507	514	13
Meteorology Atmospheric Sciences	20698	8456	2848	2567	2406	1407	472	1595	791	918	800	1174	865	619	714	326	562	454	292	240	391	12
Geosciences Multidisciplinary	18980	6091	2623	2479	2688	1190	512	1879	901	966	960	700	979	663	561	313	599	487	426	408	287	14
Ecology	14928	5746	1097	1670	1574	1857	571	1169	1044	552	650	378	738	673	149	334	500	196	498	496	398	20
Energy Fuels	8468	1562	1158	641	461	393	172	260	347	446	263	264	125	258	292	184	152	13	121	101	144	8
Geography Physical	8465	2492	88	1215	1181	526	277	799	529	483	386	224	505	316	238	157	304	210	245	218	146	14
Water Resources	8366	2132	1187	628	682	739	294	443	347	410	453	225	257	209	271	121	155	97	100	90	73	11
Multidisciplinary Sciences	5863	2307	948	860	531	610	156	434	264	231	241	194	256	197	406	139	160	78	158	165	95	7
Environmental Studies	5030	1504	423	342	522	522	112	210	172	175	333	124	157	223	78	78	127	10	106	117	88	18
Engineering Environmental	4930	1270	753	342	263	324	108	160	226	193	190	153	127	266	92	67	152	29	173	42	97	17
Plant Sciences	4891	1161	473	361	522	458	140	316	412	319	142	158	246	152	150	173	132	46	107	133	106	13
Oceanography	4693	1681	379	498	496	566	172	406	279	163	142	223	64	144	80	55	240	188	124	106	47	17
Marine Freshwater Biology	4372	1374	168	406	394	630	158	278	306	212	143	107	50	154	36	100	218	62	155	111	71	14
Engineering Civil	4325	1034	740	359	197	326	150	153	155	204	130	111	81	101	132	55	88	7	66	36	36	10
Biodiversity Conservation	4198	1580	215	584	434	589	158	302	320	167	165	71	204	164	55	150	120	33	155	155	106	19
Forestry	3863	1088	284	137	404	255	183	267	332	191	97	106	154	135	45	120	67	40	46	50	188	19
Agronomy	3204	611	341	167	276	288	80	242	180	219	140	99	74	59	210	153	37	10	79	61	70	7
Green Sustainable Science Technology	3136	551	322	249	176	227	68	122	122	140	157	118	61	126	131	79	75	2	56	50	80	8
Remote Sensing	2923	956	685	127	246	97	79	167	90	149	105	205	60	30	183	61	30	25	27	24	32	5
Soil Science	2691	594	446	127	282	224	88	143	220	162	99	96	72	72	58	115	28	70	77	86	32	18
Geochemistry Geophysics	2651	1089	349	377	435	147	59	342	106	134	121	107	138	65	103	50	67	96	39	50	34	12
Engineering Electrical Electronic	2540	540	518	101	120	87	56	90	80	103	33	170	35	30	150	42	19	5	30	13	20	4
Evolutionary Biology	2396	997	160	311	241	321	93	247	203	92	92	67	132	111	14	69	92	27	79	78	69	20
Construction Building Technology	2224	338	350	216	107	104	45	75	71	128	46	56	51	66	44	32	36	1	61	28	20	15
Economics	2159	547	260	237	177	171	37	82	92	82	117	63	50	80	31	40	50	7	22	37	31	17
Paleontology	2063	622	216	300	365	86	48	237	157	115	97	63	101	60	53	79	62	90	37	59	11	17
Agriculture Multidisciplinary	2033	268	236	99	163	200	33	101	121	87	87	68	67	33	84	133	19	2	56	54	39	11
Engineering Chemical	1941	320	237	138	88	74	37	65	102	119	30	67	23	58	67	36	16	4	28	14	21	9
Zoology	1744	565	67	125	110	181	57	98	90	97	33	34	21	32	16	78	48	43	28	32	36	20
Biology	1690	620	68	277	132	189	53	153	76	53	60	30	43	58	29	80	55	41	50	72	22	19

Table 4.5.1.9: Number of publications contributed by top 20 individual countries in top 30 individual research areas of total global climate change research during 2015-2019 and rank of India in the individual research area among top 20 countries.

Research Area	Global	USA	Peoples R China	England	Germany	Australia	Canada	France	Spain	Italy	Netherlands	Japan	Switzerland	India	Sweden	Brazil	Norway	Russia	Denmark	Scotland	Finland	India's Rank
Environmental Sciences	48201	14173	9862	4875	4502	3930	3562	2653	2725	2652	2146	1516	1696	1697	1835	1418	1099	637	1079	941	1097	12
Meteorology Atmospheric Sciences	29230	11171	6765	3614	3358	1905	1867	2022	1167	1240	1035	1411	1242	1321	946	559	892	753	372	363	548	9
Geosciences Multidisciplinary	26046	8556	5179	3445	3726	1801	1820	2382	1299	1326	1248	896	1405	1037	957	539	902	775	582	591	434	12
Ecology	21664	8691	2374	2352	2338	2714	2282	1832	1461	859	924	504	1090	388	1007	865	735	448	752	669	590	20
Water Resources	14831	2319	2531	1204	896	735	728	490	782	1050	414	389	294	722	461	356	282	79	275	219	255	9
Geography Physical	14706	3858	3092	1022	1084	1064	1081	610	647	730	668	315	390	611	346	334	220	207	159	182	127	10
Energy Fuels	11942	1716	2329	896	726	711	500	365	681	773	480	388	203	495	419	401	187	74	219	133	223	9
Multidisciplinary Sciences	11200	4535	2065	1542	1373	1141	875	930	651	519	482	387	545	602	493	433	372	191	313	288	227	13
Engineering Environmental	10374	3019	2104	1431	1566	739	742	1021	750	590	473	275	618	341	353	276	379	343	304	249	201	15
Plant Sciences	9500	2014	2232	712	535	643	539	353	480	542	389	283	232	334	404	312	187	49	314	112	200	12
Environmental Studies	9134	2344	1265	1243	1033	826	544	384	474	502	594	263	344	161	426	203	270	92	169	193	212	19
Oceanography	7860	1947	1162	596	878	750	506	545	710	524	248	250	300	350	227	398	145	123	159	140	120	11
Green Sustainable Science Technology	6849	1747	1297	475	307	486	472	226	298	399	178	158	119	294	152	95	133	56	90	69	73	9
Forestry	6714	1897	1144	241	652	384	661	382	592	380	123	170	279	65	275	271	124	115	108	101	260	20
Marine Freshwater Biology	6544	2166	459	613	542	963	617	553	473	361	174	201	110	98	211	321	266	95	212	161	156	19
Engineering Civil	6538	2420	777	870	721	884	686	576	476	333	286	144	286	146	252	330	214	110	241	231	184	18
Biodiversity Conservation	5980	2062	746	635	565	676	489	520	324	234	223	243	77	139	174	128	316	330	157	142	64	17
Agronomy	5539	1228	1067	243	483	440	281	394	340	375	196	166	113	375	121	289	57	36	129	101	98	7
Remote Sensing	4936	1601	1535	297	508	203	271	335	250	331	191	194	102	255	64	118	70	84	56	50	78	8
Soil Science	4194	908	1149	191	493	346	278	235	305	228	170	116	125	128	113	184	35	188	75	85	62	13
Geochemistry Geophysics	4178	710	678	338	169	267	196	157	214	330	88	119	89	134	112	62	77	39	100	40	61	10
Paleontology	4065	709	723	143	209	134	162	153	141	212	58	156	52	466	32	68	28	56	60	31	45	3
Engineering Electrical Electronic	3721	1620	446	461	403	484	402	376	270	133	115	102	213	42	203	184	134	77	132	105	99	20
Evolutionary Biology	3568	693	762	311	224	163	193	100	170	161	95	106	69	157	78	67	38	13	44	26	34	9
Construction Building Technology	3166	1225	699	458	474	206	191	343	120	151	139	118	151	149	90	65	87	147	39	73	30	10
Engineering Chemical	3049	458	412	165	211	265	107	174	187	183	153	109	63	208	46	210	33	9	69	54	38	6
Agriculture Multidisciplinary	2791	927	477	286	150	286	208	86	109	137	103	69	73	61	119	72	41	22	58	36	37	15
Economics	2579	399	487	154	93	66	131	79	136	262	20	67	28	135	72	58	42	20	46	21	33	6
Geology	2514	919	133	159	169	232	206	133	111	104	52	41	38	24	55	167	58	66	43	47	43	20
Public Environmental Occupational Health	2510	944	169	358	192	320	228	204	115	85	85	43	73	66	106	165	74	67	84	82	47	18

4.5.1.6. Period-wise research themes and research topic analysis of Indian research Publications on "Climate Change"

4.5.1.6.1. Quantitative evolution of keywords

The quantitative evolution and exchange of keywords from the previous period to the next period are represented in Figure 4.5.1.8 for total Indian publications, respectively. Each circle contains the number of keywords during that period which is indicated below the circle. The arrow containing the number of keywords coming towards the circle indicates newly arisen keywords. On the other hand, the arrow going outside indicates the number of keywords that are not used at successive periods. The arrow pointing from the previous to successive period represents the number of keywords exchanged (integer value) and the fraction of overlap (i.e., Similarity Index) in parentheses.

The higher value of the similarity index indicates the core themes of Indian climate change research remain more or less continuous, whereas, the quantity of newly evolved keywords indicates the diversification of the core themes in different subthemes. During the initial period (1985-1989) in Indian climate change research total of 11 publications, there was no significant keyword to designate the research theme. The number of keywords did increase from 114 during the second period to 2163 during the latest period with a CPGR of 80.15%. Indian climate change research has incorporated a decreased proportion of new keywords at successive periods (77% during 1995-1999, 66.27% during 2000-2004, 61.7% during 2005-2009, 51.39% during 2010-2014, 26.59% during 2015-2019).

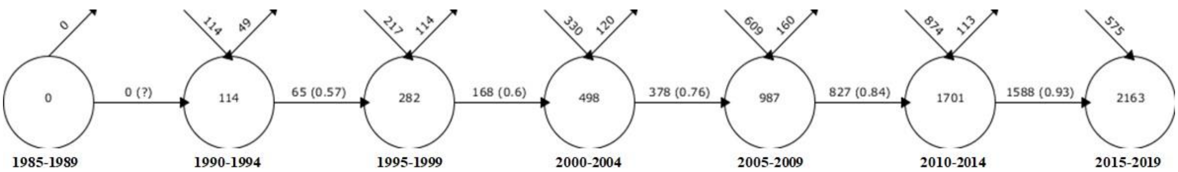


Figure 4.5.1.8: Overlapping map of keyword's quantitative perspective during successive periods of Indian research Publications on "Climate Change".

4.5.1.6.2. Thematic evolution

Figure 4.5.1.9 represents the thematic evolution of Indian climate change research, respectively. Different themes were plotted in the columns for each period indicated below their designated column. The size of the node indicating the theme cluster is proportional to the number of published documents associated with each theme cluster. Themes having a relationship between periods are connected by links. The thickness of the link is proportional to the Inclusion Index, which is explained as a degree of commonality. In the case of Indian climate change research, seven themes namely "OCEANS", "PLANTS", "ECOSYSTEMS", "SIMULATIONS", "INFECTIONS", "SEA-SURFACE-TEMPERATURES" and "SOILS" have solid links with the themes of the next period that indicates the continuity of the associated keywords vis-à-vis topics. In some of these themes have been appeared during the next period like "SEDIMENTS", "SIMULATIONS", "SOILS". During 1995-1999 the new themes have appeared like "SENSITIVITIES", and "STABLE-ISOTOPES" represent transition themes that shared the main topics. Although these themes have not appeared during the next period.

During 2000-2004 the new themes have appeared like "RECORDS", "MODELS", "CLIMATE-CHANGES", "CARBONATES", "GENERAL-CIRCULATION-MODELS", "DEPOSITS", "AEROSOLS" and "PADDY-FIELD" represent transition themes that shared the main topics. "CLIMATE-CHANGES" themes have appeared throughout the successive period from 2000-2004 to 2015-2019.

During 2005-2009 six themes namely "CLIMATE-CHANGES", "CLIMATES", "SENSITIVITIES", "METHANE-EMISSIONS", "INDIAN-MONSOONS", "WESTERN-GHATS" have solid links with the themes of the next period that indicates the continuity of the associated keywords vis-à-vis topics. During 2010-2014 eight themes namely "GLOBAL-WARMING-POTENTIALS", "CLIMATE-CHANGES", "CLIMATES", "BASINS", "INTENSITIES", "MASS-BALANCES" have solid links with the themes of the next period. In this period "SEA-SURFACE-TEMPERATURES" again appeared after 1990-1994 and "SIMULATIONS" appeared after 1995-1999.

During 2010-2014, three themes "CLIMATE-CHANGES", "GLOBAL-WARMING-POTENTIALS", "MASS-BALANCES" have appeared as transition themes among these 21 have shared the main topics with the themes of the last period (2015- 2019). It has been observed that the themes "SIMULATIONS" have shared main topics and sub-topics only with the following themes "INDIAN-SUMMER-MONSOONS" and "UNCERTAINTIES" during the last period. The themes have acted as a thematic bridge those have received topics from the previous period as well as shared its main topics of the next period "EMISSIONS" to "ENERGIES", "INTENSITIES" to "TROPICAL-CYCLONES" and "SEA-SURFACE-TEMPERATURES" to "INDIAN-SUMMER-MONSOONS".

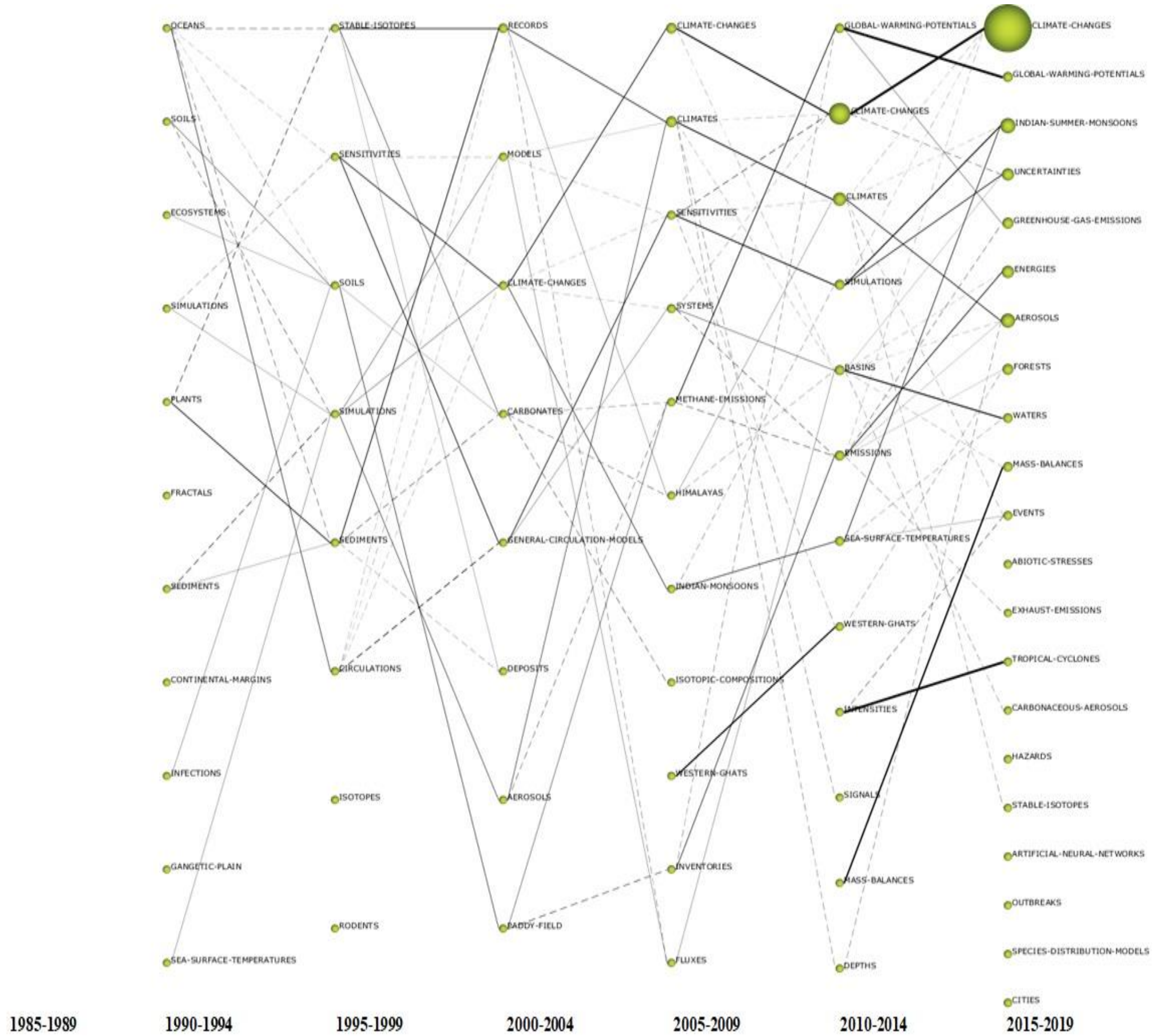


Figure 4.5.1.9: Evolution of themes of Indian research Publications on "Climate Change" during successive periods.

4.5.1.6.3. Continuity of themes

Figure4.5.1.10 illustrates how the themes are distributed at successive periods (from 1990-1995 to 2015-2019) of Indian research Publications on "Climate Change". The distribution and trend of carryover indicate a tendency of discontinuity of themes. It has been observed that none of the themes were omnipresent in every period and that most of the themes had newly arisen in each period. A very few themes have appeared at intervals although, their document frequency and citation impact were found to be very low. The theme "CLIMATE-CHANGES" was the main theme during the 2000-2004 period which has appeared throughout the last period. The themes “CLIMATES” have appeared during 2005-2009 which has appeared throughout the last period and “GLOBAL-WARMING-POTENTIALS” have appeared during the last two periods.

4.5.1.6.4. Quantitative and qualitative development of themes at successive periods

Thematic evolution was represented through strategic diagrams at successive periods. Themes were plotted as circles denoting different theme clusters according to centrality and density in strategic diagrams. The size of the circle is proportional to the number of documents and referred to as document frequency (DF) in which it’s linked or related keywords are present. The strategic diagrams are divided into four quadrants and they can be interpreted as follows: the top-right quadrant represents “motor themes”, the top-left quadrant represents “highly developed and isolated themes”, the bottom-left quadrant represents “emerging or declining themes”, the bottom-right quadrant represents “basic and transversal themes”.

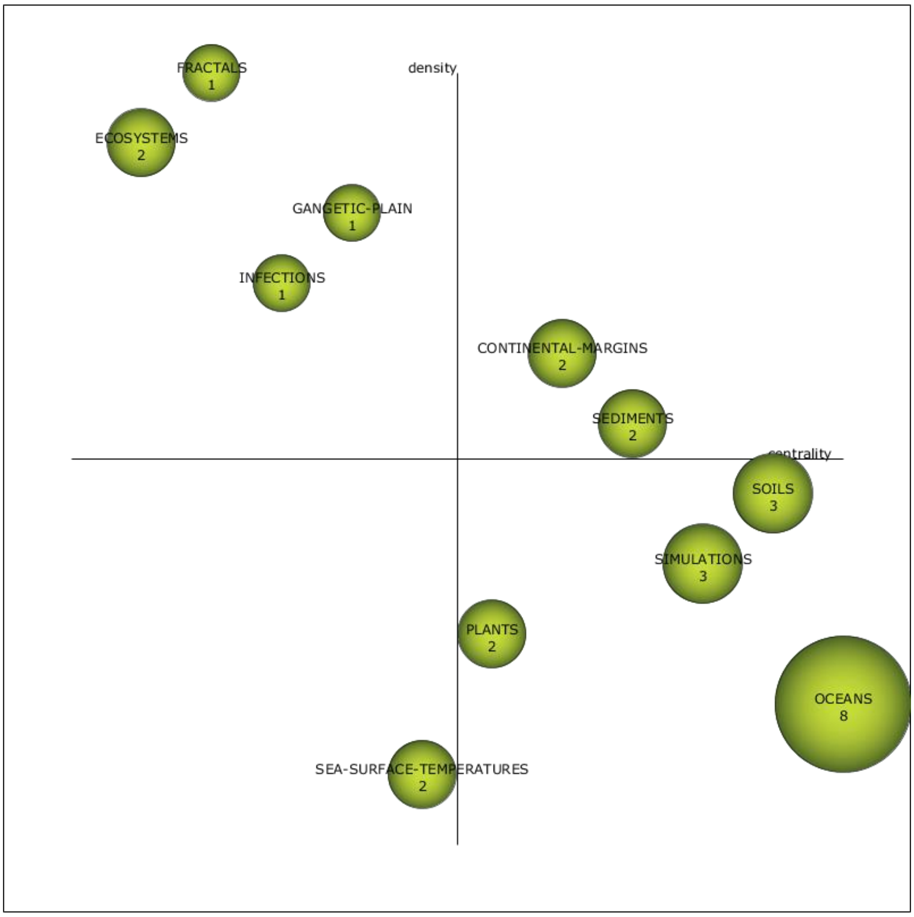


Figure 4.5.1.10: Strategic diagram of themes during 1990-1994 ofIndian research Publications on “Climate Change”

A total of 146 Indian research Publications on “Climate Change” were recorded during 1985-1989. There were not enough keywords which are required to designate particular research themes during this period. During 1990-1994 a total of only 114 keywords were observed among the total 266 publications. The second period has registered eleven themes with very lower DF. During this period “SEDIMENTS” was found to be the most active theme having a DF of 2(Figure 4.5.1.10, Table 4.5.1.10). The theme “SEDIMENTS” received maximum document citations (32). The theme “SEDIMENTS” was positioned in the top-right quadrant with the highest centrality value (11.25) indicating itself as the most important and well-connected theme with other keywords vis-à-vis themes followed by “CONTINENTAL-MARGINS” with DF of 2, documents citation 27 and centrality value of 7.5. The theme “ECOSYSTEMS”, “FRACTALS”, “INFECTIONS” and “GANGETIC-PLAIN” was positioned in the top-left quadrant with no centrality, thereby assigning it as an isolated theme. The themes “SEA-SURFACE-TEMPERATURES” were found to come under emerging focus, as they were positioned in the bottom-left quadrant. The theme “OCEANS” appeared in the bottom-right quadrant as basic and transversal themes with the highest DF (8), highest document citations (250) and also the highest centrality value of 64.67during this period. Table 4.5.1.11 shows the associated subthemes with the core themes and the number of documents in which these have appeared.

Table 4.5.1.10: Quantitative and qualitative performance measures of themes ofIndian research Publications on “Climate Change” during 1990-1994.

Name	**Centrality**	**Density**	**Core Documents Count**	**Core Documents Sum Citations**	**Secondary Documents Count**	**Secondary Documents Sum Citations**
Oceans	64.67	29.04	8	250	14	856
Soils	24.19	61.67	3	203	9	759
Ecosystems	0	140	2	5	2	5
Simulations	14.11	60	3	16	3	22
Plants	2.5	57.5	2	272	5	424
Fractals	0	150	1	0	0	0
Sediments	11.25	62.5	2	32	1	16
Continental-Margins	7.5	62.5	2	27	1	22

Infections	0	100	1	4	1	4
Gangetic-Plain	0	100	1	128	1	128
Sea-Surface-Temperatures	2.08	16.67	2	110	2	73

Table 4.5.1.11: Frequency of subtopics (keywords) of different themes ofIndian research Publications on "Climate Change" during 1990-1994.

Theme	**Subtopics (Number of Documents)**	**Theme**	**Subtopics (Number of Documents**
Oceans	Climates 5 Circulations 4 Temperatures 3 Basins 3 Winds 3 Records 2 Fields 2 Indian-Summer-Monsoons 2 Monsoons 2 Layers 2 Plateaus 1	Sediments	Dimensions 1 Delays 1 Attractors 1
Soils	Potential-Yields 3 Environments 2 Models 2 Origins 2 Simulation-Models 2 Yields 1 Fluxes 1 Field-Measurements 1 Micronutrient-Deficiencies 1	Continental-Margins	Black-Shales 1 Anomalies 1 Sinks 1
Ecosystems	Energy-Requirements 2 Wheat-Crops 2 Renewable-Energy-Sources 1 Energy-Use-Patterns 1	Infections	Goats 1 Vaccines 1
Simulations	Energy-Requirements 2 Wheat-Crops 2 Renewable-Energy-Sources 1 Energy-Use-Patterns 1	Gangetic-Plain	Ages 1 Megafans 1
Plants	Climatic-Changes 4 Ratios 1 Indicators 1 Pollens 1	Sea-Surface-Temperatures	Clouds 1 Upper-Air-Temperatures 1
Fractals	Dimensions 1 Delays 1 Attractors 1		

During 1995-1999 a total of only 282 keywords were recorded with a growth rate of 147.37% among the entire 500 publications (increased by 87.97 %). The third period has registered eight themes with a higher DF than the previous period. During this period "STABLE-ISOTOPES" was found to be the most active theme having a DF of 10(Figure 4.5.1.11, Table 4.5.1.12). The theme "STABLE-ISOTOPES" received maximum document citations (419). The theme "STABLE-ISOTOPES" was positioned in the top-right quadrant with the highest centrality value (48.26) indicating itself as the most important and well-connected theme with other keywords vis-à-vis themes. The theme "SOILS", "CIRCULATIONS" and "ISOTOPES" was positioned in the top-left quadrant with no centrality, thereby assigning it as an isolated theme. The themes "RODENTS" were found to come under emerging focus, as they were positioned in the bottom-left quadrant and also appeared in the top-left quadrant. The theme "SEDIMENTS" appeared in the bottom-right quadrant as basic and transversal themes with the highest DF (14) and "SIMULATIONS" highest document citations (1,718) during this period. Table 4.5.1.13 shows the associated subthemes with the core themes and the number of documents in which these have appeared.

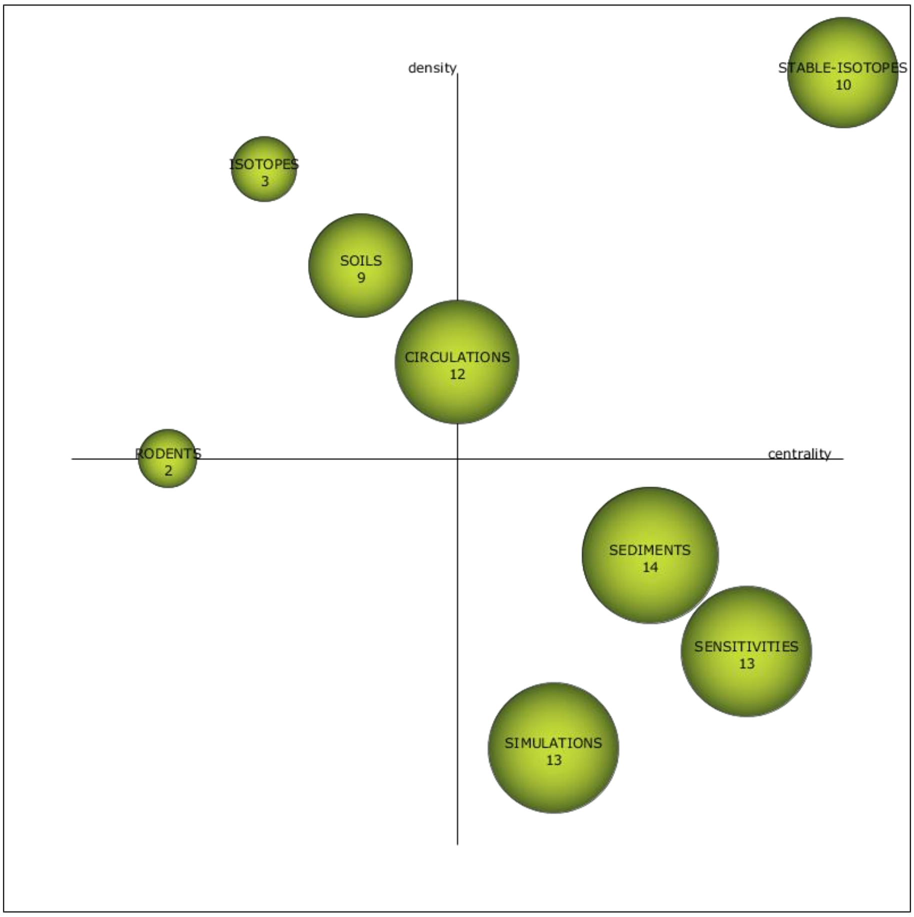


Figure 4.5.1.11: Strategic diagram of themes ofIndian research Publications on "Climate Change" during 1995-1999

Table 4.5.1.12: Quantitative and qualitative performance measures of themes ofIndian research Publications on "Climate Change" during 1995-1999.

Name	Centrality	Density	Core Documents Count	Core Documents Sum Citations	Secondary Documents Count	Secondary Documents Sum Citations
Stable-Isotopes	48.26	23.69	10	419	31	3,992
Sensitivities	48.22	12.16	13	1,097	42	2,117
Soils	25.02	19.21	9	185	14	383
Simulations	39.15	9.58	13	1,718	36	2,486
Sediments	47.1	13.09	14	549	43	1,889
Circulations	39	18.12	12	530	45	1,434
Isotopes	11.61	22.92	3	79	6	339
Rodents	3.22	13.89	2	45	3	118

Table 4.5.1.13: Frequency of subtopics (keywords) of different themes ofIndian research Publications on "Climate Change" during 1995-1999.

Name	Subtopics (No. of Documents)		Name	Subtopics (No. of Documents)	
Stable-Isotopes	Records	11	Sediments	Climates	29
	Monsoons	11		Sediments	11
	Calcretes	7		Climatic-Changes	8
	Stable-Isotopes	6		Plants	4
	Carbonates	6		Ratios	4
	Tropical-Forests	3		Events	4
	Pollens	3		Basins	3
	Pedogenic-Carbonates	3		Sea-Level-Changes	3
	Deposits	3		Deserts	3
	Peats	2		Clay-Minerals	2
	Indicators	2		Estuaries	2
	Caliches	2		C/N-Ratios	2
Sensitivities	Temperatures	19	Circulations	Oceans	17
	Climate-Changes	16		Circulations	14
	Sensitivities	11		Systems	10
	General-Circulation-Models	9		Parameterizations	7
	Impacts	3		Schemes	5
	Western-Himalayas	2		Oscillations	4
	Projects	2		Indian-Monsoons	4
	Increases	2		Flows	3
	Gcms	2		Teleconnections	3
	Asian-Monsoons	2		Generations	2
	Regional-Climates	2		Indian-Summer-Monsoons	2
	Seedlings	2		Motions	2

Soils	Soils	10	Isotopes	Waters	6
	Emissions	3		Isotopes	2
	Forests	3		Groundwaters	2
	Ecosystems	3		Glaciations	2
	Paddy-Field	3			
	Fields	2			
	Yields	2			
	Infections	2			
	Heavy-Metals	2			
	Grasslands	2			
	Wetlands	2			
	Greenhouse-Effects	2			
Simulations	Models	19	Rodents	Extinctions	3
	Simulations	16		Outbreaks	2
	Sea-Surface Temperatures	8		Rodents	2
	Greenhouse-Gases	4			
	Covers	3			
	Aerosols	2			
	Environments	2			
	Regions	2			
	Runoffs	2			
	Crops	2			
	Surfaces	2			
	Scales	2			

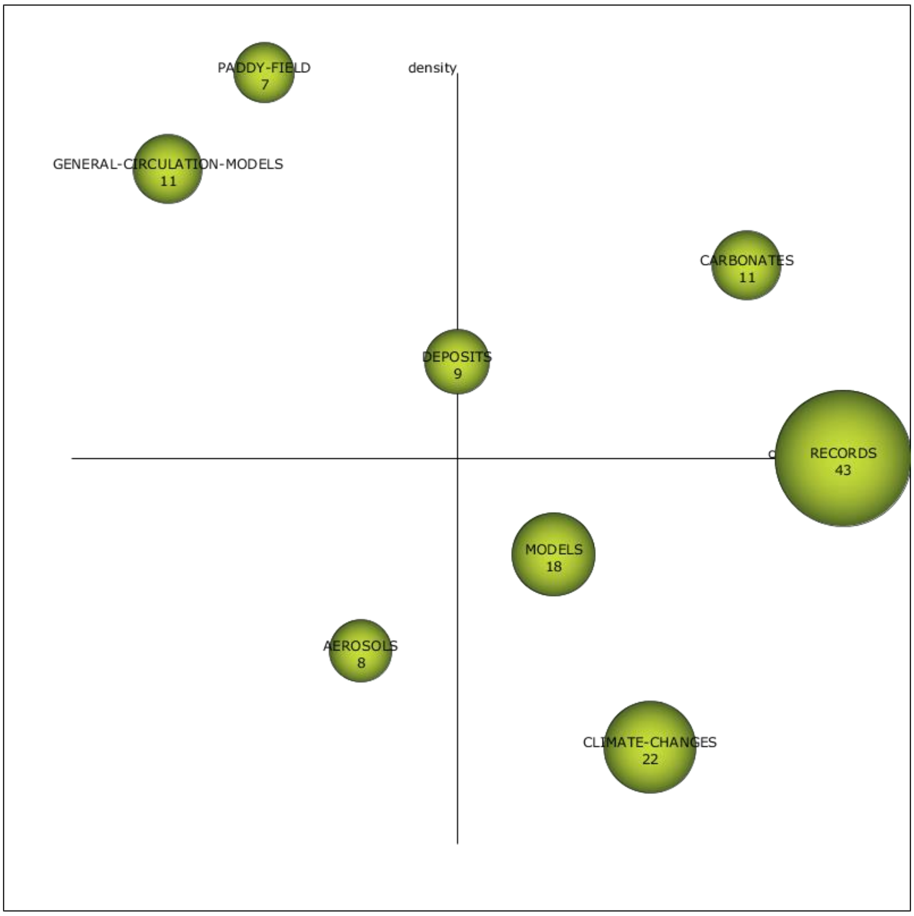


Figure 4.5.1.12: Strategic diagram of themes ofIndian research Publications on "Climate Change" during 2000-2004

During 2000-2004 a total of 498 keywords were observed with a growth rate of 76.60% among the entire 952 publications (increased by 90.40%). The fourth period has also registered eight themes with a higher DF than the previous period. During this period "RECORDS" was found to be the most active theme having a DF of 43 followed by "CARBONATES" with DF (11) (Figure 4.5.1.12, Table 4.5.1.14). The theme "RECORDS" received maximum document citations (2,986). The theme "RECORDS" was positioned in the top-right quadrant with the highest centrality value (21.36) indicating itself as the most important and well-connected theme with other keywords vis-à-vis themes followed by "CARBONATES" with centrality value (17.55). The theme "GENERAL-CIRCULATION-MODELS", "DEPOSITS" and "PADDY-FIELD" was positioned in the top-left quadrant with no centrality, thereby assigning it as an isolated theme. The themes "AEROSOLS" were found to come under emerging focus, as they were positioned in the bottom-left quadrant. The theme "CLIMATE-CHANGES" and "MODELS" appeared in the bottom-right quadrant as basic and transversal themes. Table 4.5.1.15 shows the associated subthemes with the core themes and the number of documents in which these have appeared.

Table 4.5.1.14: Quantitative and qualitative performance measures of themes ofIndian research Publications on "Climate Change" during 2000-2004.

Name	**Centrality**	**Density**	**Core Documents Count**	**Core Documents Sum Citations**	**Secondary Documents Count**	**Secondary Documents Sum Citations**
Records	21.39	7.28	43	2,986	111	5,242
Models	11.15	5.54	18	1,118	58	2,876
Climate-Changes	15.74	3.96	22	1,761	77	4,876
Carbonates	17.55	13.4	11	336	29	762
General-Circulation-Models	4.11	16.43	11	1,030	40	2,411
Deposits	8.02	9.29	9	471	12	730
Aerosols	4.73	4.76	8	698	30	2,312
Paddy-Field	4.69	18.57	7	160	17	549

Table 4.5.1.15: Frequency of subtopics (keywords) of different themes ofIndian research Publications on "Climate Change" during 2000-2004.

Theme	Subtopics (Number of Documents)		Theme	Subtopics (Number of Documents	
Records	Climates	85	General-Circulation-Models	General-Circulation-Models	17
	Records	30		Sensitivities	13
	Monsoons	24		Systems	12
	Sediments	17		Parameterizations	7
	Basins	13		Predictions	6
	Himalayas	12		Schemes	6
	Stable-Isotopes	8		Projects	5
	Oscillations	6			
	Lakes	5			
	Pollens	5			
	Periodicities	3			
	Sea-Level-Changes	3			
Models	Models	38	Deposits	Deposits	11
	Surfaces	12		Events	6
	Fluxes	10		Chronologies	5
	Anthropogenic-Aerosols	9		Ganga-Plains	4
	Clouds	6		Sandstones	3
	Indian-Summer-Monsoons	5		Palaeosols	3
	Frequencies	5			
	Particles	4			
	Sulfate-Aerosols	4			
	Increases	3			
	Sulfates	3			
	Algorithms	3			
Climate-Changes	Climate-Changes	31	Aerosols	Aerosols	14
	Temperatures	21		Greenhouse-Gases	12
	Impacts	20		Size-Distributions	8
	Rivers	9		Transports	8
	Simulations	8		Trace-Gases	3
	Responses	8		Tropospheric-Aerosols	3
	Indian-Monsoons	7			
	Regions	7			
	Trends	6			
	Surface-Temperatures	6			
	Asian-Monsoons	4			
	Developing-Countries	4			
Carbonates	Soils	15	Paddy-Field	Emissions	12
	Carbonates	11		Methane-Emissions	7
	Sequences	7		Paddy-Field	6
	Carbon-Isotopes	6		Budgets	3
	Clay-Minerals	6		Fertilizers	3
	Paleosols	5			
	Calcretes	4			
	Ratios	3			

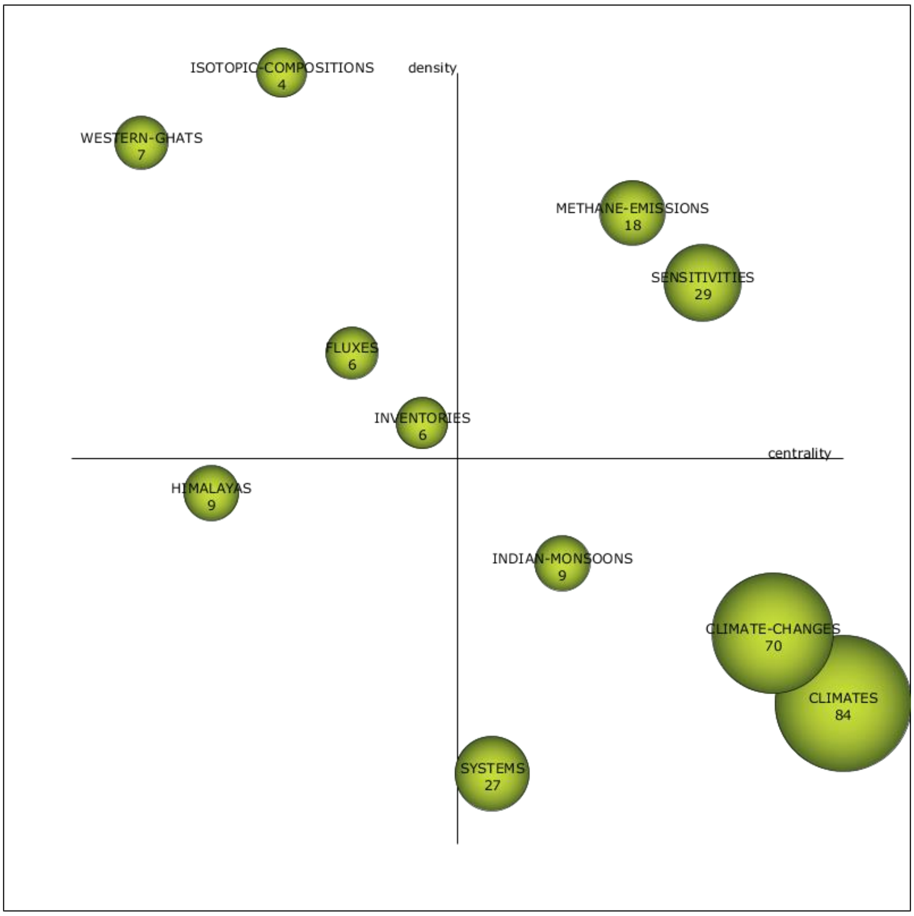


Figure 4.5.1.13: Strategic diagram of themes ofIndian research Publications on "Climate Change" during 2005-2009

During 2005-2009 a total of 987 keywords were registered with a growth rate of 98.19% among the entire 2385 publications (decreased by 150.53 %). The fifth period has registered eleven themes with much higher DF than the previous period. During this period "SENSITIVITIES" was found to be the most active theme having a DF of 29 followed by "METHANE-EMISSIONS" with DF (18) (Figure 4.5.1.13, Table 4.5.1.16). The theme "SENSITIVITIES" received maximum document citations (1,416). The theme "SENSITIVITIES" was positioned in the top-right quadrant with the highest centrality value (8.72) indicating itself as the most important and well-connected theme with other keywords vis-à-vis themes followed by "METHANE-EMISSIONS" with centrality value (8.72). The theme "ISOTOPIC-COMPOSITIONS", "WESTERN-GHATS", "INVENTORIES" and "FLUXES" was positioned in the top-left quadrant with no centrality, thereby assigning it as an isolated theme. The themes "HIMALAYAS" were found to come under emerging focus, as they were positioned in the bottom-left quadrant. The theme "CLIMATES" appeared in the bottom-right quadrant as basic and transversal themes with highest DF (84), highest document citations (4217) and also with the highest centrality value (12.38) followed by “CLIMATE-CHANGES” DF (70), document citations (3920) and centrality value (10.45) during this period. The associated subthemes also increased with a higher DF along with the core themes (Table 4.5.1.16).

Table 4.5.1.16: Quantitative and qualitative performance measures of themes ofIndian research Publications on “Climate Change” during 2005-2009

Name	Centrality	Density	Core Documents Count	Core Documents Sum Citations	Secondary Documents Count	Secondary Documents Sum Citations
Climate-Changes	10.45	2.87	70	3,920	220	11,512
Climates	12.38	2.43	84	4,217	278	12,718
Sensitivities	8.78	7.41	29	1,416	146	6,543
Systems	4.41	2.14	27	1,384	122	6,071
Methane-Emissions	8.42	11.57	18	2,312	76	4,433
Himalayas	0.62	3.78	9	428	36	1,541
Indian-Monsoons	4.45	3.42	9	362	42	1,565
Isotopic-Compositions	0.63	14.58	4	223	12	505
Western-Ghats	0.36	12.84	7	274	14	668
Inventories	2.06	3.93	6	267	39	3,213
Fluxes	0.82	4.23	6	156	43	1,794

Table 4.5.1.17: Frequency of subtopics (keywords) of different themes ofIndian research Publications on “Climate Change” during 2005-2009.

Theme	Subtopics (Number of Documents)	Theme	Subtopics (Number of Documents
Climate-Changes	Temperatures 66 Impacts 60 Rivers 19 Environmental-Changes 16 Adaptations 13 Vulnerabilities 9 Crop-Models 6 Ecosystems 6 Ices 5 Rains 4 Temperature-Trends 4	Methane-Emissions	Soils 44 Greenhouse-Gases 27 Fields 18 Methane-Emissions 18 Nitrous-Oxide-Emissions 11 Cropping-Systems 10

Climates	Models 84 Monsoons 54 Aerosols 32 Records 32 Sediments 28 Oceans 21 Transports 21 Satellites 17 Aerosol-Optical-Depths 9 Siwaliks 8 Reconstructions 7	Himalayas	Himalayas 30 Glaciers 13 Paleosols 6 Melts 5
		Indian-Monsoons	Sea-Surface-Temperatures 25 Indian-Monsoons 15 Western-Himalayas 13 Asian-Monsoons 9
Sensitivities	Simulations 41 Circulations 38 Sensitivities 29 Patterns 28 Clouds 17 General-Circulation-Models 17 Parameterizations 15 Runoffs 12 Water-Resources 12 Streamflows 7 Change-Impacts 6 River-Basins 6	Isotopic-Compositions	Oxygen-Isotopes 8 Carbon-Isotopes 6 Isotopic-Compositions 6
		Western-Ghats	Western-Ghats 15 Tropical-Forests 9 Tropical-Rain-Forests 4
Systems	Waters 46 Systems 42 Yields 37 Energies 15 Greenhouses 15 Gangetic-Plain 13 Responses 10 Heaters 4	Inventories	Emissions 31 Inventories 12 Greenhouse-Gas-Emissions 10
		Fluxes	Basins 31 Fluxes 20 Paddies 4

During 2010-2014 a total of 1701 keywords were observed with a growth rate of 72.34% among the entire 6677 publications (increased by 179.96 %). The sixth period has registered twelve themes with the increased DF within a range of 6 to 379. During this period “CLIMATE-CHANGES” was found to be the most active theme having a DF of 379 (Figure 4.5.1.14, Table 4.5.1.17). The theme “CLIMATE-CHANGES” received maximum document citations (14,836). The theme “CLIMATE-CHANGES” was positioned in the top-right quadrant with the highest centrality value (14.72) indicating itself as the most important and well-connected theme with other keywords vis-à-vis themes. The theme “SIMULATIONS”, “MASS-BALANCES” and “INTENSITIES” was positioned in the top-left quadrant with no centrality, thereby assigning it as an isolated theme. The themes “SEA-SURFACE-TEMPERATURES”, “WESTERN-GHATS” and “DEPTHS” were found to come under emerging focus, as they were positioned in the bottom-left quadrant. The theme “CLIMATES”, “SIMULATIONS” and “BASINS” appeared in the bottom-right quadrant as basic and transversal themes. The associated subthemes also increased with much higher DF along with the core themes (Table 4.5.1.18).

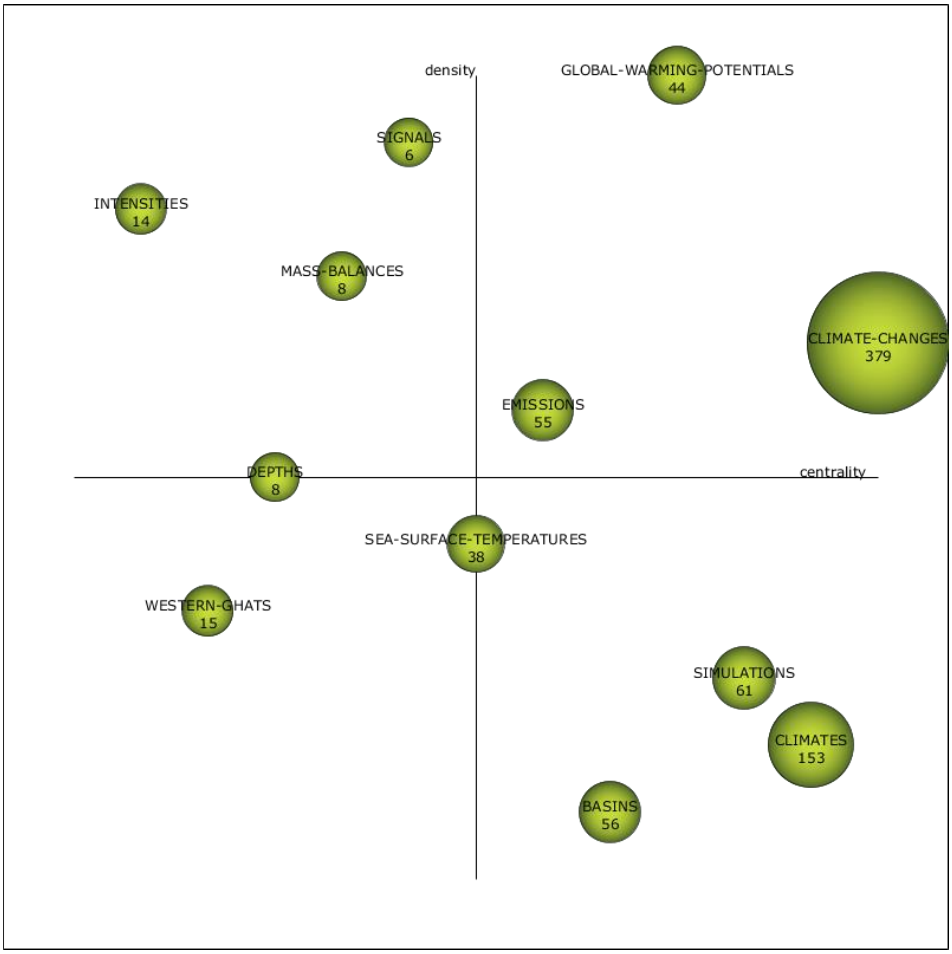


Figure 4.5.1.14: Strategic diagram of themes ofIndian research Publications on “Climate Change” during 2010-2014

Table 4.5.1.17: Quantitative and qualitative performance measures of themes ofIndian research Publications on “Climate Change” during 2010-2014

Name	Centrality	Density	Core Documents Count	Core Documents Sum Citations	Secondary Documents Count	Secondary Documents Sum Citations
Global-Warming-Potentials	8.76	37.04	44	1,117	93	5,377
Climate-Changes	14.72	5.61	379	14,836	989	38,984
Climates	12.68	2.15	153	3,791	583	20,108

Simulations	12.42	2.44	61	2,036	313	14,016
Basins	7.87	0.95	56	2,068	486	13,713
Emissions	5.54	4.35	55	2,364	395	15,659
Sea-Surface-Temperatures	4.38	3.38	38	1,613	220	7,498
Western-Ghats	0.39	2.78	15	257	102	3,723
Intensities	0.2	11.66	14	428	36	2,542
Signals	1.94	16.67	6	136	32	1,379
Mass-Balances	1.93	6.01	8	331	36	2,552
DEPTHS	1.63	3.92	8	236	45	1,244

Table 4.5.1.18: Frequency of subtopics (keywords) of different themes ofIndian research Publications on "Climate Change" during 2010-2014.

Theme	Subtopics (Number Of Documents)	Theme	Subtopics (Number Of Documents
Global-Warming-Potentials	Greenhouse-Gas-Emissions 33 Fields 32 Methane-Emissions 26 Nitrous-Oxide-Emissions 23 Rate-Constants 17 Hydrofluoroethers 11 Gas-Phase-Reactions 9 Oh-Radicals 8 Cl-Atoms 7 Atmospheric-Lifetimes 6 Lifetimes 5	Emissions	Yields 103 Energies 71 Forests 70 Soils 67 Greenhouse-Gases 58 Biofuels 32 Inventories 32 Fuels 18 Oils 10 Trace-Gases 10 Blends 6
Climate-Changes	Impacts 253 Temperatures 237 Models 208 Trends 135 Adaptations 78 Responses 58 River-Basins 44 Runoffs 38 Vulnerabilities 35 Water-Resources 27 Temperature-Trends 18	Sea-Surface-Temperatures	Indian-Summer-Monsoons 49 Oscillations 42 Events 41 Droughts 40 Indian-Monsoons 30 Madden-Julian-Oscillations 17 Teleconnections 15 Anomalies 12
Climates	Monsoons 116 Himalayas 73 Aerosols 65 Records 64 Oceans 63 Surfaces 34 Clouds 33 Particles 29 Size-Distributions 28 Brown-Clouds 7 Thecamoebians 5	Western-Ghats	Patterns 60 Tropical-Forests 20 Rain-Forests 12 Protected-Areas 8
		Intensities	Tropical-Cyclones 23 Frequencies 16 Hurricanes 6

Simulations	Predictions 66 Circulations 60 Sensitivities 55 Western-Himalayas 31 General-Circulation-Models 28 Uncertainties 28 Streamflows 26 Gcms 19 Regional-Climate-Models 18 Crop-Yields 15 Projections 15	Signals	Reconstructions 26 Tree-Rings 11
		Mass-Balances	Garhwal-Himalayas 15 Northwestern-Himalayas 9
Basins	Systems 135 Waters 100 Sediments 59 Regions 57 Areas 45 Indo-Gangetic-Plains 38 Groundwaters 28 Glaciers 27 Rivers 26 Climate-Change-Scenarios 21 Aquifers 12	Depths	Aerosol-Optical-Depths 29 Angstrom-Exponents 13

A total of 2163 keywords were observed during the last period (2015-2019) with a growth rate of 27.16% among the entire 13197 publications (increased by 97.65%). The last period has registered 21 themes with the maximum DF within a range of 6 to 1114. During this period "CLIMATE-CHANGES" was found to be the most active theme having a DF of 1,114 (Figure 4.5.1.15, Table 4.5.1.19). The theme "CLIMATE-CHANGES" received maximum document citations (18,452). The theme "CLIMATE-CHANGES" was positioned in the top-right quadrant with the highest centrality value (28.9) indicating itself as the most important and well-connected theme with other keywords vis-à-vis themes. Another theme "GLOBAL-WARMING-POTENTIALS", "INDIAN-SUMMER-MONSOONS", "UNCERTAINTIES" and "GREENHOUSE-GAS-EMISSIONS" was positioned in the top-right quadrant. The theme "EXHAUST-EMISSIONS", "TROPICAL-CYCLONES", "CARBONACEOUS-AEROSOLS", "OUTBREAKS, "SPECIES-DISTRIBUTION-MODELS" and "CITIES" was positioned in the top-left quadrant with no centrality, thereby assigning it as an isolated theme. The themes "HAZARDS", "STABLE-ISOTOPES", "ARTIFICIAL-NEURAL-NETWORKS" and "ABIOTIC-STRESSES" were found to come under emerging focus, as they were positioned in the bottom-left quadrant. The theme "GREENHOUSE-GAS-EMISSIONS", "ENERGIES", "AEROSOLS", "FORESTS", "WATERS" and "EVENTS" appeared in the bottom-right quadrant as basic and transversal themes. The number of associated subthemes and their frequency also increased with a higher DF along with the core themes (Table 4.5.1.18).

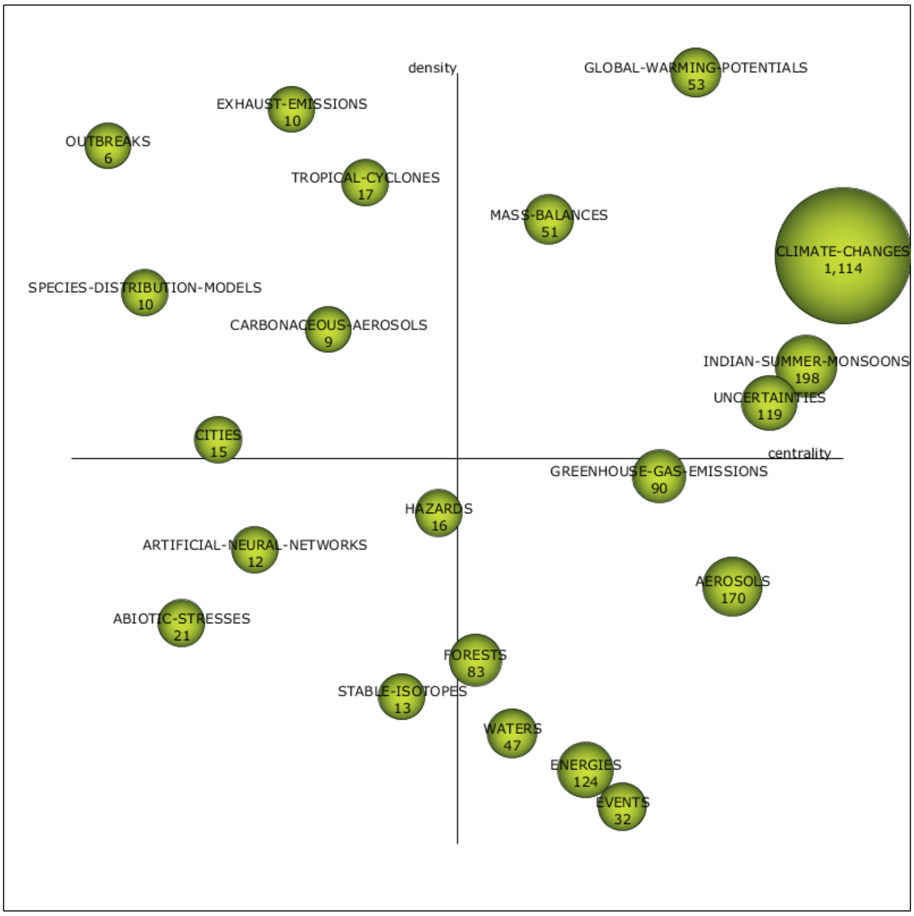


Figure 4.5.1.15: Strategic diagram of themes ofIndian research publications on “Climate Change” during 2015-2019

Table 4.5.1.19: Quantitative and qualitative performance measures of themes ofIndian research publications on “Climate Change” during 2015-2019

Name	Centrality	Density	Core Documents Count	Core Documents Sum Citations	Secondary Documents Count	Secondary Documents Sum Citations
Climate-Changes	28.9	4.84	1,114	18,452	2,312	32,529
Global-Warming-Potentials	6.62	60.37	53	652	176	2,556
Indian-Summer-Monsoons	9.29	3.63	198	2,896	702	9,108
Uncertainties	7.95	3.32	119	1,718	518	6,813
Greenhouse-Gas-Emissions	6.06	2.76	90	2,182	397	7,267

Energies	3.94	0.94	124	1,858	738	11,489
Aerosols	6.82	2.15	170	2,102	1,012	15,020
Forests	2.9	1.52	83	815	528	10,050
Waters	2.9	1.17	47	686	622	13,655
Mass-Balances	3.45	5.45	51	695	146	1,904
Events	4.8	0.78	32	553	428	4,560
Abiotic-Stresses	0.44	2.04	21	497	98	1,882
Exhaust-Emissions	0.79	13.35	10	365	29	476
Tropical-Cyclones	0.85	5.53	17	131	61	911
Carbonaceous-Aerosols	0.84	4.71	9	163	132	2,416
Hazards	1.9	2.51	16	239	152	1,860
Stable-Isotopes	1.39	1.19	13	181	154	2,189
Artificial-Neural-Networks	0.78	2.42	12	149	129	1,284
Outbreaks	0.02	6.48	6	32	39	273
Species-Distribution-Models	0.17	4.73	10	115	56	671
Cities	0.71	3.02	15	168	128	1,864

Table 4.5.1.20: Frequency of subtopics (keywords) of different themes ofIndian research publications on “Climate Change” during 2015-2019.

Theme	**Subtopics (Number Of Documents)**	**Theme**	**Subtopics (Number Of Documents**
Climate-Changes	Climate-Changes 1667 Impacts 668 Temperatures 574 Models 490 Trends 311 Yields 208 Adaptations 175 Himalayas 162 River-Basins 142 Vulnerabilities 108 Responses 100 Western-Himalayas 97	Waters	Waters 185 Droughts 165 Areas 85 Environments 82 Sediments 80 Groundwaters 50 Fluxes 48 Fishes 28 Aquifers 21
Global-Warming-Potentials	Mechanisms 55 Methane-Emissions 47 Cropping-Systems 46 Global-Warming-Potentials 42	Mass-Balances	Mass-Balances 60 Garhwal-Himalayas 54 Glaciers 47 Northwestern-

	Nitrous-Oxide-Emissions 42 Gas-Phase-Reactions 23 Rate-Constants 20 Oh-Radicals 18 Atmospheric-Lifetimes 14 Rate-Coefficients 14 Cl-Atoms 12 Hydrofluoroethers 11		Himalayas 43 Debris-Covered-Glaciers 22 Energy-Balances 20 Equilibrium-Line-Altitudes 12 Surface-Velocities 8
Indian-Summer-Monsoons	Simulations 280 Predictions 184 Sea-Surface-Temperatures 119 Circulations 116 Oceans 106 Parameterizations 58 General-Circulation-Models 36 Intraseasonal-Oscillations 33 Gcms 27 Teleconnections 26 Convection-Schemes 11	Events	Monsoons 158 Indexes 102 Events 101 Extremes 59 Floods 47 Frequencies 46 Precipitation-Extremes 23
		Abiotic-Stresses	Genes 35 Transcription-Factors 22 Antioxidants 19 Heat-Shock-Proteins 16
Uncertainties	Basins 123 Sensitivities 117 Runoffs 75 Water-Resources 67 Projections 61 Scenarios 61 Catchments 56 Streamflows 49 Climate-Change-Impacts 44 Ensembles 39 Change-Impacts 35	Exhaust-Emissions	Blends 18 Vegetable-Oils 13 Ci-Engines 6
		Tropical-Cyclones	Tropical-Cyclones 39 Intensities 35 Hurricanes 11 Storm-Surges 10
Greenhouse-Gas-Emissions	Soils 150 Greenhouse-Gases 75 Fields 54 Carbon-Footprints 36 Fertilizers 35 Environmental-Impacts 30 N2o-Emissions 25 Ch4-Emissions 15 Food-Wastes 13 Vehicles 12 Production-Systems 8	Carbonaceous-Aerosols	Indo-Gangetic-Plains 70 Particulate-Matters 51 Biomass-Burning-Emissions 18 Carbonaceous-Aerosols 15
		Hazards	Risks 87 Frameworks 50 Hazards 40 Glacial-Lakes 9
Energies	Systems 373 Designs 98 Efficiencies 62 Technologies 60 Strategies 59	Stable-Isotopes	Records 69 Stable-Isotopes 49 Asian-Monsoons 39 Environmental-Changes 35

	Biofuels 54 Generations 45 Fuels 32 Photovoltaics 24 Collectors 23 Oils 23	Artificial- Neural- Networks	Algorithms 64 Artificial-Neural-Networks 63 Support-Vector-Machines 23 Extreme-Learning-Machines 7
Aerosols	Climates 593 Emissions 176 Regions 160 Transports 81 Satellites 69 Clouds 56 Seasonal-Variations 47 Aerosol-Optical-Depths 42 Particles 36 Optical-Depths 27 Masses 20	Outbreaks	Infections 20 Epidemics 17 Outbreaks 14
		Species- Distribution- Models	Distributions 41 Ranges 20 Species-Distribution-Models 17
Forests	Patterns 126 Plants 112 Land-Uses 109 Ecosystems 61 Communities 56 Ecosystem-Services 49 Trees 32 Mangroves 28 Stocks 27 Landscapes 26 Gradients 17	Cities	Cities 74 Covers 57 Urban-Heat-Islands 27

4.5.2. Analysis from Scopus database:

4.5.2.1. Comparative total global and Indian contribution in different subject areas:

The top 10 subject areas of total global research on climate change have contributed 85 % cumulatively. India has contributed 83.34 % of total Indian publications in the global top 10 research areas. India has contributed at a higher proportion than the global in some research areas namely: Engineering, Energy, Biochemistry, Genetics & Molecular Biology, Computer Science, Multidisciplinary, Physics and Astronomy, Materials Science, Chemical Engineering which are mainly deal with the mitigation and adaptive measures of the climate change. India has contributed at a lower proportion than the global in some research areas namely: Environmental Science, Earth and Planetary Sciences, Agricultural & Biological Sciences, Social Sciences, Medicine and Business, Management & Accounting which are mainly deal with the causal factor identification and impact assessment of the climate change (Figure 4.5.2.1).

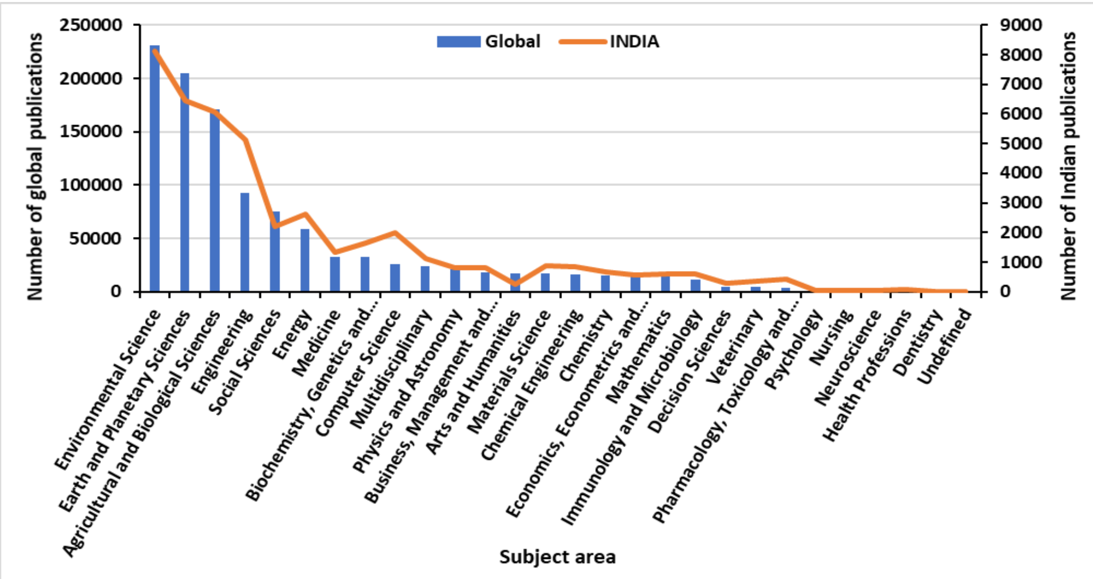


Figure 4.5.2.1: Global and Indian publication contribution in different subject areas

4.5.2.2. Period-wise growth of top 30 research areas of Indian publications:

Figure 4.5.2.2 shows the period-wise growth of the top 30 research areas of Indian publications on climate change. Figure 4.5.2.3 shows the CPGR of an individual research area. Some of the research areas of Indian publications contributed at higher CPGR than the CPGR of total Indian publications (111.37 %) namely: Computer Science (240.81 %), Economics, Econometrics and Finance (225.25 %), Decision Sciences (198.75 %), Mathematics (196.85 %), Business, Management and Accounting

(189.20 %), Biochemistry, Genetics and Molecular Biology(150.53 %), Social Sciences (149.54 %), Engineering (147.63 %), Materials Science (139.27 %), Nursing (134.52 %), Agricultural and Biological Sciences (128.62 %), Chemical Engineering (124.35 %), Chemistry (122.30 %), Pharmacology, Toxicology and Pharmaceutics (119.88 %), Arts and Humanities (119.88 %), Environmental Science(115.84 %). Other research areas contributed at lower CPGR than the CPGR of total Indian publications.

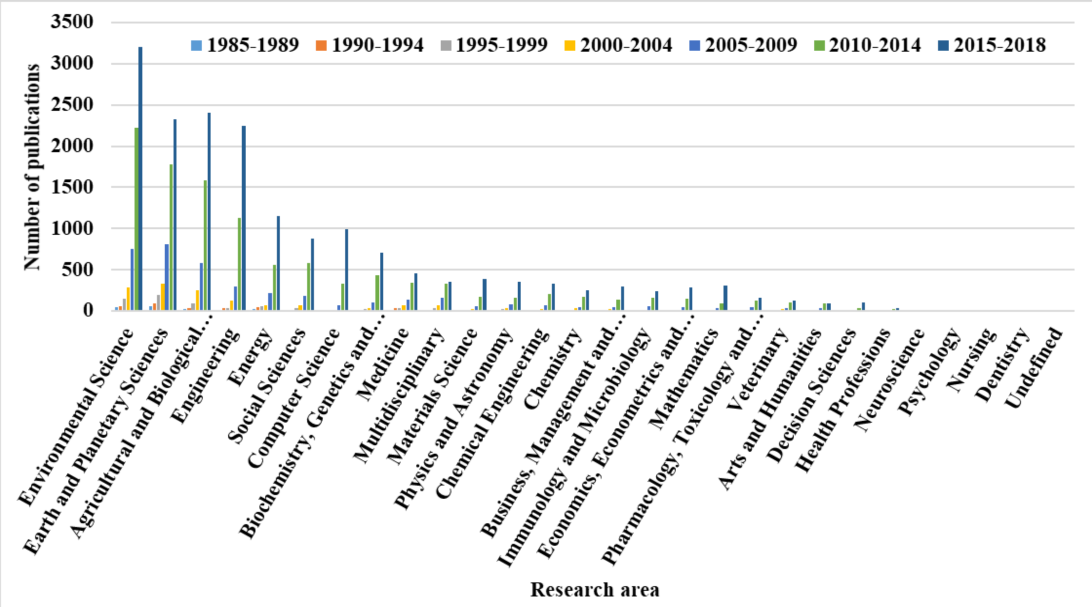


Figure 4.5.2.2: Period-wise evolving trends of subject areas of Indian publications on "Climate Change"

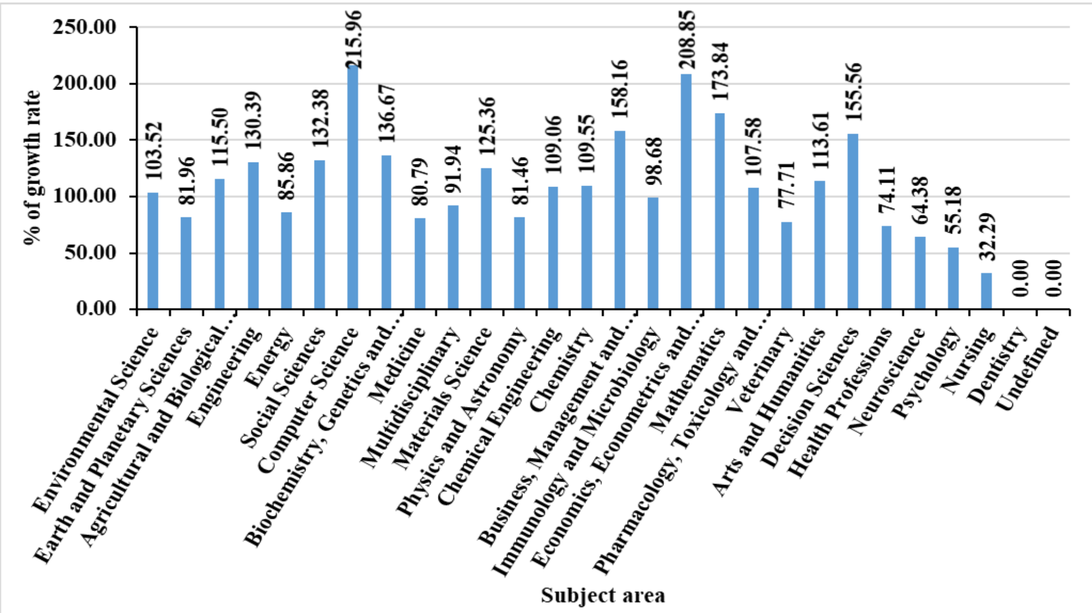


Figure 4.5.2.3: Period-wise growth rate of subject areas of Indian publications on "Climate Change"

4.5.2.3. Comparative Evolving trend of different subject areas among top 20 countries:

Table 4.5.2.1, Table 4.5.2.2, Table 4.5.2.3, Table 4.5.2.4, Table 4.5.2.5, Table 4.5.2.6, Table 4.5.2.7 and Table 4.5.2.8 show the number of publications contributed by the top 20 individual countries in different subject areas of total global climate change research and rank of India in the individual research area among top 20 countries during the total period (1985-2019), 1985-1989, 1990-1994, 1995-1999, 2000-2004, 2005-2009, 2010-2014 and 2015-2019 respectively. Throughout the periods the following subject areas namely Computer Science (Rank-3), Chemical Engineering (Rank-3), Veterinary (Rank-3), Pharmacology, Toxicology and Pharmaceutics (Rank-3), Engineering (Rank-4) and Materials Science (Rank-5), and Energy (Rank-7) cumulatively contributed more publications and placed better as compared with the top 20 countries. In the top ten subject areas of global cumulative publications, India ranked better in the following three subject areas Computer Science (Rank-3), Engineering (Rank-4), Energy (Rank-7). During the last period, Computer Science ranked 2nd, Engineering ranked 3rd and Energy ranked 6th among the top 20 countries and these subject areas are also positioned in the top ten subject areas of global cumulative publications.

Table 4.5.2.1: Number of publications contributed by top 20 individual countries in individual subject areas of total global climate change research during 1985-2019 and rank of India in the individual research area among top 20 countries.

SUBJECT AREA	GLOBAL	United States	United Kingdom	China	Germany	Australia	Canada	France	Italy	Spain	India	Japan	Netherlands	Switzerland	Sweden	Brazil	Norway	Russian Federation	Denmark	Finland	South Korea	India's rank
Environmental Science	231212	67897	24280	28048	18963	16131	15696	11534	9379	9569	8128	6843	8694	6672	7132	5253	4970	4280	4215	3906	3186	11
Earth and Planetary Sciences	205011	69492	24355	26983	21457	11420	12826	14966	8414	7022	6454	8343	6930	6745	4989	3493	4884	7036	2902	2697	3125	14
Agricultural and Biological Sciences	171219	50600	16751	20037	14948	13715	12472	11177	7511	9209	6083	5181	5443	5010	4849	6430	3637	3046	3510	3233	1780	11
Engineering	92629	19461	7193	11645	4908	3933	4133	3096	3838	2699	5138	4299	1983	1043	1599	1490	1173	1445	1054	895	1918	4
Social Sciences	75341	20029	10755	5296	5132	5900	4443	2730	2274	2208	2195	1618	2936	1681	2421	1192	1793	1332	1161	1062	869	12
Energy	59154	12001	5146	6180	3763	2603	2815	1928	2839	2090	2631	2323	1834	988	1578	1326	1175	651	865	813	1118	7
Medicine	33136	8818	4076	1727	2082	2311	1599	1712	1301	1016	1340	754	883	966	955	1041	580	546	498	392	346	8
Biochemistry, Genetics and Molecular Biology	33021	10270	3752	3807	2719	2776	2143	2293	1435	1867	1639	1133	1002	1002	990	1187	623	587	637	494	557	9
Computer Science	26084	5716	1597	3824	1544	1035	1012	994	1139	778	2003	1346	671	325	288	456	221	644	250	232	488	3
Multidisciplinary	24469	9717	3199	3390	2082	1895	1443	1502	646	834	1138	567	801	899	678	744	528	304	504	317	190	8
Physics and Astronomy	20989	6208	2018	2558	1985	609	857	1493	1178	711	826	1383	598	528	343	374	293	1000	230	187	387	10
Business, Management and Accounting	18160	5638	3392	1356	981	1386	830	539	626	518	795	395	624	302	488	384	287	184	261	308	224	7
Arts and Humanities	17485	3600	2017	906	1657	1177	1131	1202	733	657	268	268	618	620	682	174	626	399	435	279	140	17
Materials Science	16757	3249	772	2243	1029	488	538	622	596	466	866	1083	267	203	204	329	171	718	81	116	438	5
Chemical Engineering	15998	3200	848	1552	747	522	622	478	557	458	863	590	273	182	202	263	105	711	106	132	577	3
Chemistry	15738	4570	1283	2167	1198	672	837	721	549	635	661	805	340	409	309	327	274	305	229	152	474	9
Economics, Econometrics and Finance	15472	4406	1886	614	1457	1139	735	709	646	455	580	414	730	433	436	181	402	253	197	178	129	10
Mathematics	14651	3550	1537	1736	1262	1128	589	817	811	533	603	644	458	311	235	250	217	515	131	156	243	9
Immunology and Microbiology	11862	3103	1514	935	1029	856	655	906	562	699	598	255	423	375	378	515	211	173	298	174	188	9
Decision Sciences	4910	1004	438	678	307	557	253	196	235	172	284	134	122	98	103	136	82	81	63	63	56	6
Veterinary	4257	606	371	207	279	231	160	198	196	161	372	52	106	93	72	407	52	29	88	15	22	3
Pharmacology, Toxicology and Pharmaceutics	3520	708	279	478	209	111	148	129	170	119	426	87	108	64	64	114	44	91	51	48	42	3
Psychology	3079	1299	432	54	201	245	177	79	76	125	37	43	160	77	70	32	81	16	37	34	23	15
Nursing	1927	574	265	57	83	172	106	63	67	45	42	18	53	32	55	43	23	6	14	22	17	13
Neuroscience	1661	683	195	111	116	103	105	94	65	78	35	51	49	37	32	62	34	20	23	15	15	14
Health Professions	1110	222	120	47	64	118	69	36	28	30	75	19	23	27	33	18	25	30	13	9	6	4
Dentistry	163	31	31	17	2	7	3	3	5	5	12	2	2	1	8	8	3	1	3	1	1	4
Undefined	81	18	10	2	5	19	5	3	2	2	3	4	3	2	2	1	1	1	1	0	1	8

Table 4.5.2.2: Number of publications contributed by top 20 individual countries in individual research areas of total global climate change research during 1985-1989 and rank of India in the individual research area among top 20 countries.

SUBJECT AREA	GLOBAL	United States	United Kingdom	China	Germany	Australia	Canada	France	Italy	Spain	India	Japan	Netherlands	Switzerland	Sweden	Brazil	Norway	Russian Federation	Denmark	Finland	South Korea	India's rank
Earth and Planetary Sciences	4272	1248	327	94	119	201	223	1	39	16	64	71	68	57	64	11	31	26	19	20	1	9
Environmental Science	2850	739	217	34	69	131	137	149	23	11	45	34	49	34	44	14	14	18	13	19	0	8
Agricultural and Biological Sciences	1545	486	121	19	66	125	110	66	12	12	24	48	41	25	47	8	21	17	5	18	1	11
Engineering	1452	273	53	8	30	13	19	43	7	3	15	15	7	6	6	2	0	20	0	1	0	7
Medicine	1008	186	68	1	46	19	18	36	7	4	13	18	15	23	11	6	1	8	12	10	0	10
Social Sciences	698	183	73	14	20	30	27	17	1	0	0	21	11	10	24	1	2	11	0	7	0	18
Multidisciplinary	281	144	41	2	13	18	17	22	1	0	7	3	2	6	2	3	1	1	3	1	0	7
Energy	276	56	20	5	10	3	7	4	5	1	28	2	2	4	5	0	2	2	0	5	0	2
Arts and Humanities	248	124	22	2	5	10	22	5	4	0	1	1	3	6	11	0	8	2	1	1	0	14
Biochemistry, Genetics and Molecular Biology	211	49	27	3	20	12	7	16	4	3	4	13	5	3	9	3	1	0	2	1	1	11
Physics and Astronomy	200	84	13	3	10	3	3	12	6	3	10	3	1	8	0	0	2	1	1	0	0	5
Materials Science	168	50	3	1	5	1	4	2	4	4	3	1	0	3	2	0	2	2	0	4	0	8
Immunology and Microbiology	144	25	14	0	5	16	5	12	4	2	4	1	1	2	2	1	0	0	2	1	0	8
Veterinary	114	12	11	0	1	18	2	0	2	0	4	0	3	1	1	1	3	0	0	1	0	4
Computer Science	89	24	4	0	0	1	4	0	1	0	1	3	1	0	0	0	0	0	0	0	0	7
Chemistry	87	24	3	0	2	0	2	1	0	3	3	2	0	1	1	1	0	1	0	0	0	4
Chemical Engineering	77	14	2	1	5	0	2	3	0	0	4	1	0	1	0	0	0	0	0	0	0	3
Business, Management and Accounting	59	20	6	1	1	2	2	2	0	0	1	3	0	2	0	0	0	0	0	0	0	10
Psychology	54	33	5	1	1	0	1	0	1	0	0	2	1	0	1	0	2	0	0	0	0	17
Mathematics	49	24	5	0	1	3	0	1	0	0	0	2	1	0	0	0	0	1	0	0	0	13
Health Professions	44	7	5	0	3	0	3	3		0	0	1	0	1	3	0	0	0	0	0	0	12
Nursing	38	13	1	0	0	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
Economics, Econometrics and Finance	33	21	4	0	2	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0	12
Pharmacology, Toxicology and Pharmaceutics	26	8	2	0	3	1	0	2	0	0	2	0	2	1	0	0	0	0	1	0	0	5
Neuroscience	15	8	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	11
Decision Sciences	10	4	1	0	0	2	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	12
Dentistry	7	0	0	0	0	0	0	260	0	0	1	0	0	0	0	0	0	0	0	0	0	2
Undefined	5	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10

Table 4.5.2.3: Number of publications contributed by top 20 individual countries in individual research areas of total global climate change research during 1990-1994 and rank of India in the individual research area among top 20 countries.

SUBJECT AREA	GLOBAL	United States	United Kingdom	China	Germany	Australia	Canada	France	Italy	Spain	India	Japan	Netherlands	Switzerland	Sweden	Brazil	Norway	Russian Federation	Denmark	Finland	South Korea	India's rank
Earth and Planetary Sciences	8058	2067	572	231	353	314	362	372	120	54	88	159	134	81	87	36	74	100	40	34	3	12
Environmental Science	5872	1498	464	101	201	191	238	162	49	43	61	62	138	54	83	25	41	81	28	42	1	12
Agricultural and Biological Sciences	3353	883	373	68	140	223	222	189	50	59	37	105	88	39	72	12	40	31	40	40	3	17
Engineering	2071	673	128	52	57	25	64	47	27	6	35	63	26	26	20	12	18	52	12	7	3	9
Social Sciences	1525	401	176	47	30	63	70	28	4	4	13	12	29	10	23	4	14	15	4	8	0	12
Medicine	1222	235	122	8	58	40	21	51	32	9	40	22	15	31	26	6	18	10	13	13	0	6
Energy	895	220	117	9	41	17	25	21	22	3	47	20	14	9	15	5	13	8	8	4	0	3
Arts and Humanities	569	232	91	11	20	15	45	42	24	5	6	4	16	9	24	2	22	0	10	4	0	14
Multidisciplinary	564	298	81	3	22	20	24	37	1	1	16	2	7	10	5	1	8	10	12	3	1	7
Physics and Astronomy	522	141	23	6	26	6	8	14	22	2	5	12	7	4	2	1	4	9	1	0	0	12
Biochemistry, Genetics and Molecular Biology	431	126	70	14	30	10	15	13	4	8	12	16	10	2	11	1	2	4	2	6	0	8
Materials Science	425	69	11	1	16	5	8	9	4	3	14	7	4	7	6	0	4	8	1	1	0	3
Chemistry	375	84	17	1	15	4	9	4	7	3	8	16	6	1	3	0	2	5	0	1	0	6
Chemical Engineering	268	56	14	2	5	2	13	4	3	2	10	17	5	1	2	0	1	7	1	3	3	5
Computer Science	263	112	9	1	5	3	3	7	5	1	3	11	4	3	3	3	0	3	1	1	0	10
Immunology and Microbiology	215	43	40	1	16	13	8	11	7	14	6	2	6	4	6	1	0	3	4	3	0	9
Mathematics	149	67	6	0	6	3	6	3	3	2	2	2	3	1	1	1	1	5	1	0	0	11
Veterinary	120	23	14	0	9	10	0	10	1	4	0	1	7	2	0	0	0	1	4	2	0	16
Economics, Econometrics and Finance	118	53	8	0	5	4	6	3	0	0	1	0	2	0	1	0	7	2	0	1	0	10
Business, Management and Accounting	110	38	12	0	1	5	2	1	0	0	0	1	1	0	0	0	1	0	1	0	1	15
Pharmacology, Toxicology and Pharmaceutics	96	33	16	1	16	0	4	1	0	0	5	4	2	1	1	0	2	0	1	2	0	4
Psychology	74	47	7	0	1	1	2	0	1	1	1	0	0	0	2	0	1	0	0	0	0	9
Health Professions	37	10	2	0	4	1	1	2	0	0	0	0	2	0	1	0	1	0	1	1	0	15
Neuroscience	36	17	5	0	1	0	0	1	1	2	0	2	0	0	0	1	0	0	0	0	0	12
Nursing	36	13	2	1	0	1	2	1	2	0	0	0	1	0	0	0	0	0	0	0	0	11
Decision Sciences	20	15	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	10
Undefined	16	3	0	0	2	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	3
Dentistry	9	1	1	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	4

Table 4.5.2.4: Number of publications contributed by top 20 individual countries in individual research areas of total global climate change research during 1995-1999 and rank of India in the individual research area among top 20 countries.

SUBJECT AREA	GLOBAL	United States	United Kingdom	China	Germany	Australia	Canada	France	Italy	Spain	India	Japan	Netherlands	Switzerland	Sweden	Brazil	Norway	Russian Federation	Denmark	Finland	South Korea	India's rank
Earth and Planetary Sciences	13318	4628	1412	487	1038	569	818	827	303	236	190	398	373	290	240	104	202	421	167	110	35	16
Environmental Science	9446	3004	1018	159	608	441	628	397	161	173	146	241	391	180	279	93	164	198	130	171	28	17
Agricultural and Biological Sciences	7040	2207	800	157	540	482	495	523	178	194	98	237	233	146	205	112	141	147	118	147	12	19
Engineering	3158	971	242	80	169	43	138	140	59	33	39	173	59	25	45	15	20	91	21	19	10	13
Social Sciences	2349	553	331	117	136	91	98	87	25	16	34	43	72	44	52	9	32	33	27	24	0	12
Medicine	1746	375	186	9	110	69	45	120	51	48	41	34	39	41	55	17	26	35	27	16	2	10
Energy	1450	380	141	29	76	34	63	33	33	11	55	84	37	21	22	18	13	26	19	11	2	6
Multidisciplinary	953	449	99	45	49	42	34	40	6	5	34	10	14	31	13	22	9	13	16	3	0	8
Physics and Astronomy	913	316	68	19	104	15	28	54	41	10	22	69	15	15	11	3	3	40	5	5	0	9
Arts and Humanities	893	273	187	22	56	36	70	58	62	15	14	2	44	26	49	7	28	18	23	17	3	17
Biochemistry, Genetics and Molecular Biology	856	239	139	39	51	51	38	57	31	19	24	40	25	20	28	7	6	22	12	11	2	12
Materials Science	811	225	32	20	61	13	16	30	20	12	7	71	12	13	9	3	6	55	4	7	5	15
Computer Science	648	269	42	12	46	34	21	23	12	5	4	45	22	4	4	4	5	20	1	2	8	15
Immunology and Microbiology	513	98	84	4	30	32	15	50	17	31	9	15	19	11	24	9	11	6	14	1	0	16
Chemistry	494	148	42	11	36	9	15	17	18	10	8	39	6	11	3	1	4	13	3	5	2	13
Chemical Engineering	487	98	27	12	18	5	22	10	7	8	10	23	5	7	2	0	1	55	1	3	9	9
Mathematics	378	137	33	11	41	13	10	21	9	9	2	19	12	3	1	1	2	19	1	2	3	15
Economics, Econometrics and Finance	363	141	28	2	30	17	12	11	3	0	9	5	24	3	11	2	13	1	2	3	0	10
Business, Management and Accounting	269	83	30	1	6	6	10	6	1	2	3	8	11	1	3	2	2	1	0	1	5	10
Veterinary	208	44	17	0	16	17	8	12	3	7	7	2	10	3	8	5	6	0	4	0	0	10
Pharmacology, Toxicology and Pharmaceutics	135	37	12	3	12	3	8	4	3	3	12	3	6	4	4	0	2	3	2	2	4	4
Psychology	126	66	14	0	6	5	6	2	0	3	0	1	4	1	6	0	0	0	3	2	4	17
Nursing	97	30	15	0	5	4	2	3	1	0	0	1	1	0	1	0	0	0	0	1	1	15
Health Professions	76	18	10	0	14	5	5	1	1	0	2	2	2	5	6	0	1	1	3	1	0	9
Neuroscience	74	29	7	0	4	3	1	2	4	0	1	4	1	0	0	4	1	0	0	0	0	10
Decision Sciences	57	27	8	0	4	3	3	2	1	1	1	2	3	0	0	0	2	0	0	0	1	12
Undefined	15	1	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	12
Dentistry	8	3	1	0	0	0	0	0	0	0	1	0	0	0	2	0	1	0	0	0	0	4

Table 4.5.2.5: Number of publications contributed by top 20 individual countries in individual research areas of total global climate change research during 2000-2004 and rank of India in the individual research area among top 20 countries.

SUBJECT AREA	Global	United States	United Kingdom	China	Germany	Australia	Canada	France	Italy	Spain	India	Japan	Netherlands	Switzerland	Sweden	Brazil	Norway	Russian Federation	Denmark	Finland	South Korea	India's rank
Earth and Planetary Sciences	21108	8356	2510	1206	2195	878	1486	1456	762	500	328	903	692	580	477	257	418	825	333	231	185	17
Environmental Science	14711	5243	1669	509	1270	709	1104	769	388	379	286	515	514	386	509	229	343	338	262	292	85	17
Agricultural and Biological Sciences	12348	4187	1301	461	1135	752	1034	849	407	464	251	456	414	296	375	252	279	281	250	225	63	17
Engineering	6410	1846	579	304	381	155	378	251	211	101	124	431	137	65	121	55	52	138	42	87	54	12
Social Sciences	3704	1031	561	186	269	164	232	142	47	70	72	115	114	63	121	35	85	94	61	53	13	13
Energy	2918	543	218	74	195	81	119	95	42	34	65	189	73	37	67	27	36	32	37	28	13	11
Medicine	2578	569	307	41	166	138	71	154	106	74	71	57	46	65	68	75	43	24	47	26	11	10
Multidisciplinary	1912	813	243	175	107	58	78	66	15	13	65	23	33	57	30	24	22	31	18	6	2	7
Physics and Astronomy	1753	619	163	130	140	36	65	102	87	35	37	171	49	40	15	19	11	108	15	12	23	12
Biochemistry, Genetics and Molecular Biology	1643	479	206	67	134	82	84	140	53	68	31	59	52	35	49	30	42	40	27	37	6	17
Materials Science	1511	385	62	129	96	42	59	55	46	35	27	125	35	26	31	11	10	70	5	14	17	14
Arts and Humanities	1504	506	307	54	159	68	105	102	81	33	11	36	67	48	75	12	62	60	49	32	8	19
Computer Science	1499	554	90	170	88	42	87	79	69	45	17	122	53	22	13	14	15	68	5	18	4	15
Chemical Engineering	1483	179	53	35	63	33	42	30	13	19	27	86	13	15	19	10	5	107	4	2	23	10
Chemistry	1095	242	71	43	75	24	51	47	44	41	35	91	18	18	21	12	9	20	13	4	18	10
Mathematics	960	353	90	108	70	14	42	45	35	32	12	70	32	20	3	6	5	61	6	6	4	14
Immunology and Microbiology	853	201	141	16	64	43	41	92	38	47	18	17	30	30	27	30	15	16	23	7	3	14
Business, Management and Accounting	825	165	90	8	30	34	26	7	11	7	22	12	17	9	13	1	6	0	5	6	6	6
Economics, Econometrics and Finance	706	231	65	6	78	39	41	25	10	13	7	27	35	10	18	7	23	4	17	10	7	16
Veterinary	316	50	36	2	18	11	15	18	11	12	24	2	7	13	6	13	3	0	16	2	0	3
Pharmacology, Toxicology and Pharmaceutics	254	67	28	12	18	11	16	6	10	10	11	10	6	10	8	4	3	1	0	3	2	7
Psychology	211	99	39	1	14	7	8	3	3	10	1	3	9	1	5	0	2	1	2	0	1	15
Nursing	126	49	30	1	6	9	7	4	3	1	0	1	0	0	2	2	4	0	1	0	0	15
Decision Sciences	122	44	9	1	6	3	12	7	2	1	1	4	4	2	5	0	0	1	3	0	0	14
Neuroscience	94	27	7	1	6	2	6	9	7	2	4	5	5	0	1	3	5	0	1	0	2	10
Health Professions	85	22	12	0	15	10	9	3	3	0	0	0	4	2	3	1	0	0	1	0	0	18
Dentistry	12	2	1	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1	0	0	4
Undefined	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10

Table 4.5.2.6: Number of publications contributed by top 20 individual countries in individual research areas of total global climate change research during 2005-2009 and rank of India in the individual research area among top 20 countries.

SUBJECT AREA	GLOBAL	United States	United Kingdom	China	Germany	Australia	Canada	France	Italy	Spain	India	Japan	Netherlands	Switzerland	Sweden	Brazil	Norway	Russian Federation	Denmark	Finland	South Korea	India's rank
Earth and Planetary Sciences	33549	12510	4272	3150	3692	1622	2448	2583	1492	1027	814	1649	1232	1222	791	483	775	1138	441	465	442	14
Environmental Science	30502	9849	3518	2217	2522	1803	2388	1727	1102	1105	759	1115	1207	948	876	502	673	533	519	548	285	14
Agricultural and Biological Sciences	24876	7831	2683	1964	2160	1689	2001	1709	1019	1310	580	924	824	732	608	753	513	432	487	519	166	15
Engineering	12768	3035	1154	1108	731	422	686	447	364	273	300	884	327	147	197	155	122	125	110	136	135	11
Social Sciences	9035	2454	1403	432	491	588	626	362	199	171	182	191	305	192	250	86	206	149	100	97	24	14
Energy	7749	1727	652	345	463	267	410	250	205	161	222	415	234	108	173	150	102	56	74	58	72	10
Medicine	5038	1245	668	110	270	326	206	282	213	164	135	112	112	151	131	137	57	51	79	58	27	11
Biochemistry, Genetics and Molecular Biology	3820	1249	470	262	290	255	271	287	129	163	103	148	75	107	89	94	49	54	61	66	20	12
Computer Science	3799	1022	195	649	217	257	193	169	130	88	70	274	123	55	34	60	34	61	29	41	36	12
Physics and Astronomy	3326	1013	292	386	251	99	126	204	163	94	83	291	84	64	37	52	34	139	29	23	44	13
Multidisciplinary	3161	1334	420	298	248	170	165	175	51	53	161	50	102	95	58	51	58	36	49	30	6	8
Chemical Engineering	2859	584	126	89	117	100	113	82	41	41	68	111	35	14	20	34	11	163	9	18	48	10
Materials Science	2793	618	113	332	175	72	72	117	80	60	64	252	66	31	35	63	22	52	14	19	37	11
Arts and Humanities	2656	855	583	114	246	178	178	210	107	98	32	51	111	128	108	23	105	52	75	47	11	18
Chemistry	2530	695	150	121	176	88	130	87	74	64	51	141	49	62	33	47	41	19	32	16	42	12
Business, Management and Accounting	2265	470	232	26	90	139	109	69	30	21	46	22	89	51	56	8	27	8	16	21	10	10
Mathematics	2187	578	241	282	150	249	81	109	83	50	31	131	77	33	25	34	30	48	17	17	13	15
Economics, Econometrics and Finance	1942	613	215	23	205	109	84	93	66	41	43	50	118	60	53	11	65	9	22	18	10	13
Immunology and Microbiology	1795	439	278	75	148	109	103	168	77	92	58	35	64	51	52	56	26	23	43	34	14	11
Veterinary	586	80	64	7	60	35	33	38	27	32	35	6	19	21	10	57	6	2	17	3	3	7
Pharmacology, Toxicology and Pharmaceutics	536	135	58	30	40	12	32	20	37	19	44	19	19	11	14	19	3	1	7	13	6	3
Decision Sciences	509	118	49	45	28	84	46	17	15	13	5	15	9	15	8	5	7	0	4	8	2	16
Psychology	341	135	52	0	18	20	17	6	12	11	3	5	18	5	10	2	8	0	3	4	0	15
Nursing	250	69	31	7	10	30	9	8	10	2	4	2	7	5	8	2	2	2	3	4	3	12
Neuroscience	199	86	18	4	16	4	11	14	13	14	6	8	4	6	4	8	4	2	2	3	0	10
Health Professions	156	28	15	3	11	19	9	8	3	3	4	6	2	5	6	3	5	0	2	0	0	11
Dentistry	28	10	10	1	2	3	1	1	2	2	1	0	2	0	3	2	0	0	0	1	1	13
Undefined	10	1	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	11

Table 4.5.2.17: Number of publications contributed by top 20 individual countries in individual research areas of total global climate change research during 2010-2014 and rank of India in the individual research area among top 20 countries.

SUBJECT AREA	GLOBAL	United States	United Kingdom	China	Germany	Australia	Canada	France	Italy	Spain	India	Japan	Netherlands	Switzerland	Sweden	Brazil	Norway	Russian Federation	Denmark	Finland	South Korea	India's rank
Environmental Science	63958	19346	6967	7233	5593	5181	4412	3248	2765	2754	2222	1912	2557	2033	2061	1277	1483	817	1230	1068	906	11
Earth and Planetary Sciences	51538	17971	6652	7039	6060	3395	3220	4186	2397	2118	1777	2296	1969	1996	1366	924	1396	1373	824	751	1017	13
Agricultural and Biological Sciences	48169	14358	5069	5397	4539	4369	3590	3278	2195	2768	1587	1489	1609	1619	1439	1809	1134	633	1099	932	555	13
Engineering	24886	5364	2044	4045	1183	1268	1063	726	911	689	1126	1227	480	272	396	375	324	144	294	223	642	7
Social Sciences	21665	5918	3453	1242	1473	1918	1377	778	526	560	583	483	883	544	728	294	531	242	381	306	185	10
Energy	15704	3637	1326	1430	969	717	860	522	657	503	556	651	525	231	425	320	368	87	217	233	261	9
Biochemistry, Genetics and Molecular Biology	9671	3095	1176	1067	770	978	664	738	403	581	434	336	322	343	292	316	218	132	210	155	139	8
Medicine	8674	2349	1123	456	540	721	467	415	351	263	348	196	238	233	262	294	177	119	132	109	109	9
Computer Science	7505	1579	474	1410	491	362	276	275	328	227	337	494	180	93	98	146	50	48	85	62	182	7
Multidisciplinary	5322	2071	743	784	430	433	325	310	129	150	334	135	194	211	128	131	102	47	108	69	31	6
Arts and Humanities	5043	1578	1032	293	483	387	330	367	190	203	89	74	170	206	201	48	192	77	139	70	46	15
Physics and Astronomy	4937	1439	505	637	471	146	203	339	261	143	162	334	108	100	62	143	79	154	45	60	112	9
Business, Management and Accounting	4745	1054	609	278	245	475	228	142	135	127	133	101	171	96	123	57	74	18	66	97	53	10
Economics, Econometrics and Finance	4514	1356	631	153	417	351	205	201	207	156	148	108	222	141	116	39	109	27	47	40	23	11
Chemistry	4086	1395	365	508	310	184	235	190	139	164	170	181	80	114	86	84	83	34	74	48	133	9
Chemical Engineering	4014	1058	246	337	189	131	155	158	136	122	209	134	78	42	51	69	29	158	28	41	150	4
Mathematics	3816	1000	436	457	332	312	169	216	212	101	88	170	90	77	36	87	45	63	30	34	73	12
Materials Science	3815	850	217	525	297	114	147	123	125	93	174	287	53	45	39	90	48	56	13	29	142	6
Immunology and Microbiology	3234	897	409	246	304	257	202	265	158	189	156	63	127	108	97	144	67	41	83	33	56	10
Veterinary	1143	163	103	67	78	57	48	56	54	45	102	15	29	20	19	128	23	4	22	6	7	4
Decision Sciences	1082	262	113	163	80	72	59	44	65	42	35	26	28	25	26	23	15	5	15	9	13	10
Pharmacology, Toxicology and Pharmaceutics	879	165	72	135	53	24	19	39	47	28	124	24	39	15	16	30	17	10	21	16	11	3
Psychology	831	319	120	10	42	67	71	24	17	40	13	15	39	21	17	11	26	2	7	18	6	15
Nursing	514	134	75	15	26	46	36	11	17	9	15	2	9	8	20	11	8	2	7	7	4	9
Neuroscience	331	156	52	13	21	27	24	15	8	11	7	11	12	7	8	9	10	4	7	3	4	15
Health Professions	286	60	30	26	6	26	15	5	11	8	23	5	6	5	7	4	7	10	5	3	1	5
Dentistry	35	5	6	1	0	1	0	1	1	3	6	1	0	1	1	5	0	0	0	0	0	3
Undefined	33	7	10	2	1	16	4	2	2	2	1	3	2	2	1	1	1	1	1	0	1	18

Table 4.5.2.8: Number of publications contributed by top 20 individual countries in individual research areas of total global climate change research during 2015-2019 and rank of India in the individual research area among top 20 countries.

SUBJECT AREA	GLOBAL	United States	United Kingdom	China	Germany	Australia	Canada	France	Italy	Spain	India	Japan	Netherlands	Switzerland	Sweden	Brazil	Norway	Russian Federation	Denmark	Finland	South Korea	India's rank
Environmental Science	101722	27738	10291	17587	8534	7633	6697	5047	4832	4997	4550	2873	3782	3002	3235	3068	2247	2259	1990	1757	1847	10
Earth and Planetary Sciences	72653	22679	8568	14661	7867	4437	4262	5195	3302	3034	3228	2802	2432	2514	1948	1678	1971	3075	1069	1061	1446	9
Agricultural and Biological Sciences	71719	20027	6328	11760	6261	6042	4883	4523	3570	4288	3427	1846	2184	2132	2076	3400	1513	1484	1493	1332	950	10
Engineering	40538	7009	2926	5908	2251	1989	1748	1384	2205	1541	3459	1368	924	494	798	872	634	861	569	403	1048	3
Social Sciences	35483	9343	4641	3237	2661	2947	1976	1290	1457	1365	1258	746	1479	820	1204	752	903	768	579	561	642	11
Energy	29382	5315	2614	4246	1974	1436	1319	979	1852	1350	1621	927	935	570	858	783	637	426	509	463	768	6
Biochemistry, Genetics and Molecular Biology	16008	4932	1660	2319	1408	1385	1029	1027	796	1013	989	495	501	486	507	733	304	329	323	223	377	9
Medicine	12911	3969	1630	1122	889	1037	776	672	537	457	694	311	424	434	413	511	265	286	197	157	203	7
Computer Science	12226	2058	787	1563	676	449	423	444	585	414	1567	370	280	154	133	232	115	435	122	103	261	2
Multidisciplinary	10486	3960	1347	1911	1064	945	703	748	376	524	488	306	384	427	378	463	281	152	257	184	147	9
Business, Management and Accounting	9527	1696	1003	1037	588	693	439	308	434	347	585	243	330	141	282	309	171	158	170	175	146	6
Physics and Astronomy	8780	2190	859	1336	825	294	380	634	554	365	515	405	276	271	209	143	157	499	118	85	200	7
Economics, Econometrics and Finance	7396	1902	897	423	696	553	367	369	340	215	364	220	323	208	227	117	176	209	105	98	89	8
Materials Science	7143	976	338	1198	387	234	227	272	305	255	563	282	99	85	86	141	82	474	45	54	231	3
Mathematics	6935	1298	740	851	657	476	279	431	474	333	461	223	239	179	167	121	134	313	79	96	152	7
Chemistry	6729	1928	600	1435	564	357	392	349	244	315	362	283	176	197	158	170	133	194	101	77	263	6
Chemical Engineering	6467	1154	356	1035	312	241	257	167	341	243	510	188	124	95	100	145	56	220	63	53	327	3
Arts and Humanities	6370	1998	1128	414	668	473	376	421	266	298	113	98	204	205	211	80	205	184	141	108	68	16
Immunology and Microbiology	4921	1358	546	580	442	386	269	312	236	319	332	109	171	170	163	270	92	82	123	90	108	6
Decision Sciences	2981	539	261	462	185	276	133	125	151	112	238	83	72	57	61	107	57	75	41	45	41	5
Veterinary	1676	221	118	120	90	82	56	59	74	60	195	24	30	31	28	198	15	22	28	3	12	3
Pharmacology, Toxicology and Pharmaceutics	1475	242	86	282	60	59	63	48	65	54	226	23	29	21	19	53	18	76	19	7	21	3
Psychology	1455	597	194	42	119	149	80	45	43	66	20	17	89	49	29	18	43	12	22	10	16	15
Neuroscience	871	327	105	93	66	65	61	52	32	51	16	18	26	23	18	39	14	14	13	9	10	15
Nursing	812	259	103	32	29	75	48	34	33	31	22	8	33	18	24	21	9	2	3	9	10	12
Health Professions	400	74	46	15	8	54	24	11	12	20	44	4	6	9	7	10	12	18	2	5	5	4
Dentistry	60	8	10	15	0	3	0	1	2	0	1	1	0	0	0	1	2	1	2	0	0	9
Undefined	5	5	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10

4.5.2.4. Evolving Trends of research topics vis-à-vis keywords of Indian research publications on "Climate Change" during successive periods

Table 4.5.2. shows the top 50 keywords and their frequency of Indian research publications on "Climate Change" during successive periods. The keyword and its frequency depicted the important research topics and their dimensions. During the first six periods "India" was the most frequent keyword followed by different keywords during different periods indicated that the research works were performed on those research topics focusing on the Indian context. Throughout the periods "Climate Change" has appeared in the top five keywords excluding India. During the last period, "Climate Change" has appeared as the most frequent keyword. "Global Warming", "Greenhouse Gases" and "Solar Energy" also appeared throughout the periods with increasing frequency and rank at successive periods. "Carbon Dioxide" and "Sustainable Development" appeared in the top 50 list during 2000-2004 and then its frequency and rank increased at successive periods. "Weather Forecasting" first appeared in the top 50 list during 2005-2009. "Fossil Fuels", "Climate Modeling", "Energy Efficiency", first appeared during 2010-2014. During the last period, some keywords secured their position in the top 50 list namely: "Economics", "Trend Analysis" etc.

Table 4.5.2.9: The top 50 keywords and their frequency of Indian research publications on "Climate Change" during successive periods

1985-1989		1990-1994		1995-1999		2000-2004		2005-2009		2010-2014		2015-2019	
Keyword	**Frequency**	**Keyword**	**Frequency**	**Keyword**	**Frequency**	**Keyword**	**Frequency**	**Keyword**	**Frequency**	**Keyword**	**Frequency**	**Keyword**	**Frequency**
India	32	India	85	India	142	India	353	India	791	India	1804	Climate Change	3410
Solar Energy	13	Human	42	Climate Change	63	Climate Change	190	Eurasia	692	Climate Change	1728	India	2984
Human	10	Female	27	Climate	39	Asia	113	Asia	685	Global Warming	680	Global Warming	1155

Nonhuman	8	Male	26	Priority Journal	39	Eurasia	99	South Asia	623	Greenhouse Gases	469	Greenhouse Gases	1087
Animal	7	Tropical Climate	26	Human	34	South Asia	91	Climate Change	573	Carbon Dioxide	457	Carbon Dioxide	855
Climatic Change	7	Priority Journal	22	Humans	31	Monsoon	85	Monsoon	211	Monsoon	364	Nonhuman	614
Meteorology - Climatology	7	Adult	21	Mathematica l Models	28	Climate	81	Global Warming	192	Rainfall	345	Monsoon	596
Biogas	6	Climate	21	Monsoon	28	Climatology	81	Climatology	176	Nonhuman	325	Rain	584
Climate	6	Solar Energy	21	Rain	25	Human	60	Indian Ocean	170	Human	317	Climate Models	561
Diagnosis	6	Climate Change	19	Solar Energy	23	Priority Journal	58	Rain	148	Rain	310	Sustainable Development	555
Geographic Distribution	6	Mathematic al Models	14	Greenhouse Effect	21	Humans	57	Seasonal Variation	136	Indian Ocean	279	Human	546
Quaternary	6	Adolescent	13	Male	21	Nonhuman	56	Rainfall	123	Seasonal Variation	271	Rainfall	536
Seasons	6	Controlled Study	12	Temperature	21	Rain	56	Human	119	Climate	257	Agriculture	534
Tropical Climate	6	Child	11	Female	19	Indian Ocean	52	Humans	115	Priority Journal	254	Remote Sensing	469
Epidemiology	5	Developing Country	11	Climatology	18	Agriculture	51	Climate	111	Greenhouse Gas	246	Himalayas	462
Male	5	Pancreatitis	11	Tropical Climate	18	Controlled Study	51	Nonhuman	109	Himalayas	227	Seasonal Variation	458
Priority Journal	5	Support, Non-U.S. Gov't	11	Agriculture	17	Greenhouse Effect	49	Priority Journal	109	Humans	223	Temperature	455

SOLAR ENERGY	5	Chronic Disease	10	Tropic Climate	16	Female	43	Animals	102	Sustainable Development	223	Indian Ocean	440
Adult	4	Global Warming	10	Adult	15	Global Warming	42	Carbon Dioxide	102	Remote Sensing	221	Carbon	431
Agriculture	4	Palaeoclima te	10	Atmospheric Temperature	15	Paleoclimate	41	Greenhouse Gases	101	Atmospheric Thermodyna mics	219	Atmospheric Thermodyna mics	415
BUILDINGS	4	Tropic Climate	10	Developing Countries	15	Seasonal Variation	41	World	95	Biodiversity	215	Fossil Fuels	414
Clinical Article	4	Air Pollution	9	Global Warming	15	Crops	40	Mathematica l Models	91	Climate Effect	213	Climate	411
Feces	4	Animal	9	Rainfall	15	Male	39	Remote Sensing	89	Animals	205	Crops	401
Irrigation	4	Buildings	9	Sea Surface Temperature	15	Tropical Climate	39	Controlled Study	88	Agriculture	199	Energy Efficiency	393
Nematode Infections	4	Child, Preschool	9	Developing Country	14	Rainfall	37	Greenhouse Gas	88	Biomass	197	Climate Modeling	382
Therapy	4	Climatic Change	9	Carbon Dioxide	13	Mathematica l Models	34	Agriculture	85	Temperature	195	Biomass	380
Tropic Climate	4	Comparativ e Study	9	Environment al Protection	13	Environment al Impact	33	Atmospheric Temperature	84	Precipitation (climatology)	193	Gas Emissions	371
AIR CONDITIONI NG	3	Chronic Pancreatitis	8	Indian Ocean	13	Forestry	32	Greenhouse Effect	82	Climatology	192	Precipitation (climatology)	367
Air Pollution	3	Climatology	8	Nonhuman	13	Air Pollution	31	Tropical Climate	80	Computer Simulation	192	Solar Energy	354
Animal Disease	3	Developing Countries	8	Paleoclimate	13	Animals	30	Biomass	79	Climate Models	188	Controlled Study	338

Carbon Dioxide	3	Diabetes Mellitus	8	Conference Paper	12	Biodiversity	30	Solar Energy	78	Numerical Model	184	Greenhouse Gas	334
Climate Model	3	Distillation	8	Environmental Impact	12	Carbon Dioxide	30	Biodiversity	77	Controlled Study	180	Biodiversity	323
Economic Aspect	3	Heat Transfer	8	Greenhouse Gas	12	Biomass	28	Eastern Hemisphere	77	Energy Efficiency	176	Summer	323
Greenhouse Effect	3	Middle Age	8	Seasonal Variation	12	Carbon	28	Sustainable Development	76	Summer	173	Land Use	311
HEAT TRANSFER - Mathematical Models	3	Performance	8	Solar Collectors	12	Environmental Monitoring	28	Weather Forecasting	76	Solar Energy	168	Drought	308
Heat	3	Quaternary	8	Arabian Sea	11	Greenhouse Gas	28	Air Pollution	75	Climate Modeling	165	Humans	286
Helminthiasis	3	Review	8	Holocene	11	Methane	28	Solar Radiation	74	Carbon	162	Forecasting	280
Meteorology--Climatology	3	Clinical Article	7	Palaeoclimate	11	Plants (botany)	28	Aerosol	73	Gas Emissions	162	Climate Effect	275
Methodology	3	Distillation Equipment	7	Quaternary	11	Adult	27	Air Temperature	73	Methane	155	Weather Forecasting	274
Monsoon	3	Holocene	7	Remote Sensing	11	Remote Sensing	27	Sea Surface Temperature	73	Fossil Fuels	148	Sustainability	265
Palaeoclimatology	3	Humans	7	Season	11	Crop Production	26	Computer Simulation	71	Paleoclimate	147	Animals	261
Parasite Egg Count	3	Major Clinical Study	7	Drug Storage	10	Tropic Climate	26	Temperature	71	Sea Surface Temperature	147	Soils	261

Parasitology	3	Nonhuman	7	Hydrology	10	Computer Simulation	25	Crops	69	Water Supply	146	Environmental Monitoring	259
Physiology	3	Seasons	7	Review	10	Soils	25	Summer	69	Weather Forecasting	143	Adaptation	255
Pleistocene	3	Temperature	7	Rice	10	Solar Energy	25	Animalia	67	Environmental Monitoring	142	Energy Utilization	253
Season	3	Agriculture	6	Adolescent	9	Summer	25	Himalayas	67	Review	142	Economics	251
Solar Radiation--Collectors	3	Animals	6	Animals	9	Aerosol	24	Triticum Aestivum	67	Drought	140	Forestry	250
Support, Non-U.S. Gov't	3	Bay Of Bengal	6	Energy Utilization	9	Review	24	Environmental Impact	66	Air Temperature	138	Chemistry	246
Temperature	3	Energy Utilization	6	Environmental Temperature	9	Sustainable Development	24	Oceanography	65	Environmental Impact	138	Trend Analysis	246
Theoretical Study	3	Foraminifera	6	Gas Emissions	9	Temperature	24	Atmospheric Aerosols	64	Crops	136	Climatology	240

4.5.3. Analysis from Indian citation index database:

4.5.3.1. Total Global and Indian comparative contribution in different subject areas:

Total global research on "Climate Change" has been performed in 495 research areas indexed in the Indian Citation index. The top 30 research areas of total global research on climate change have contributed 79.09% cumulatively. India has contributed to 457 research areas during total periods. The top 30 research areas of total Indian research on climate change have contributed 70.04 % cumulatively. India has contributed at a higher proportion than the global in some research areas namely: Agriculture, General Science and Technology, Botany, Engineering Science and Technology, Meteorology and Agricultural Meteorology. India has contributed a lower proportion than the global in some research areas namely: Environmental Science, Biological Science, Earth and Geological Science, Ecology and Environment,

Economics etc. are mainly deal with the causal factor identification and impact assessment of climate change (Figure 4.5.3.1).

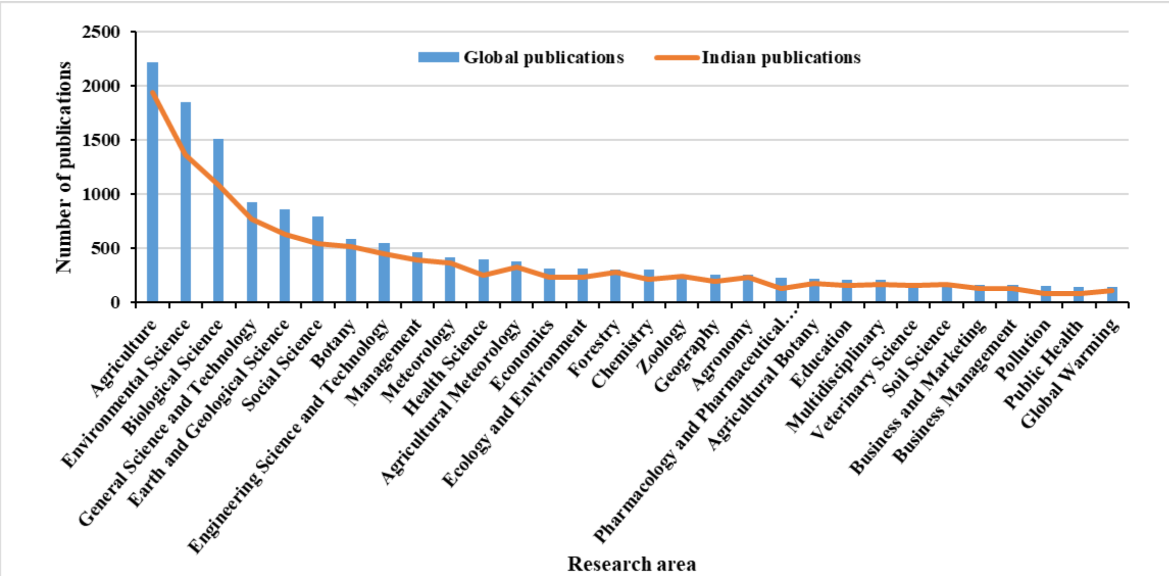


Figure 4.5.3.1: Global and Indian publication contribution in different subject areas

4.5.3.2. Evolving trend of top 30research areas during successive periods of Indian research:

Table 4.5.3.1 shows the period-wise growth of the top 30 research areas of Indian publications on climate change. Figure 4.5.3.2 shows the CPGR of an individual research area of Indian publications on climate change. Some of the research areas of Indian publications have contributed at higher CPGR than the average CPGR of total Indian publications (87.42 %) namely Pharmacology and

Pharmaceutical Science (383.05 %), Business and Marketing(182.84 %), Education (153.31 %), Economics (138.37 %), Management (133.93 %), Business Management (117.94 %), Multidisciplinary (110.26 %), Social Science (108.99 %), Chemistry (97.30 %), Dairying, Dairy, Animals and Animals Produce (93.31 %), Engineering Science and Technology (93.06 %) and Botany (88.00 %).

Table 4.5.3.1: India's Period-wise evolving trends of top 30 research areas

Research area	2005-2009	2010-2014	2015-2019	total
Agriculture	292	628	1017	1937
Environmental Science	199	493	670	1362
Biological Science	152	418	510	1080
General Science and Technology	130	293	342	765
Earth and Geological Science	162	220	245	627
Social Science	68	180	297	545
Botany	73	187	258	518
Engineering Science and Technology	55	190	205	450
Management	36	160	197	393
Meteorology	69	85	209	363
Agricultural Meteorology	63	106	160	328
Forestry	59	104	114	277
Health Science	42	105	101	248
Zoology	46	73	118	237
Ecology and Environment	60	122	49	231
Economics	22	84	125	231
Agronomy	41	79	110	230
Chemistry	28	77	109	214
Geography	39	80	70	189
Agricultural Botany	34	65	78	177
Multidisciplinary	19	64	84	167
Soil Science	29	55	80	164
Education	12	69	77	158
Veterinary Science	25	51	81	157
Business and Marketing	8	60	64	132
Business Management	12	63	57	132
Pharmacology and Pharmaceutical Science	3	54	70	127
Dairying, Dairy, Animals and Animals Produce	19	36	71	126
Biodiversity	27	73	17	117
Biochemistry	22	54	30	106

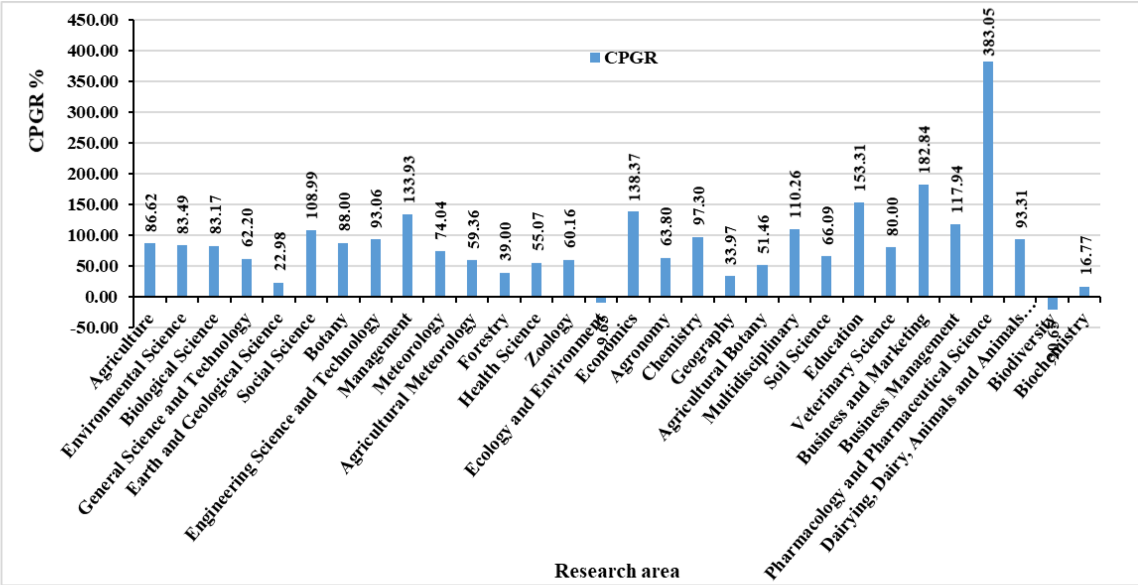


Figure 4.5.3.2: Period-wise growth rate of India's Research areas of Indian publications

4.5.3.4. Most frequent research topics vis-à-vis keywords during successive periods of Indian research:

Table 4.5.3.2:: Top 50 keywords and their frequency during different periods

2005-2009		**2010-2014**		**2015-2019**	
Keyword	Frequency	Keyword	Frequency	Keyword	Frequency
Climate change	110	Climate change	534	Climate change	463
Global warming	43	Global warming	108	Global warming	108
India	25	India	70	India	77
Climate	28	Rainfall	60	Rainfall	76
Palaeoclimate	19	Temperature	56	Climate	58
Remote sensing	17	Remote sensing	49	Environment	58
Environment	21	Yield	43	Agriculture	55
Temperature	19	Climate	54	Remote sensing	53
Biodiversity	21	Biodiversity	49	Carbon sequestration	48
Monsoon	21	Sustainability	40	Rice	46
Greenhouse gases	14	Biomass	39	GIS	45
Holocene	16	Food security	39	Drought	41
Carbon sequestration	21	Sustainable development	36	Conservation	40
Rainfall	13	Agriculture	49	Mitigation	40
Wheat	10	Environment	42	Productivity	38
Diversity	9	Carbon sequestration	50	Biodiversity	36
Food security	9	Adaptation	56	Adaptation	34
GIS	10	GIS	36	Food security	32
Himachal Pradesh	10	Mitigation	27	Precipitation	31
Agro-climatic zones	12	Wheat	32	Perception	30

Climatic change	9	productivity	27	Growth	29
Mitigation	8	Conservation	28	Production	28
Productivity	9	Growth	24	Greenhouse gases	26
Sustainable development	9	Rice	31	Management	24
Yield	8	Drought	26	Pollution	24
Agroforestry	11	Management	19	Maize	23
Rice	13	Monsoon	19	Mann-kendall test	23
Conservation	7	Greenhouse gases	22	Evapotranspiration	22
Growth	8	Phenology	18	Irrigation	22
Indian Ocean	11	Simulation	18	Biomass	21
Kyoto Protocol	8	Vulnerability	19	Diversity	21
Paleoclimate	7	Pollution	19	Elevated CO2	21
Punjab	7	Energy	16	Himalaya	21
Rajasthan	7	Himalaya	18	Livelihood	20
Soil	9	Perception	18	Methane	20
Adaptation	8	Correlation	16	Quality	20
Agriculture	7	Health	14	Farmers	19
Climatic factors	8	Soil organic carbon	17	Heat stress	19
Disease	6	Impact	15	Renewable energy	19
drought	9	Relative humidity	13	Constraints	18
Energy	7	Salinity	13	Impact	18
Oxygen isotopes	6	Deforestation	15	Energy	17
pollution	7	Palaeoclimate	12	Phenology	17
Sea level rise	6	Photosynthesis	12	Relative humidity	17
Varieties	6	Precipitation	14	Simulation	17
Andhra Pradesh	5	Water resources	14	CO2	16
Economics	5	Carbon dioxide	19	Development	16
Evapotranspiration	6	Diversity	13	Livestock	16
Flowering	5	Groundnut	12	Salinity	16
Gujarat	5	Maize	14	Carbon stock	15

Table 4.5.3.2 shows the top 50 keywords and their frequency of Indian research publications on "Climate Change" during successive periods from the Indian Citation Index. The keyword and its frequency depicted the important research topics and their dimensions. Throughout the periods "Climate Change", "Global warming" and "India" have appeared as the top three keywords indicated that the research works were performed on those research topics focusing on the Indian context. The following keywords namely "Rainfall", "Climate", "Environment", "Agriculture", "Remote sensing", "Carbon sequestration", "Rice", "GIS", "Drought", "Conservation", "Mitigation", "Diversity", "Adaptation", "Food security", Precipitation etc. also appeared throughout the periods with increasing frequency at successive periods. "Management", "Himalaya",

"Impact", "Simulation", "Himalaya" appeared in the top 50 list during 2010-2014 and then its frequency and rank increased at successive periods. "Elevated CO2", "Heat stress", 'Renewable energy", "Development", "Livestock", "Carbon stock" secured their position in the top 50 list during the last period.

4.6 Inter-relationship among the carried-out research topics and country-specific socio-economic & environmental problems

4.6.1. Inter-relationship of CO_2 emission and publications of top 20 countries based on the number of publications from Scopus

Figure 4.6.1 shows the share of global cumulative CO_2 emission up to 2017, CO_2 emission in metric tons per capita, and the cumulative publication share during 1985-2019 from Web of Science and Scopus of top 20 countries. The total share of the total global cumulative CO_2 of the top 20 countries based on the number of publications from the Scopus database is about 73.59 % with an average of 3.68%. India registered 7th position by sharing 3.08% of the total global cumulative CO_2 emission up to 2017.The average per capita CO_2 emission of the top 20 countries is about 8.24metric tons.India is the lowest per capita CO_2 emitting country among the top 20 countries with a value of 1.73 metric tons per capita. A highly positive correlation (r=0.93) was observed between the number of publications (both from WoS and Scopus database) and the share of global cumulative CO_2 emissions of the top 20 countries. India ranked 13th and 9th based on the number of publications during 1985-2019 from the Web of Science and Scopus database respectively.

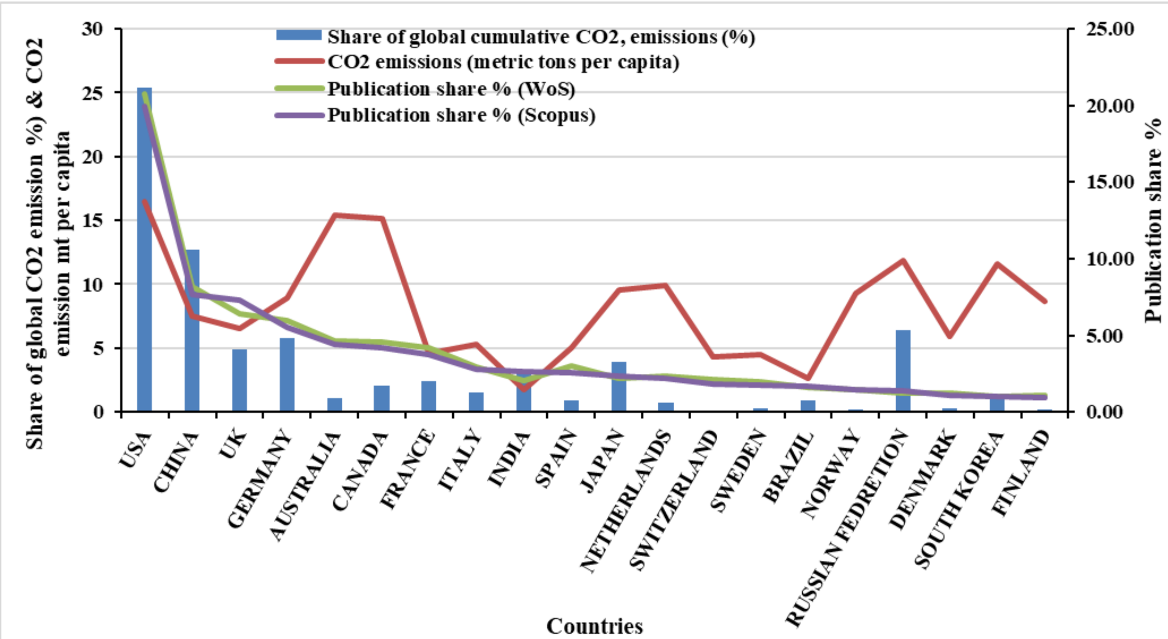


Figure 4.6.1: Share of global cumulative CO2 emissions (%)/(University of OXFORD, 2017), CO2 emissions (metric tons per capita)/(The World Bank,2014), Publication share % from Scopus and Web of Science database of top 20 countries based on publications data (Scopus)

4.6.2. Total Greenhouse gas emission % change from 1990 of the top 20 countries based on the number of publications from Scopus

Figure 4.6.2 represents the total greenhouse gas emission % change from 1990 (The World Bank, 2012) of the top 20 countries based on publications data from Scopus. The total greenhouse gas emission % change from 1990 is about 27.47 % of the top 20 countries cumulatively. Some countries achieved negative acceleration and Denmark is leading the list with a value of -25.91% followed by the UK (-24.63 %), Germany (-24.23 %), Russian Federation (-21.99 %), Sweden (-14.78 %), Netherlands (-12.74 %) and so on. On the other hand, some countries attained positive acceleration regarding the greenhouse gas emission change and China is the leading country with a value of 219.95 % followed by South Korea (122.62 %). India ranked the 3rd with a positive acceleration value of 116.44 %.

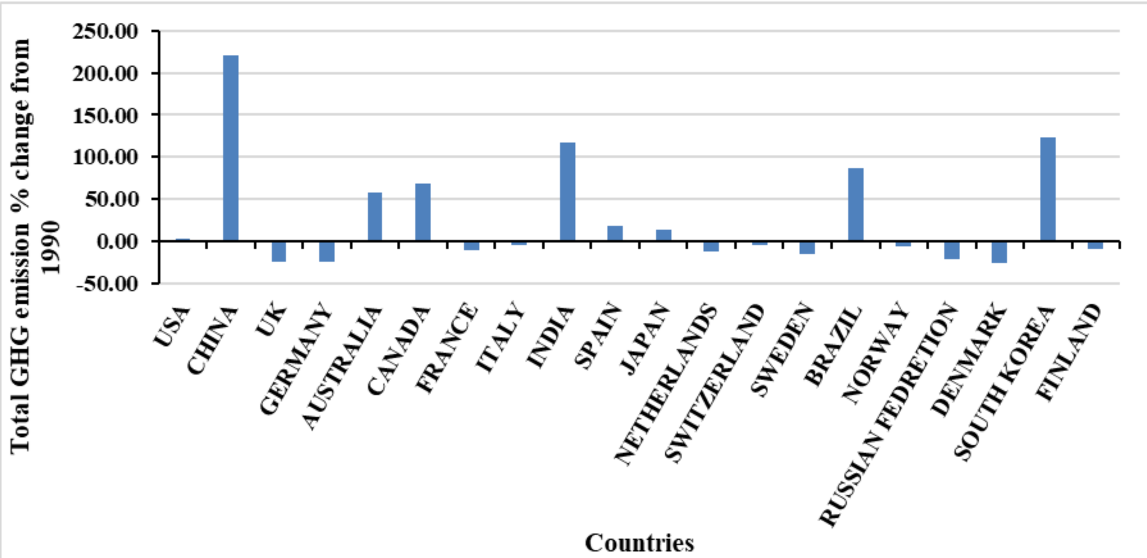


Figure 4.6.2: Total Greenhouse gas emission % change from 1990 (The World Bank, 2012) of top 20 countries based on publications data (Scopus)

4.6.3. Inter-relationship of CO2 emission and GDP of top 20 countries

Figure 4.6.3 represents the CO_2 emission in kilo tons (Our World in Data based on Global Carbon Project, 2020) and GDP current prices (2018) in billions of US dollars (International Monetary Fund,2018) of top 20 countries based on publications data (Scopus). A highly positive correlation (r=0.82) was observed between total CO_2 emission and GDP current prices (2018) in billions of US dollars. Four countries have emitted more than the group average CO_2 emission in tons during 2018 and India is the 3rd most emitting country with an amount of 2591323.74 kilotons. The 1st and 2nd most emitting countries are China (9956568.523 kilotons)and the USA (5424881.502kilotons) respectively. In the case of GDP, four countries also contributed more than the group average GDP these are namely the USA, China, Japan and Germany. India ranked 7th by contributing 2718.732 GDP current prices (2018) in billions of US dollars.

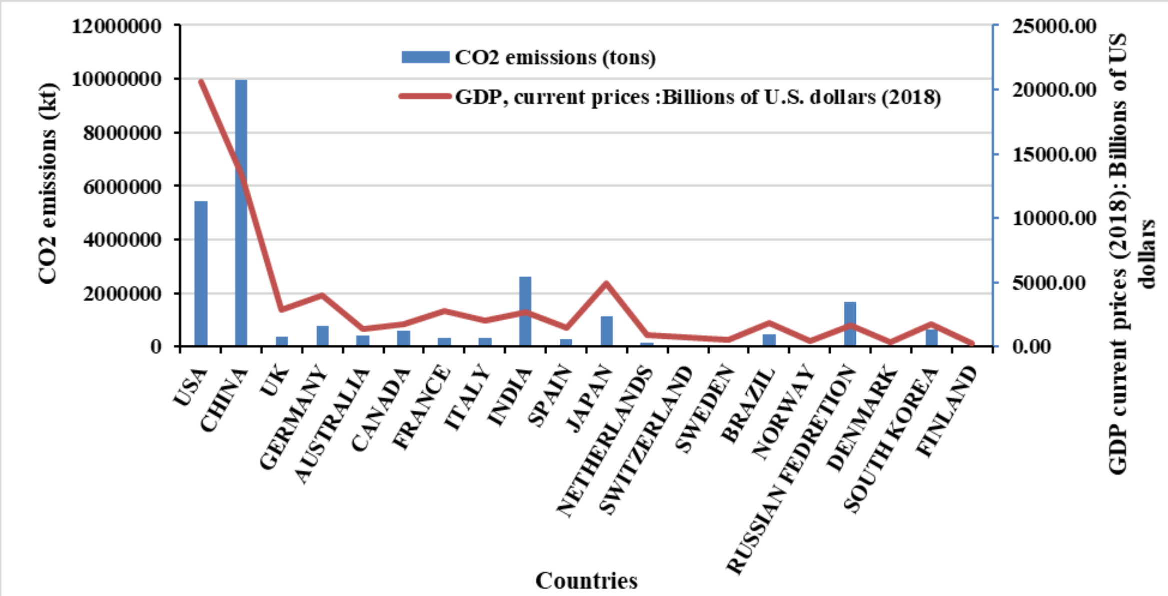


Figure 4.6.3: Total CO_2 emission(Our World in Data based on Global Carbon Project, 2020) and GDP current prices (2018) in billions of US dollars (International Monetary Fund,2018) of top 20 countries based on publications data (Scopus)

4.6.4. Inter-relationship of publications, GERD in % of GDP and GERD in billions of US dollar of top 20 countries

Inter-relationship between Research and development expenditure as % of GDP (GERD as % of GDP) (The World Bank,2015) and Publication share % from Scopus and Web of Science database of top 20 countries based on publications data (Scopus) has been shown in Figure 4.6.4. There was no correlation (r=0.03) between GERD as % of GDP and the number of publications from both of the databases.Eight countries have a higher GERD as % of GDPthan the group average (2.46%) and India is the last country with a value of 0.62. Figure 4.6.5 shows the inter-relationship between Gross Research and development expenditure in billions of US dollar GDP (GERD in billions of US dollars) (The World Bank,2015) and Publication share %. Results depicted a highly positive correlation (0.85) between the GERD PPP in billions of US dollars and the number of publications from both of the databases. Only four countries have a higher GERD PPP in billions of US dollars than the group average (93.95) and India is the 7th country with a value of 56.75 billion US dollars.

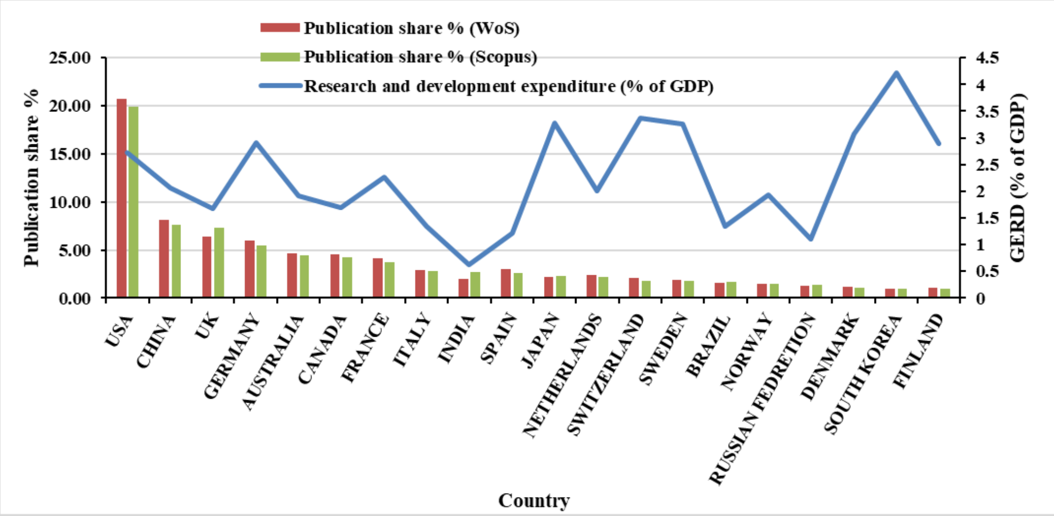


Figure 4.6.4: Research and development expenditure (% of GDP) (The World Bank,2015), Publication share % from Scopus and Web of Science of top 20 countries based on publications data (Scopus)

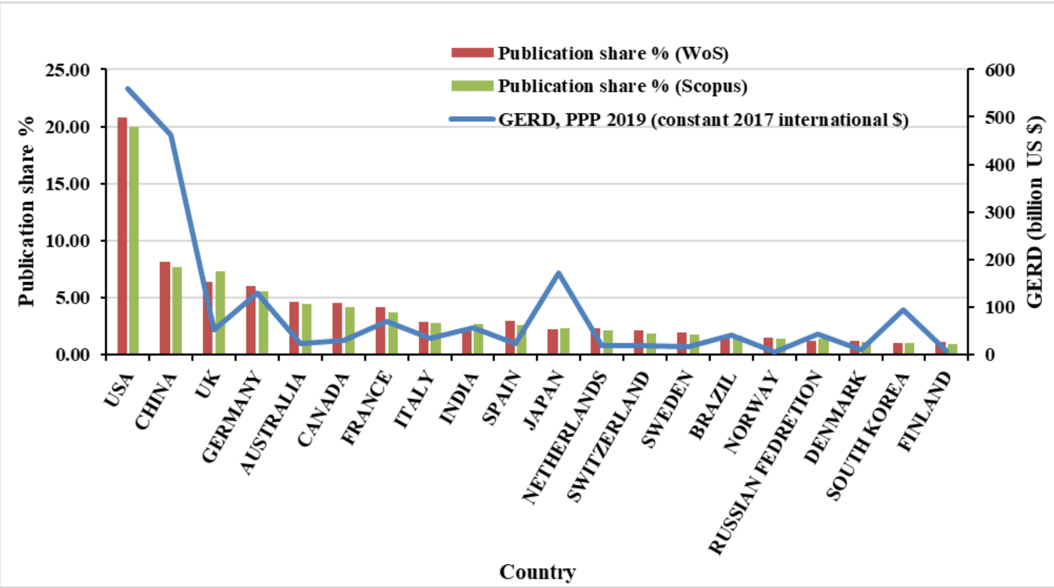


Figure 4.6.5:GERD in billions of US dollar, Publication share % from Scopus and Web of Science database of top 20 countries based on publications data (Scopus)

4.6.5. Comparative analysis of electricity production from coal sources and fossil fuel energy Consumption of top 20 countries

Figure 4.6.6 represents the electricity production from coal source and fossil fuel energy Consumption of the top 20 countries based on publications data (Scopus). Eight countries have a higher % of electricity production from coal sources than the group average and India registered the highest % of electricity production from coal sources with a value of (75.31 %) followed by China (70.31 %), Australia (62.87 %), and so on. Switzerland and Norway have a value of near zero % of electricity production from coal sources. Twelve countries have a higher % of fossil fuel energy consumption than the group average. Japan ranked at the top with a value of 94.41%of total energy consumption followed by Australia (93.39 %), the Russian Federation (92.14 %), and so on. India registered the 11th position in this parameter with a value of (73.58 % of total).

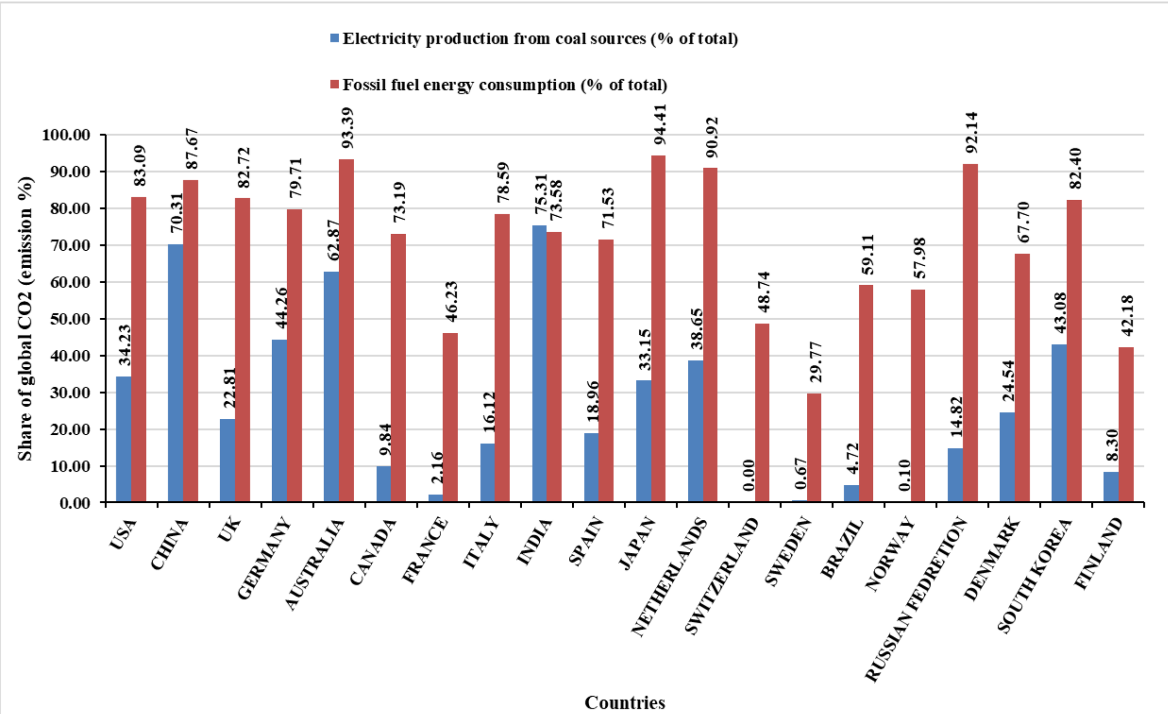


Figure 4.6.6: Electricity production from coal sources (% of total) (The World Bank,2015), Fossil fuel energy consumption (% of total) (The World Bank,2014) of top 20 countries based on publications data (Scopus)

4.6.6. Comparative analysis of renewable energy Consumption of top 20 countries

Figure 4.6.7 represents the renewable energy consumption in % of total final energy consumption of the top 20 countries based on publications data (Scopus). Eight countries have a higher % of renewable energy consumption than the group average. Norway ranked at the top with a value of 57.77 % of total energy consumption followed by Sweden (53.25 %), Brazil (43.79 %), Finland

(43.24 %) and so on. India ranked fifth with a value of 36.02 % of renewable energy consumption. The USA, UK, Australia, Japan, Netherlands, Russian Federation and South Korea have only less than 10 % of renewable energy consumption share in % of total final energy consumption.

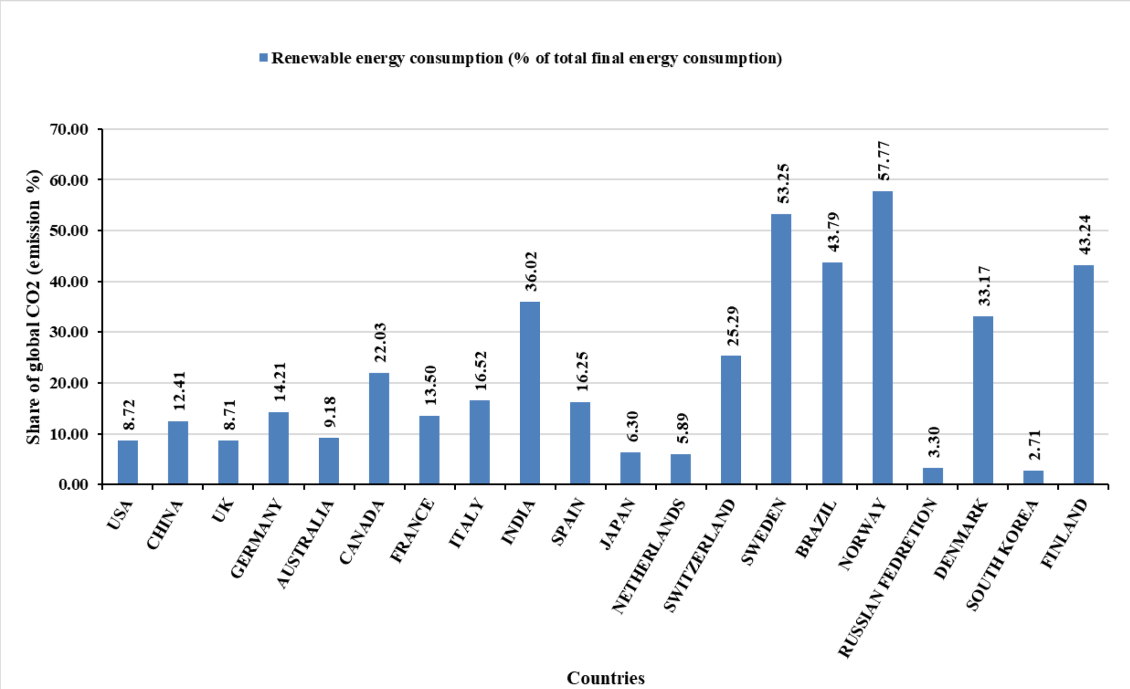


Figure 4.6.7: Renewable energy consumption (% of total final energy consumption) (The World Bank, 2015) of top 20 countries based on publications data (Scopus)

4.6.7. Comparative analysis of the land area and forest cover of top 20 countries

Figure 4.6.8 represents forest area cover in % of total land area (The World Bank,2016), Land area in sq. km (The World Bank,2018) and forest cover in sq. km (calculated) of top 20 countries based on publications data (Scopus). Seven countries have a higher % of forest cover than the group average of 37.68%. India registered the 15th with a forest cover of 23.83 % of total land. Finland topped the list with a forest cover of 73.10 % followed by Sweden (68.92 %), Japan (68.46 %), South Korea (63.35 %), Brazil (58.93 %), and so on. Based on the total forest area, seven countries have a higher forest cover in sq km than the group average of 10449724.54 sq. km. India ranked the 7th by covering 12475033.97 sq. km of forest and also ranked the 7th in respect to the total land area.

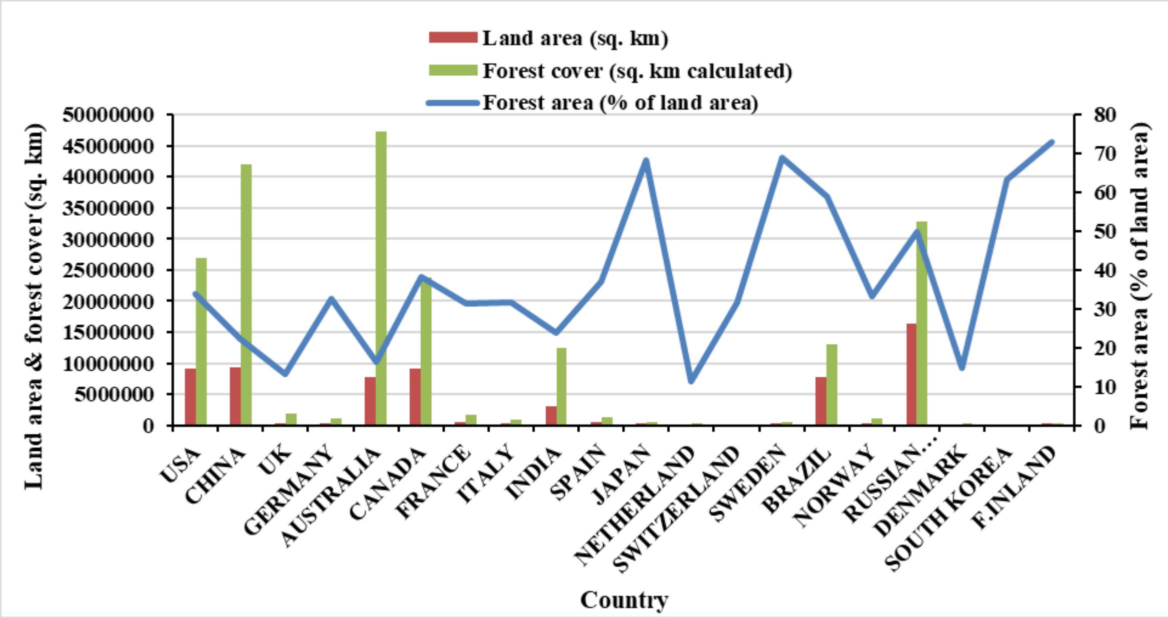


Figure 4.6.8: Forest area (% of land area)/(The World Bank,2016), Land area (sq. km)/(The World Bank,2018), Forest cover (sq. km calculated) of top 20 countries based on publications data (Scopus).

4.6.8. Comparative analysis of the number of patent publications and number of research publications on climate change from WoS and Scopus

A total of 19634 total global patent publications were recorded from World Intellectual Property Organization (WIPO) on 31.03.2021 using the search string which was used to retrieve the publication data from the Web of Science and Scopus. Figure 4.6.9 represents the year-wise number of global and Indian patent publications from 1985 to 2019 where Indian patent publications were recorded with 545 the total number of patent publications since 2006. The highest global patent publication registered with 1710 and Indian patent publication registered with 66 during 2019. A highly positive correlation (r=0.92) was observed between the number of patent publications (both from global and India).

Figure 4.6.10 represents the year-wise number of global patent publications from 1985 to 2019, and the global number of publications from Web of Science (1985-2019) and Scopus (1985-2019). A total of 17113 global patent publications were recorded on total “Climate Change” from WIPO using the search string which was used to retrieve publication data from the Web of Science (466426) and Scopus(649544). A highly positive correlation (r=0.97) was observed between the number of patent publications (both from WoS and Scopus database)and the number of global patent publications.

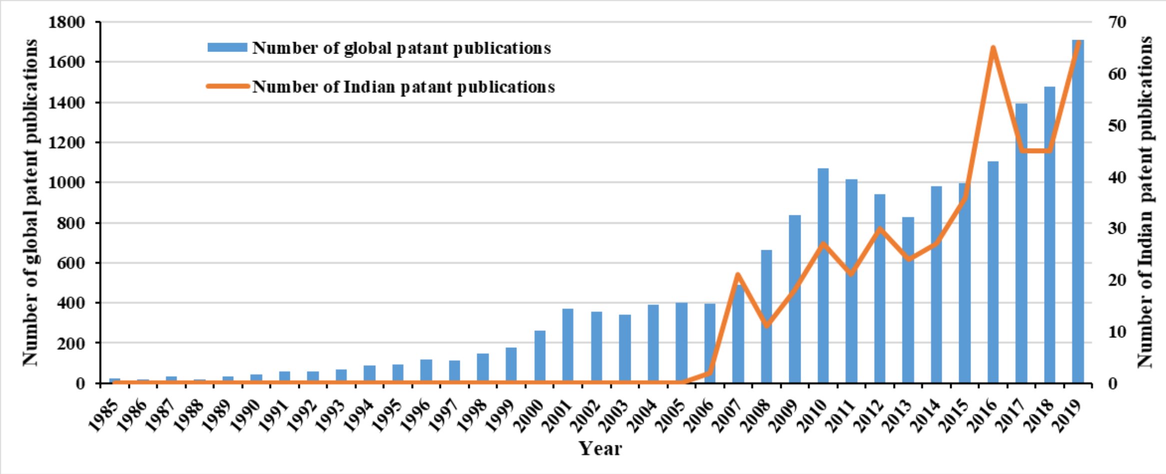


Figure 4.6.9: Year-wise number of global and Indian patent publications from 1985 to 2019

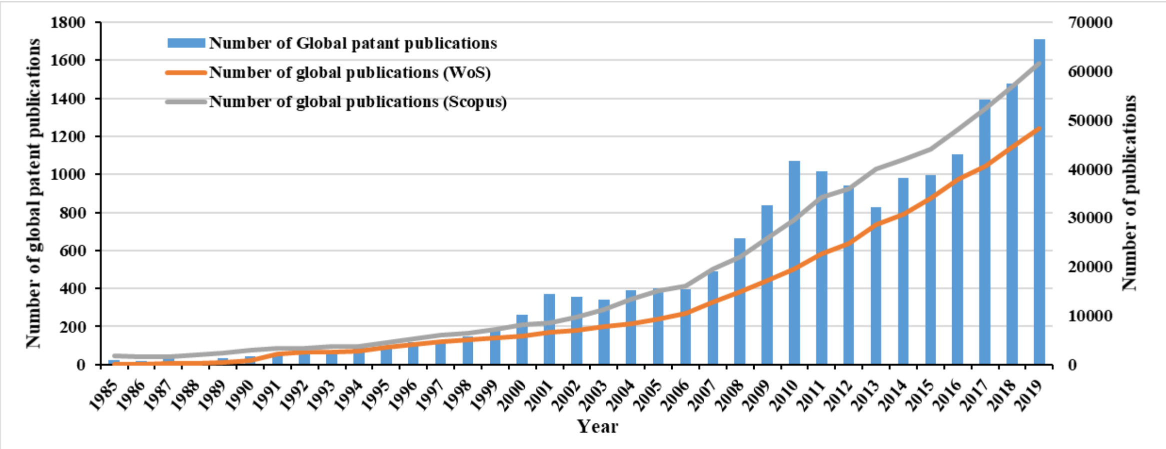


Figure 4.6.10: Year-wise number of global patent publications and research publication on total "Climate Change" from 1985 to 2019

Figure 4.6.11 represents the year-wise number of Indian patent publications from 1985 to 2019, and the global number of publications from Web of Science and Scopus during the same period. The total number of Indian patent publications is 438 whereas the Indian number of research publications on total "Climate Change" are 14663 and 24865 from the Web of Science and Scopus respectively. Before 2005 there was no patent publication from India on "Climate Change". Although, a highly positive correlation (r=0.95) was observed between the number of publications (both from WoS and Scopus database)and the number of Indian patent publications.

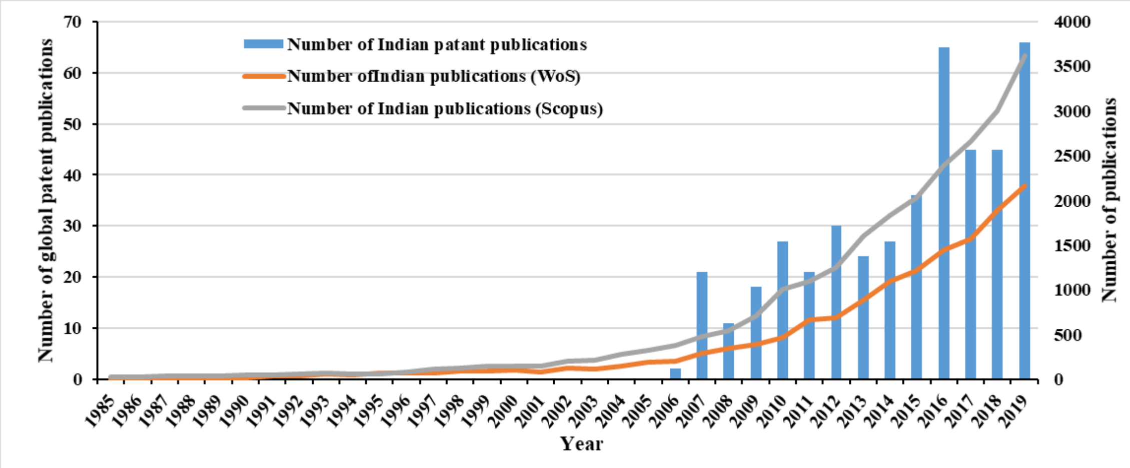


Figure 4.6.11: Year-wise number of total Indian patent publications and research publication on total "Climate Change" from 1985 to 2019.

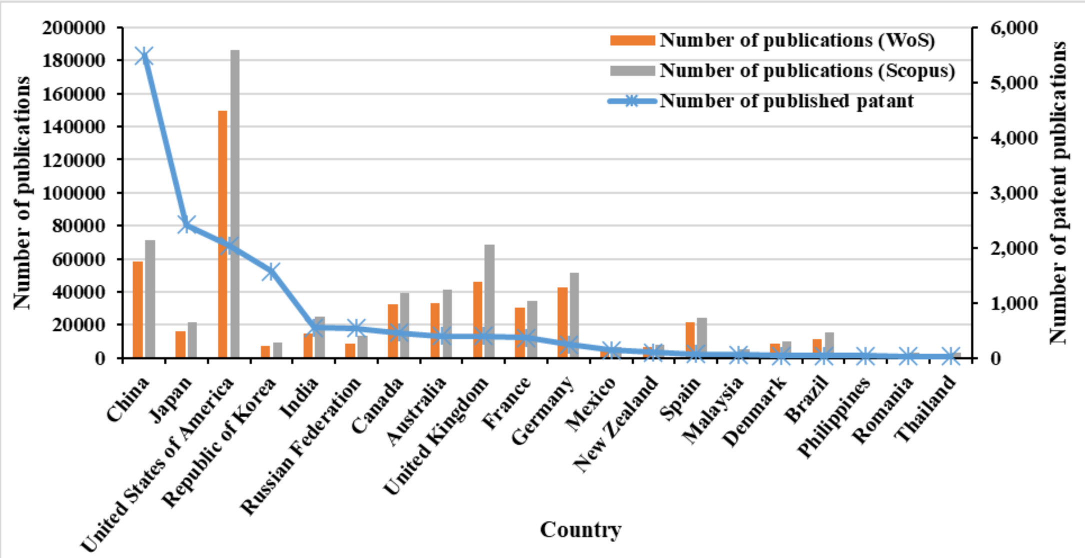


Figure 4.6.12: Top 20 countries based on the number of patent publications on climate change and their number of publications from WoS and Scopus

Figure 4.6.12 represents the number of patent publications on climate change and the publications on climate change of top 20 countries from Web of Science and Scopus during 1985-2019. Four countries have a higher number of patent publications than the group average on climate change. China registered the highest position with 5494 patent publications followed by Japan (2,415), the United States of America (2,040), and so on. The USA registered with the highest number of publications in both the (WoS-149215 & Scopus-186066) databases followed by china (WoS-58608 & Scopus-71360). India registered 5^{th} position with 554patent publications. A lower positive correlation (r=0.45) was observed between the number of publications (both from WoS and Scopus database) and the number of patent publications of the top 20 countries.

4.6.9. Comparative analysis of patent publications from the WIPO GREEN Database

Figure 4.6.13 representsthe number of patent publications from the WIPO GREEN database and their number of publications of the top 30 countries from Web of Science and Scopus during 1985-2019. Five countries have a higher number of patent publications on climate change than the group average. USA leads the list with 1305 patent publications from the WIPO GREEN database followed by Japan (961). Similarly, the USA also registered with the highest number of publications in both the databases (WoS-149215 & Scopus-186066) database followed by china (WoS-58608 and Scopus-71360). India registered 14th position with 34 patent publications from the WIPO GREEN database. A moderate positive correlation (r=0.71) was observed between the number of publications (both from WoS and Scopus database) and the number of patent publications from the WIPO GREEN database of the top 20 countries.

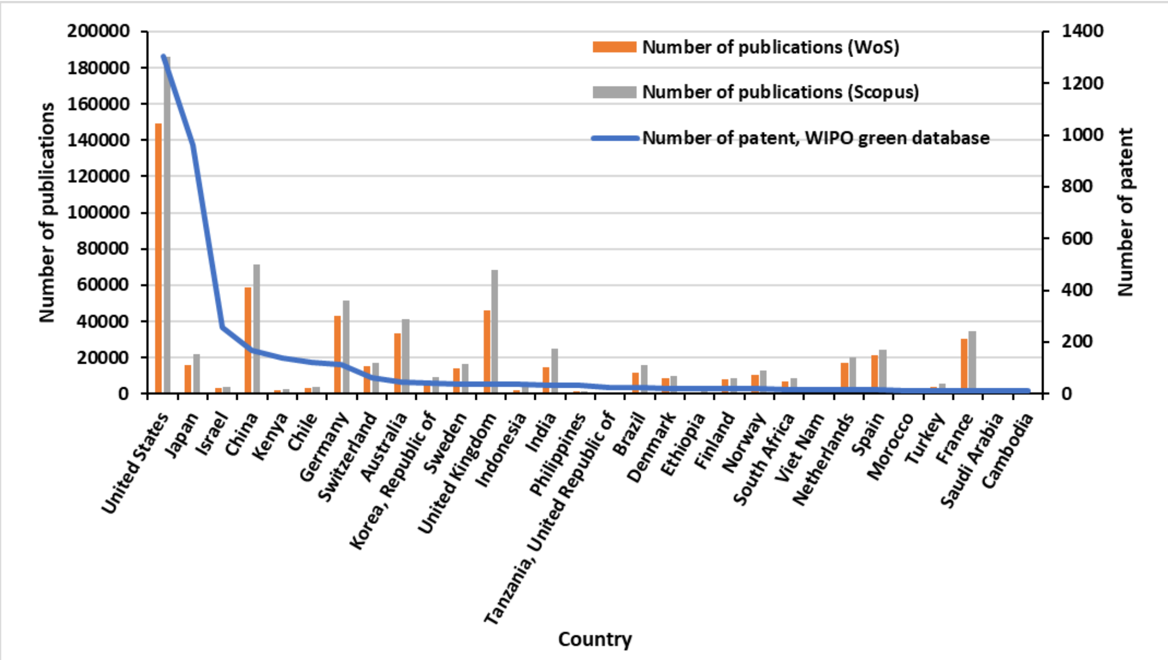


Figure 4.6.13: Top 30 countries based on the number of patent publications from WIPO GREEN database and their number of publications from WoS and Scopus.

Table 4.6.1: Number of total patent publication and patent publications by different categiries of the top countries from WIPO GREEN Database

Country	Total Patent	Energy	Solar	Pollution & Waste	Product, materials and processes	Farming & Forestry	Building & Construction	Water	Transportation
United States	1305	621	229	275	139	196	66	56	44
Japan	961	290	67	233	299	47	73	18	4
Israel	257	96	31	63	12	17	7	59	3
China	166	54	7	42	41	10	8	5	11
Kenya	139	41	7	5	4	40	3	32	2
Chile	120	4	3	0	6	67	0	11	0
Germany	112	52	5	15	21	12	9	3	3
Switzerland	64	4	0	46	3	3	3	6	3
Australia	44	7	1	2	5	18	7	5	1
South Korea	42	16	8	14	5	4	2	2	2
Sweden	39	5	1	8	0	14	14	3	0
United Kingdom	37	7	1	7	5	14	3	6	1
Indonesia	36	7	0	15	1	7	0	1	0
India	34	10	3	3	9	7	0	6	3
Philippines	31	11	0	14	0	0	1	0	1
Tanzania	25	0	0	0	1	10	0	7	0
Brazil	25	6	1	2	2	2	0	3	0
Denmark	22	0	0	3	1	10	5	2	0
Ethiopia	22	0	0	0	0	12	1	2	0
Finland	22	2	1	9	2	7	5	0	0
Norway	21	2	0	4	1	11	5	0	0
South Africa	17	6	2	6	0	0	0	3	2
Viet Nam	17	0	0	13	0	0	0	3	0
Netherlands	16	0	0	0	0	2	2	2	8
Spain	15	5	1	3	4	0	1	2	1
Morocco	13	4	1	0	3	2	0	2	1
Turkey	13	7	1	3	0	0	0	0	2
France	12	6	2	3	0	0	3	0	3
Saudi Arabia	12	4	0	0	1	0	2	1	0
Cambodia	12	8	0	0	0	0	0	1	0

Table 4.6.1 shows the number of total patent publications and patent publications by different categories from the WIPO GREEN Database of the top 30 countries. The patent publications by different categories are Energy, Solar, Pollution & Waste, Product, materials and processes, Farming & Forestry, Building & Construction, Water, Transportation, etc. USA registered the highest position

in the total number of patent publication and also registered the highest position in five different categories like Energy (621), Solar (229), Pollution & Waste (275), Farming & Forestry (196), Transportation (44), Japan registered the highest position in two different categories like Product, materials, and processes (299), Building & Construction (73) and Israel registered the highest position in only Water (59) categories from the WIPO GREEN database. India registered different positions by different categories from the WIPO GREEN database such as Energy-9th, Solar-9th, Pollution & Waste-17th, Product, materials and processes-6th, Farming & Forestry-16th, Building & Construction-23rd, Water-9th, Transportation-8th (Table 4.6.1) with very few numbers of patents.

Chapter 5

Result and Discussions

5.1. Period-wise evolving trends of research productivity and contributions by different bibliometric parameters of India and other countries:

5.1.1. Results from the Web of Science database

5.1.1.1. Growth of total global publications and publications by top 30 countries from Web of Science database

Using the final search string, the Web of Science (WoS) database resulted in a total of 4,66,426 publications worldwide. The annual compound growth rate was 18.77 percent. Reviews, essays, and editorial materials, as well as papers delivered at meetings and conferences, are among the publications considered for the study. More than 232 countries or regions added publications to the total global publications with a compound period-wise growth rate (CPGR) of 151.63 percent. The total number of publications increased from 808 in the first period (1985-1989) to 205135 in the last period (2015-2019) (Figure 4.1.1.2).

With a compound period-wise growth rate (CPGR) of 29.75 percent, the total number of countries or regions engaged in climate change research increased from 48 in 1985-1989 to 229 in 2015-2019. (Figure 4.1.1.3). The top 30 countries or regions contributed about 87.22 percent (normalised) of total global publications, while the top 20 countries contributed about 79 percent (normalised) of total global publications (Figure 4.1.1.4). The top seven countries contributed more than the group average (28348.05 papers). India was ranked 13th with 14532 publications, accounting for 2% (normalised) of all global publications.

5.1.1.2. Period-wise growth of the number of publications of top 20 countries from Web of Science database

Five year'speriod-wise average publications by the top 20 countries were increased from 32.30 in 1985-1989 to 13157.1 in 2015-2019 with a CPGR of 172.26 %. Throughout the times, the United States placed first. Six countries contributed more publications than the group average in recent times. With 8140 publications, India is ranked 10th (Table 4.1.1.1) (Figure 4.1.1.6). India was ranked 13th, With a CPGR of 200.74 percent which is lower than the group's average CPGR (Figure 4.1.1.7).

In the case of the ten-year period-wise growth, the CPGR of publication number of top 20 countries (254.54 %) was also higher than the CPGR of 214.12 % of total global publications. Throughout the times, the United States placed first. Over the last time, seven countries contributed more publications than the group's average, with India taking 11th place (Table 4.1.1.2) with 12290 publications (Figure 4.1.1.10). Seven countries had higher CPGR than the group's average CPGR, with India ranking fifth with a CPGR of 175.03%. (Figure 4.1.1.11).

5.1.1.3. Period-wise growth of organization numbers of top 20 countries from Web of Science database

The total number of organizations involved in the total global climate change research was increased from 453 in 1985-1989) to 55637 in 2015-2019 with a CPGR of 122.95 % (Figure 4.1.1.12). The average number of organizations of the top 20 countries were increased with a CPGR of 160.69 % (Table 4.1.1.3) which is higher than the total global publications. The USA ranked the 1st throughout the periods. By involving 6588 organisations during the last time, India was ranked 15th, a better place than in previous periods (Table 4.1.1.3) (Figure 4.1.1.13).

With a CPGR of 212.21 percent, the overall number of organisations engaged in climate change research increased from 7597 during 1990-1999 to 74053 during 2010-2019 (Figure 4.1.1.14) which is higher than the CPGR of five-year periods (Figure 4.1.1.14). The number of organizations of Indian publication increased with a CPGR of 342.07 % which is quite higher than the CPGR of the total as well as top 20 countries (266.66) (Table 4.1.1.4). India ranked 15th position (Table 4.1.1.4) by involving 7915 organizations during the last period (Figure 4.1.1.15).

5.1.1.4. Global and Indian top organizations

The top 100 and top 500 organizations contributed 30.02 % and 60.31 % of the total global publications respectively. There are no Indian organization among the top 100 global organisations. There are only nine organizations from India in the top 500 organization's list namely Indian Institute Of Technology System IIT System (Rank-109), Indian Council of Agricultural Research ICAR (Rank-169), Ministry of Earth Sciences MOES India (Rank-218), Department of Space DOS Government of India (Rank-258), Council of Scientific Industrial Research CSIR India (Rank-285), Department of Science Technology India (Rank-395), Indian Institute of Tropical Meteorology IITM

(Rank-407), Indian Space Research Organisation ISRO (Rank-432), Indian Institute of Science IISC Bangalore (Rank-467). Figure 4.1.1.16 and 4.1.1.17representing the publications contributions by the top 30 global and top 30 Indian organizations respectively.

5.1.1.5. Period-wise growth of Number of Authors by top 20 countries

With a CPGR of 201.42 percent, the total number of authors from the top 20 countries increased from 58.35 in the first period (1985-1989) to 43760.9 in the last period (2015-2019). (Table 4.1.1.6, Figure 4.1.1.18). India ranked 16th position by involving 24689 authors during the last period with a CPGR of 243.61 % (Figure 4.1.1.18). In the case of ten-year period, the average number of authors from the top 20 countries were increased from 3369.5 during the initial period (1990-1999) to 55020.6 during the last period (2010-2019) with a CPGR of 304.09 % (Table **4.1.1.7**). India ranked 18th position (Table 4.1.1.7) by involving 31671 authors during the last period with a CPGR of 432.71 % (Figure 4.1.1.19).

5.1.1.6. Period-wise growth of Funded Research by top 20 countries

The number of funded research publications increased by 65.82 percent over the last two five-year periods, from 223165 to 370060. The growth rate of Indian-funded research was 336.82 percent during the same time frame. With a CPGR of 273.14%, the total number of supported researches by the top 20 countries increased from 13.15 in the first period (1985-1989) to 35495.55 in the last period (2015-2019). (Table 4.1.1.8). India ranked 20th position (Table 4.1.1.8) by funding 9846 pieces of research during the last period (Figure 4.1.1.21). In the case of the ten-year periods, the number of funded researches from seven countries has involved more than the group average number of funded researches during the last periods and India ranked the last position (Table 4.1.1.9) by funding 13543 pieces of research during the last period (Figure 4.1.1.23).

5.1.1.7. Period-wise growth of meeting abstract by top 20 countries

The number of meeting titles was increased from 100 during the initial five-year period (1985-1989) to 19997 during the last period (2015-2019) with a CPGR of 254.95%. The average number of meeting titles that were participated by the top 20 countries were increased from 1.5 during the initial period (1985-1989) to 827.3 during the last period (2015-2019) with a CPGR of 186.37 % (Table 4.1.1.10). The USA ranked the 1st throughout the periods. India ranked 6th position (Table 4.1.1.10) by participating in 1134 meetings, among the nine countries those have participated in the number of meeting titles more than the group average participation in meeting titles during the last periods. In ten-year periods, the number of meeting titles was from 7329 during the initial period (1990-1999) to 35914 during the last period (2010-2019) with a CPGR of 121.37 %. India ranked 6th position (Table 4.1.1.11) by participating in 1679 meeting titles during the last period with a CPGR of 352.50 % (Figure 4.1.1.26).

5.1.1.8. Period-wise growth of Source Titles by top 20 countries

In the case of five-year periods, the number of source titles or journals were increased from 248 during the initial period (1985-1989) to 11255 during the last period (2015-2019) with a CPGR of 88.86 %. The average number of source titles or journals to communicate research publication by the top 20 countries were increased from 13.3 during the initial period (1985-1989) to 1805.05 during the last period (2015-2019) with a CPGR of 126.69 % (Table 4.1.1.12). India ranked 9th position (Table 4.1.1.12) by publishing in 1978 source titles or journals during the last period with a CPGR of 162.83 % (Figure 4.1.1.28) among the ten countries that have the number of source titles or journals to communicate research publication more than the group average number of source titles or journals. Throughout the periods, India's average number of publications per journal is significantly lower than the top 20 countries' average number of publications per journal (Table 4.1.1.12).

In the case of ten-year periods, the number of source titles or journals were increased from 4054 during the initial period (1990-1999) to 16561 during the last period (2010-2019) with a CPGR of 102.11 % (Figure 4.1.1.29). The top 20 countries increased their total number of source titles or journals to communicate research publication from 454.2 at the beginning (1990-1999) to 2499.9 in the last time (2010-2019), with a CPGR of 134.60 percent (Table 4.1.1.13). The top 20 countries increased their average number of source titles or journals to communicate research publication from 454.2 in the beginning (1990-1999) to 2499.9 in the last time (2010-2019), with a CPGR of 134.60 percent (Table 4.1.1.13). India ranked 9th position (Table 4.1.1.13) by publishing in 1612 source titles or journals during the last period with a CPGR of 131.41 % (Figure 1.2.16). Throughout the periods, India's average number of publications per journal is significantly lower than the top 20 countries' average number of publications per journal (Table 4.1.1.13).

5.1.1.9 India's contribution in Top 30 Source Titles (Journals)

Climate change literature has been reported in 23688 source titles or articles worldwide. The top 30 source titles or journals have published 22.21 percent of all global climate change studies. In total, 3006 source titles or journals have published Indian climate change research. The top 30 source titles or journals have published 15.93 percent of all Indian climate change studies. In some low-impact journals, India has contributed more than the rest of the world (IF range 2-5). In some high-impact journals, such as Nature and Science, India has contributed at a lower rate than the rest of the world (Figure 4.1.1.31).

5.1.2. Results from the Scopus database

In the Scopus database, the information about various bibliometric parameters is limited to only the top 160 entities therefore the comparative quantitative evaluation of all the bibliometric parameters has not been performed.

5.1.2.1. Year-wise total global publications and publications by top 30 countries

From 1985 to 2019, 649544 publications were extracted from the Scopus database using the final search string with a CAGR of 11.09% .Tthe top 30 countries contributed about 83.87 percent (normalised) of total global publications, while the top 20 countries contributed about 76.37 percent (normalised). Six countries out of the top 20 contributed more than the community average (35626.8 papers) (Figure 4.1.2.2). India held 9th rank with 24865 publications i.e., 2.66 % (normalised) of the total global publications. India has contributed more to total global publications in the Scopus database than the Web of Science database, with a higher proportion of publications in the Scopus database.

5.1.2.2. Period-wise growth of the number of Publications of top 20 countries

With a compound period-wise growth rate (CPGR) of 94.20 percent, average publications of the top 20 countries increased from 280.9 in the first period (1985-1989) to 15071.1 in the last period (2015-2019). (Table 4.1.2.1). Throughout the times, the United States placed first. Six countries contributed more publications than the group's average, with India coming in eighth place with 13717 publications over the last five years (2015-2019). (Figure 4.1.2.4). Seven countries had a higher

CPGR than the group's average (114.89%), with India coming in eighth with a CPGR of 112.73 percent (Figure 4.1.2.5).

In the case of the ten-year period, average publications of the top 20 countries increased from 1937.85 in the first period (1990-1999) to 25617.55 in the last period (2015-2019) with a compound period-wise growth rate (CPGR) of 263.58 percent (Table 4.1.2.2). Five countries contributed more publications than the group's average, with India coming in eighth place with 20511 publications over the last ten years (2010-2019). (Figure 4.1.2.7). Six countries had a higher CPGR than the group's average (335.80%), with India ranking fifth with a CPGR of 412.80%. (Figure 4.1.2.8).

5.1.2.3. Global and Indian top organizations

The top 30 organisations contributed 24.78 percent of all global publications (Figure 4.1.2.8). The top 100 organisations accounted for 54.10 percent of all global publications. There are no Indian organisations in the top 30 or top 100 global organisations (Figure 4.1.2.8).

5.1.2.4. India's contribution to the top 30 Source Titles (Journals)

The top 30 source titles or journals have published 16.95 percent of all global climate change studies. The top 30 source titles or journals have published 12.41 percent of all Indian climate change studies. In some low-impact journals, India has contributed more than the rest of the world (IF range 2-5). In several high-impact journals, India has contributed at a lower rate than the rest of the world namely Nature, Science (Figure 1.2.19). In the case of the Web of Science database, a similar situation was observed.

5.1.3. Results from Indian Citation index database

5.1.3.1. Year-wise total global publications and Indian publications

A total of 9845 publications were recorded globally from the Indian Citation Index database from 2005 to 2019. With a CAGR of 12.43 percent, the global number of publications rose from 182 in 2005 to 939 in 2019. Besides, with a CAGR of 10.72 percent, the number of Indian publications increased from 158 in 2005 to 658 in 2019.

5.1.3.2. Period-wise (5 years) growth of the number of Publications of top 20 countries

Total global publications ere increased from 1420 during the initial period (2005-2009) to 4988 during the last period (2015-2019) with a compound period-wise growth rate (CPGR) of 87.42 %

(Figure 4.1.3.2). Total Indian publications ere increased from 1145 during the initial period (2005-2009) to 3861 during the last period (2015-2019) with a compound period-wise growth rate (CPGR) of 83.63 % (Figure 4.1.3.2). India ranked the 1st throughout the periods.

5.1.3.3. India's contribution to Top 30 Source Titles (Journals)

The top 30 source titles or journals of the Indian Citation Index have published 34.57 % of the total global publications and 33.20 % of the total Indian publications on climate change (Figure 4.1.3.3).

5.2. Period-wise impact evaluation of the research publications through citation analysis

5.2.1. Results from Web of Science database

5.2.1.1. Period-wise Average Citation of top 20 and top 30 countries

During the first period (1985-1989), the average citation of publications from the top 20 countries was 61.65, but it dropped to 54.16 during the second period. (Figure 4.2.1.1). The average citation was then increased for two consecutive periods (57.09 and 67.20), before declining in subsequent periods. This is because articles require a time before they can be cited. (Table 4.2.1.1). During the last period (2015-2019), ten countries had average citations higher than the group average, with India ranking last (Figure 4.2.1.1).

5.2.1.2. Calculated 5-year impact factor of top 20 countries

The estimated 5-year impact factor of the top 20 countries' publications increased from 1.42 in the beginning (1985-1989) to 7.073 in the last period 2015-201. (Table 4.2.1.3., Figure 4.2.1.3.). During the last five years (2015-2019), ten countries had a higher 5-year impact factor than the group average, with India ranking 19th (Figure 4.2.1.3). The estimated 5-year impact factor of the top 30 countries' publications increased from 1.20 in the first period (1985-1989) to 6.97 in the most recent period (2015-201). (Table 4.2.1.4). During the last five years (2015-2019), fourteen countries had a higher 5-year impact factor than the community average, with India ranking 29th (Figure 4.2.1.4).

5.2.1.3. h-index of total publication and Period-wise h-index of top 20 and top 30 countries

The average h-index of the top 20 countries' total publications is 324.25. India is ranked 19th out of eight countries with a higher h-index than the group average (Figure 4.2.1.5). The average h-index of the top 20 countries increased from 10.8 in the first period (1985-1989) to 178.1 in the second period (2005-2009) (Table 2.2.3), while the h-index of the last two periods decreased (Table 2.2.3, Figure

4.2.1.6). During the last three periods (2015-2019), nine countries had a higher h-index than the group average h-index, with India occupying the 18th spot (Table 4.2.1.5). The cumulative publication of the top 30 countries has a group average h-index of 269.67. India is ranked 21st among the countries with a higher h-index than the group average (Figure 4.2.1.7). The average h-index of the top 30 countries increased from 7.93 during the first period (1985-1989) to 150.50 during the second period (2005-2009) (Table 4.2.1.6), while the h-index decreased for the last two periods. During the last three periods (2015-2019), fourteen countries had a higher h-index than the group average h-index, and India was ranked 21st during last period (Table 4.2.1.6, Figure 4.2.1.8).

5.2.1.4. Publication's % in country-specific top 100 journals of top 20 countries

The top 100 journals published 41.07 percent of all global publications, according to research. Based on the number of publications in the top 20 countries. The average percent of overall publications in country-specific top 100 journals for the top 20 countries is 53.39 percent. Ten countries published more articles in country-specific top 100 journals, with India coming in 14th with 51.77 percent of all Indian publications (Figure 4.2.1.9).

5.2.1.5. Average impact factor of country-specific top 100 journals of top 20 countries

The impact factor of the top 100 journals from each of the top 20 countries is 4.43 (Figure 4.2.1.10). The average impact factor of country-specific top 100 journals in the top 20 countries is higher in fifteen countries than it is in the top twenty countries. India ranked last with having an average impact factor of 2.97. The average impact factor of individual publications in country-specific top 100 journals of top 20 countries is 4.63. Twelve countries have more average impact factors than the average impact factor of individual publications in country-specific top 100 journals of top 20 countries (Figure 4.2.1.10). India ranked the last with having an average impact factor of 2.386.

5.2.1.6. Publication frequency distribution among different IF categories of country-specific top 100 journal's publication of top 20 countries

The most frequent publications of the top 20 countries were published in the 3 to 4.99 IF category followed by 1 to 2.99 and 5to 9.99 IF categories. Above 20 IF was the lowest frequent IF category followed by 10 to 19.99 IF category (Figure 4.2.1.11). Eleven to twelve countries have more frequency than that of the average frequency of the top 20 countries among different IF categories of above IF 1 Table 4.2.1.7. India ranked better in below one and no IF categories.

5.2.2. Impact analysis from Scopus database

5.2.2.1. h-index of total publication and Period-wise h-index of top 20 countries

The cumulative publication of the top 20 countries has a group average h-index of 331.55. India is ranked 18th out of eight countries with a higher h-index than the group average (Figure 4.2.2.1). The top 20 countries' h-index over time is depicted in Figure 4.2.2.2. The average h-index of the top 20 countries increased from 37.25 during the first period (1985-1989) to 193.45 during the second period (2005-2009) (Table 2.3.1), while the h-index decreased for the last two periods. During the last two periods (2015-2019), nine countries had h-indices higher than the group average h-index, and India was ranked 17th (Figure 4.2.2.2).

5.2.2.2. % of publication in country-specific top 100 journals of top 20 countries

The top 100 journals have been found to have published 30.75 percent of all global publications. Based on the number of publications in the top 20 countries, Figure 4.2.3.3 indicates the percent of publications in country-specific top 100 journals. The average percent of total publications in country-specific top 100 journals for the top 20 countries is 43.92 percent. In the last ten years, ten countries have published more publications than the rest of the world combined and India ranked the last by publishing 36.66 % of total Indian publications.

5.2.2.3. Average impact factor of country-specific top 100 journals of top 20 countries

The average impact factor of the top 100 journals from the top 20 countries is 4.15. Thirteen countries' average impact factors are higher than the average impact factor of the top 100 journals in each of the top 20 countries. With an average impact factor of 2.88, India was ranked 19th. Individual publications in the top 100 journals of the top 20 countries have an average impact factor of 4.617. The average impact factor of individual publications in country-specific top 100 journals of the top 20 countries is higher in twelve countries than in individual publications in country-specific top 100 journals of the top 20 countries. With an average impact factor of 2.54 per publication, India was ranked 19th.

5.2.3.4. Publication frequency distribution among different IF categories of country-specific top 100 journal’s publication of top 20 countries

The top 20 countries' most frequent publications were in the 3 to 4.99 IF range, followed by 1 to 2.99 and 5 to 9.99 IF categories. The least common IF group was above 20 IF, followed by 10 to 19.99 IF. Ten to thirteen countries have a higher frequency than the top 20 countries in various IF groups above IF 1 than the average frequency of the top 20 countries (Table 4.2.2.3). In the groups below one and no IF, India performed better. Table 4.2.2.3 shows the top performers in different IF categories.

5.2.3. Indian Citation Index

5.2.3.1. Period-wise total and average citation of global and Indian publication

The total number of citations for all global publications rose marginally in the second period before dropping in the third period. In contrast, the number of not cited publications in both global and Indian publications has risen over time (Figure 4.2.3.2). The average number of citations in total global and Indian publications decreased over time. The average citation of Indian publications was significantly higher than the average citation of all global publications, which is very motivating (Figure 4.2.3.3).

5.2.3.2. Period-wise h-index of global and Indian publication

At different times, the h-index of total global publications and Indian publications decreased. During the first (20) and second (14) periods, the h-indices of both global and Indian publications were the same (Figure 4.2.3.4). The h-index of global publications (7) was higher than the h-index of Indian publications during the previous century (6).

5.3. Research collaboration of India with different countries

5.3.1. Results from Web of Science database

5.3.1.1. Period-wise growth of Number of Collaborating countries of top 20 countries

The top 20 countries' total number of partnering countries increased from 5.1 at the beginning (1985-1989) to 180.1 in 2015-2019. (Table 4.3.1.1, Figure 4.3.1.1). It was increased from 2 to 172 in the case of India. Throughout the time, the United States was the most cooperative nation. During the last five years (2015-2019), eight countries collaborated with more countries than the community average, with India coming in 15th place. The research collaboration network map among the top 20 countries of the total global climate change research shows (Figure 4.3.1.2) that the USA was the most collaborating country followed by China. All developed countries have strong collaboration linkages among them. The strength of Indian collaboration linkages with top countries is very weak even these are lower than the collaboration linkages of the same or lower publication's group. .

5.3.1.2. Indian research collaboration

India has published the maximum collaborative research publications with the USA followed by England, Germany and France (Figure 3.2.3).

5.3.1.3. Impact of Indian Collaborative research

The total number of collaborative publications in India was found to be 31.97 percent. The partnership with the top 20 India's collaborating countries resulted in 4022 (27.43 percent) of the total 14663 Indian publications. Just 639 publications (4.36 percent) were produced in collaboration with India's other collaborating countries. (Figure 4.3.1.5.) There were 321021 citations in total for Indian articles. The top 20 Indian cooperating countries earned 50.89 percent (163396 citations) of total Indian citations, accounting for 27.43 percent of total Indian publications (Figure 4.3.1.6). As a result, the average citations of collaborative publications with India's top 20 collaborating countries is roughly two times higher than the average citations of all Indian publications (Figure 4.3.1.7). The average number of citations in joint publications with the rest of India's collaborating countries was marginally lower than the total number of citations in Indian publications. There are no citations in about 13.45% of all Indian publications. As compared to total Indian publications, the percentage of publications without any citations for the top 20 India-collaborating countries is very poor (5.20 percent). Around 9.86 percent of the joint publications with the rest of India's collaborating countries had no citations, which is lower than the overall number of citations in all Indian publications (Figure 4.3.1.8).

5.3.1.4. Collaborative national and International Organizations:

India's most collaborative organisation is the Indian Institute of Technology framework, which is preceded by the Ministry of Earth Sciences and the Council of Scientific and Industrial Research

Figure (4.3.1.10). National Center for Scientific Research (CNRS) In Indian collaborative research, the CNRS is the most collaborative international organisation (Figure 4.3.1.11).

5.3.1.5. Collaboration network among the top 100 organisations of Indian publications

Collaboration network analysis of the top 100 Indian organization of total Indian climate change research revealed that surprisingly, the Indian publication does not rank first among the top 100 Indian climate change partnership research organisations. The Indian Institute of Tropical Meteorology was ranked 10th, and it was the only organisation in the top 20 based on total connection intensity. In Indian climate change research collaboration, the Chinese Academy of Sciences had the strongest collaboration relation intensity, followed by Columbia University, University of Washington, University of California San Diego, The University of Maryland, and The University of Tokyo.

5.3.1.6. Collaboration network among top 500 authors of Indian publications

Indian author's collaboration networks map among the top 500 authors and the name of the top 50authors among the top 500 collaborative authors of Indian publications and their number of collaboration links, total link strength, number of documents, total citations, and average citations of the total Indian climate change research shown that KUMAR, A registered with the highest number of collaboration with 247 authors in 287 publications, and with 973 collaboration strength followed by SINGH, AK and SINGH, R number of collaboration of authors of 163 and 149 with link strength of 644.

5.3.1.7. Bibliographic coupling among the top 100 organisations of Indian publications

The bibliographic coupling network of the top 100 organizations (Figure 4.3.1.13), as well as the number of co-citation links, total link strength, number of articles, total citations, and average citations (Table 4.3.1.4) of Indian climate change research organisations, revealed that among the top 100 organisations in terms of bibliographic coupling, the Indian Institution of Tropical Meteorology had the most co-citations, followed by another Indian agency, the India Meteorological Department.

5.3.1.8. Bibliographic coupling among the top 500 authors of Indian publications

The bibliographic coupling network of the top 500 authors (Figure 4.3.1.14) and the name of the top 50 co-cited authors of Indian publications and their number of co-citation links, total link strength, number of documents, total citations, and average citations (Table 4.3.1.5) of Indian climate change research shown that the top three authors in this area, A. KUMAR, M. RAJEEVAN, and A. K. SRIVASTAVA, were the most co-cited authors in Indian publications. KUMAR, A registered with the highest number of authors of 499 with whom he was co-cited in 287 documents followed by RAJEEVAN, M co-cited with 438 authors in 50documents.

5.3.2. Results from Scopus database

5.3.2.1. Indian research collaboration

The research collaboration network with the top 50 collaborating countries of Indian research on climate change refected the similar observations were noticed in the Scopus database like that of the Web of Science database. India has published the maximum collaborative research publications with the USA followed by England, Germany and Australia (Figure 4.3.2.2).

5.3.2.2. Impact of Indian Collaborative research

Collaboration was found to account for 30.63 percent of all Indian publications. 6555 (26.36 percent) of the 24865 collaborative Indian publications were published in collaboration with the top 20 collaborating countries in India. Just 1062 publications (4.27%) were published in cooperation with the rest of India's collaborating countries (Figure 4.3.2.3). In total, 439132 citations were found in Indian publications. The top 20 Indian collaborating countries earned 47.31 percent (207746 citations) of total Indian citations (Figure 4.3.2.4). As a result, the average citations of collaborative publications with India's top 20 collaborating countries is nearly twice as high as the average citations of all Indian publications (Figure 3.2.5). The average number of citations in collaborative publications with India's other collaborating countries was lower than the total number of citations in Indian publications. The h-index of all Indian publications is higher than the h-index of collaborative publications with the top 20 India-collaborating countries and the rest of India's collaborators (Figure 4.3.2.6).

There are no citations in about 36.37 percent of all Indian publications (Figure 4.3.2.7). In comparison to the overall Indian publications, the proportion of publications without any citation is much lower for publications with the top 20 India's collaborating countries (12.68%) and the rest of India's collaborating countries (17.89%).

5.3.2.3. Collaborative national and International Organizations:

Indian Institute of Technology Delhi is the most collaborative organization from India followed by the Indian Institute of Tropical Meteorology IITM, Indian Institute of Science IISC Bangalore, Indian Space Research Organisation (Figure 4.3.2.8). Centre National De La Recherche Scientifique CNRS is the most collaborative international organization in Indian collaborative research (Figure 4.3.2.9).

5.4. Evaluation of the interrelationship among the national goal on climate change and the research publications of India covering Indian Journals

5.4.1. National Solar Mission

5.4.1.1. Results from the Web of Science data related to "National Solar Mission"

5.4.1.1.1. Number of publications related to the National Solar Mission by top 30 countries

The Web of Science database resulted in a total of 270916 global and 20686 Indian publications using the National Solar Mission's final search string. The United States is the leading contributor to publications related to "National Solar Mission" among the top 30 nations, with 63051 publications (Figure 4.4.1.1.1.). India is ranked fourth in the world in terms of the number of publications, with 20686.

5.4.1.1.2. Year-wise Growth of global and Indian publications related to "National Solar Mission"

The compound annual growth rate of Indian publications was slightly lower than that of total global publications from 1987 to 2019. The CAGR of Indian publications was lower than that of total global publications before 2008. It's interesting to note that the CAGR of Indian publications between 2009 and 2019 is substantially higher than the global average (Table 4.4.1.1.1). As a result, it is possible to infer that India's National Solar Mission initiates research and development activities on various solar mission goals, increasing the number of publications.

5.4.1.1.3. Total Global and Indian comparative contribution in top 30 research areas

In India's overall climate change study, the top 30 research areas contributed a total of 89.99 percent (normalised), compared to 87.72 percent globally (normalised). Energy fuel, Electrical Engineering, Physics Condensed Matter, Green Sustainable Science Technology, Thermodynamics, Mechanics, and Automation Control Systems, both of which are concerned with technological development to tackle climate change, have contributed more than the global average (Figure 4.4.1.1.3).

5.4.1.1.4. Indian publication contribution in top 30 research areas before and after the adoption of the mission

After the introduction of the mission, Energy Fuels, Engineering Electrical Electronic, Materials Science Multidisciplinary, Physics Applied, Chemistry Physical, Physics Condensed Matter, Chemistry Multidisciplinary, Green Sustainable Science Technology, and Nanoscience Nanotechnology were the most important and contributed more than 1000 publications.

5.4.1.1.5. The quantitative evolution and exchange of keywords of Indian publication related to "National Solar Mission"

The higher the similarity index value, the more consistent the core themes of Indian publications on "National Solar Mission" research are, while the quantity of newly developed keywords indicates that the core theme is improving, resulting in the diversification of different subthemes. With a growth rate of 150.59 percent, the number of keywords rose from 1012 in 1985 to 2536 in 2009-2019. More than half of the keywords from pre-mission research were integrated into Indian publications on the National Solar Mission after the mission was launched.

5.4.1.1.6. Quantitative and qualitative development of themes at successive periods of Indian publication related to "National Solar Mission"

During 1985-2008 a total of only 1012 keywords during the before mission were observed among the total 2754 publications. The initial period has registered fourteen themes with a DF range of 8 to 265. During this period "OPTICAL-PROPERTIES" was found to be the most active theme having a DF of 265 (Figure 4.4.1.1.6, Table 4.4.1.1.2) followed by "PERFORMANCES". The themes "SEMICONDUCTOR-ELECTRODES", "OSCILLATIONS" and "WATERS" were found to come under emerging focus.

Total keywords increased by 150.59 percent after the introduction of the mission, out of a total of 18143 publications (increased by more than 558.79 percent). During that period, the number of themes increased to 41, with a higher proportion of DF. During this time, the most active theme was "SOLAR-CELLS," with a DF of 3,471, followed by "ORGANIC-DYES," with a DF of 595, and

“NANOSTRUCTURES,” with a DF of 466. (Figure 4.4.1.1.7, Table 4.4.1.1.3). The themes "POWER-SYSTEMS," "ABSORBERS," "DISTRIBUTED-GENERATIONS," and "SURFACES" were discovered to be getting more popular. The basic and transversal themes were "ENERGIES," "RENEWABLE-ENERGIES," "DEGRADATIONS," and "NANOFLUIDS."

5.4.1.2. Results from the Scopus publication data related to “National Solar Mission”

5.4.1.2.1. Number of publications by top 30 countries related to “National Solar Mission”:

Using the final search string, a total of 3,48,464 publications were included in the Scopus database. Among the top 30 countries, the United States is the top contributor, with 74251 publications (Figure 4.4.1.2.1). India has contributed 25933 publications to the “National Solar Mission” and is ranked third in the world for “National Solar Mission” publications.

5.4.1.2.2. Year-wise Growth of global and Indian publications related to “National Solar Mission”

During the period 1987-2019, the compound annual growth rate (11.81 percent) of Indian publications was higher than the total global publications (Table 4.4.1.2.1). Up until 2008, when the National Solar Mission was created, the CAGR (5.70 percent) of Indian publications was higher than the total global publications to the “National Solar Mission.” It's fascinating to note that the CAGR of Indian publications (25.77%) is also higher than the global total publications. As a result, it is possible to infer that India's "National Solar Project" initiates R&D activities on various solar mission targets, increasing the number of publications.

5.4.1.2.3. Total global and Indian comparative contribution in top 30 research areas:

The top ten subject areas in total Indian climate change research contributed a total of 93.09 percent (normalised) which is similar to the global contribution. In some research fields, such as engineering, energy, chemical engineering, computer science, mathematics, social sciences, multidisciplinary, decision sciences, and so on, India has contributed more than the global average. In certain research fields, such as Materials Science, Physics and Astronomy, Chemistry, Earth and Planetary Sciences, India has contributed less than the global average.

5.4.1.2.4: Indian publication contribution related to "National Mission on Sustainable Habitat" in different research areas before and after the introduction of the mission:

Before the introduction of the "National Solar Mission," the most important research areas were energy, engineering, materials science, physics and astronomy, earth and planetary sciences, chemistry, environmental science, and chemical engineering, with over 200 publications. Following the introduction of the mission, the following research areas emerged as the most prominent, contributing over 1500 publications: Engineering, Energy, Materials Science, Physics and Astronomy, Computer Science, Chemistry, Chemical Engineering, Mathematics, and Environmental Science.

5.4.1.3. Results from the Indian Citation Index data related to "National Solar Mission"

5.4.1.3.1. Year-wise Growth of global and Indian publications related to "National Solar Mission"

During the period 2005-2019, the compound annual growth rate of Indian publications was marginally higher than that of total global publications. Before the introduction of the "National Solar Mission", the CAGR of Indian publications was significantly higher than that of total global publications. While the CAGR of Indian publications from 2009 to 2019 is lower than the global total publications, (Table 4.4.1.3.1).

5.4.1.3.2. Total Global and Indian comparative contribution in top 30 research areas

The top 30 research areas of total Indian research have contributed 77.70% on the Indian "National Solar Mission" related topic as compared to total global contribution of 77.23%. In some research areas, India has contributed more than the rest of the world, such as Engineering Science and Technology, Agriculture, Electrical Engineering, Energy and Fuel Science, and Chemical Engineering, which all deal with solar technological growth (Figure 4.4.1.3.2).

5.4.1.3.3: Indian publication contribution in top 30 research areas before and after the adoption of the mission

After the introduction of the mission, the following research areas Engineering Science and Technology, General Science and Technology, Chemistry, Environmental Science, Agriculture, Electrical Engineering, Energy and Fuel Science were the most important and contributed more than 90 publications.

5.4.2. National Mission for Enhanced Energy Efficiency

5.4.2.1. Results from the Web of Science data related to the "National Mission for Enhanced Energy Efficiency"

5.4.2.1.1. Number of publications related to the "National Mission for Enhanced Energy Efficiency" by top 30 countries

The Web of Science database resulted in a total of 157811 global and 10239 Indian publications using the National Mission for Enhanced Energy Efficiency's final search string. The Peoples R China is the leading contributor to publications related to " National Mission for Enhanced Energy Efficiency" among the top 30 nations, with 34122 publications (Figure 4.4.2.1.1.). India is ranked third in the world in terms of the number of publications, with 10239.

5.4.2.1.2. Year-wise Growth of global and Indian publications related to "National Mission for Enhanced Energy Efficiency"

The compound annual growth rate of Indian publications was slightly higher than that of total global publications from 1987 to 2019. The CAGR of Indian publications was lower than that of total global publications before 2008. It's interesting to note that the CAGR of Indian publications between 2009 and 2019 is substantially higher than the global average (Table 4.4.2.1.1). As a result, it is possible to infer that India's National Mission for Enhanced Energy Efficiency initiates research and development activities on various National Mission for Enhanced Energy Efficiency goals, increasing the number of publications

5.4.2.1.3. Total Global and Indian comparative contribution in top 30 research areas

In India's overall climate change study, the top 30 research areas contributed a total of 91.4 percent (normalised), compared to 86.3 percent globally (normalised). Engineering Electrical Electronic, Telecommunications, Computer Science Information Systems, Computer Science Hardware Architecture, Computer Science Theory Methods, Computer Science Artificial Intelligence, Automation Control Systems, Computer Science Interdisciplinary Applications, Computer Science Software Engineering, Engineering Multidisciplinary, both of which are concerned with technological development to tackle climate change, have contributed more than the global average (Figure 4.4.2.1.3).

5.4.2.1.4: Indian publication contribution in top 30 research areas before and after the adoption of the mission

After the introduction of the mission, Energy Fuels, Engineering Electrical Electronic, Telecommunications, Computer Science Theory Methods, Computer Science Information Systems were the most important and contributed more than 1000 publications.

5.4.2.1.5. The quantitative evolution and exchange of keywords of Indian publication related to "National Mission for Enhanced Energy Efficiency"

The higher the similarity index value, the more consistent the core themes of Indian publications on "National Mission for Enhanced Energy Efficiency" research are, while the quantity of newly developed keywords indicates that the core theme is improving, resulting in the diversification of different subthemes. With a growth rate of 254.18 percent, the number of keywords rose from 347 in 1985-2008 to 1229 in 2009-2019. More than half of the keywords from pre-mission research were integrated into Indian publications on the National Mission for Enhanced Energy Efficiency after the mission was launched.

5.4.2.1.6. Quantitative and qualitative development of themes at successive periods of Indian publication related to "National Mission for Enhanced Energy Efficiency"

During 1985-2008 a total of only 347 keywords during the before mission were observed among the total 737 publications. The initial period has registered two themes with a DF range of 16 to 39. During this period "ENERGIES" was found to be the most active theme having a DF of 39 (Figure 4.4.2.1.6, Table 4.4.2.1.2). The themes "ENERGY-EFFICIENCIES" were found to come under emerging focus.

Total keywords increased by 254.18 percent after the introduction of the mission, out of a total of 9832 publications (increased by maximum). During that period, the number of themes increased to 7, with a higher proportion of DF. During this time, the most active theme was "WIRELESS-SENSOR-NETWORK" with a DF of 941, followed by "ENERGIES," with a DF of 455. (Figure 4.4.2.1.7, Table 4.4.2.1.3). The themes "WSNS", "GREEN-COMMUNICATIONS" and "CO2-EMISSIONS " were discovered to be getting more popular. The basic and transversal themes were "DESIGNS".

5.4.2.2. Results from the Scopus publication data related to "National Mission for Enhanced Energy Efficiency"

5.4.2.2.1. Number of publications by top 30 countries related to "National Mission for Enhanced Energy Efficiency"

Using the final search string, a total of 2,72,519 publications were included in the Scopus database. Among the top 30 countries, the China is the top contributor, with 52439publications (Figure 4.4.2.2.1). India has contributed 19094 publications to the "National Mission for Enhanced Energy Efficiency" and is ranked third in the world for "National Mission for Enhanced Energy Efficiency" publications.

5.4.2.2.2. Year-wise Growth of global and Indian publications related to "National Mission for Enhanced Energy Efficiency"

During the period 1987-2019, the compound annual growth rate (24.55 percent) of Indian publications was higher than the total global publications (Table 4.4.2.2.1). Up until 2008, when the National Mission for Enhanced Energy Efficiency was created, the CAGR (23.48 percent) of Indian publications was higher than the total global publications to the "National Mission for Enhanced Energy Efficiency" It's fascinating to note that the CAGR of Indian publications (26.83 %) is also higher than the global total publications. As a result, it is possible to infer that India's "National Mission for Enhanced Energy Efficiency Project" initiates R&D activities on various solar mission targets, increasing the number of publications.

5.4.2.2.3. Total Global and Indian comparative contribution in different subject areas

The top ten subject areas in total Indian climate change research contributed a total of 91.38 percent (normalised) which is similar to the global contribution. In some research fields, such as Computer Science, Mathematics, Medicine, Decision Sciences, Veterinary, India has contributed more than the global average. In certain research fields, such as Engineering, Energy, Chemical engineering, Materials Science, Physics and Astronomy, Chemistry, Earth and Planetary Sciences, Environmental Science, Business, Management and Accounting, Social Sciences, Agricultural and Biological Sciences, Multidisciplinary, Biochemistry, Genetics and Molecular Biology, Economics, Econometrics and Finance, Arts and Humanities and so on, India has contributed less than the global average.

5.4.2.2.4: Indian publication contribution related to "National Mission for Enhanced Energy Efficiency" in different research areas before and after the introduction of the mission:

Before the introduction of the "National Mission for Enhanced Energy Efficiency" the most important research areas were Energy, Engineering, Computer Science. Materials Science, Chemistry, Environmental Science, Chemical Engineering, with over 150 publications. Following the introduction of the mission, the following research areas emerged as the most prominent, contributing over 1500 publications: Energy, Engineering, Computer Science. Materials Science, Chemistry, Environmental Science, Chemical Engineering, Mathematics, Physics and Astronomy.

5.4.2.3. Results from the Indian Citation Index data related to "National Mission for Enhanced Energy Efficiency"

5.4.2.3.1. Year-wise Growth of global and Indian publications related to "National Mission for Enhanced Energy Efficiency"

During the period 2005-2019, the compound annual growth rate of Indian publications was lower than that of total global publications. Before the introduction of the " National Mission for Enhanced Energy Efficiency ", the CAGR of Indian publications was quite higher than that of total global publications. While the CAGR of Indian publications from 2009 to 2019 is lower than the global total publications, (Table 4.4.2.3.1).

5.4.2.3.2. Total Global and Indian comparative contribution in different subject areas

The top 30 research areas of total Indian research have contributed 76.54% on the Indian "National Solar Mission" related topic as compared to total global contribution of 76.19%. In some research areas, India has contributed more than the rest of the world, such as namely Engineering Science And Technology, General Science And Technology, Computer Science And Technology, Agriculture, Artificial Intelligence, Social Science, Electronic And Communication Engineering, Computer Engineering, Computer Network, General Engineering, Management, Mechanical Engineering, Energy And Fuel Science, Health Science, Agricultural Engineering, Agronomy, Material Science, Library And Information Science, which all deal with energy-related technological growth (Figure 4.4.2.3.2).

5.4.2.3.3: Indian publication contribution in top 30 research areas before and after the adoption of the mission

After the introduction of the mission, the following research areas Engineering Science And Technology, General Science And Technology, Computer Science And Technology, Environmental Science, Agriculture, Electronic And Communication Engineering, Artificial Intelligence, Social Science were the most important and contributed more than 100 publications.

5.4.3. National Mission on Sustainable Habitat

5.4.3.1. Analysis of Web of Science publication data of "National Mission on Sustainable Habitat"

5.4.3.1.1. Number of publications related to the "National Mission on Sustainable Habitat"by top 30 countries

The Web of Science database resulted in a total of 1,66,865 global and 7187 Indian publications using the National Mission on Sustainable Habitat's final search string. The Peoples R China is the leading contributor to publications related to "National Mission on Sustainable Habitat" among the top 30 nations, with 35085 publications (Figure 4.4.3.1.1.). India is ranked seventh in the world in terms of the number of publications, with 7187.

5.4.3.1.2. Year-wise Growth of global and Indian publications related to "National Mission on Sustainable Habitat"

The compound annual growth rate of Indian publications was slightly higher than that of total global publications from 1987 to 2019. The CAGR of Indian publications was higher than that of total global publications before 2008. It's interesting to note that the CAGR of Indian publications between 2009 and 2019 is fairly higher than the global average (Table 4.4.3.1.1). As a result, it is possible to infer that India's National Mission on Sustainable Habitat initiates research and development activities on various National Mission on Sustainable Habitat goals, increasing the number of publications.

5.4.3.1.3. Total Global and Indian comparative contribution in top 30 research areas:

In India's overall climate change study, the top 30 research areas contributed a total of 83.71 percent (normalised), compared to 80.88 percent globally (normalised). : Engineering Electrical Electronic, Engineering Chemical, Green Sustainable Science Technology, Computer Science Information Systems,Computer Science Theory Methods, Biotechnology Applied Microbiology, Automation Control Systems, Chemistry Multidisciplinary, Engineering Multidisciplinary, Chemistry Physical, Computer Science Interdisciplinary Applications, Computer Science Artificial Intelligence, Computer Science Hardware Architecture, Agricultural Engineering, both of which are concerned with sustainable development related technological development to tackle climate change, have contributed more than the global average (Figure 4.4.3.1.3).

5.4.3.1.4. Indian publication contribution in top 30 research areas before and after adoption of the mission

After the introduction of the mission, Engineering Electrical Electronic, Energy Fuels, Environmental Sciences, Engineering Environmental, Green Sustainable Science Technology, Engineering Chemical, Telecommunications were the most important and contributed more than 500 publications.

4.4.3.1.5. The quantitative evolution and exchange of keywords of Indian publication related to "National Mission on Sustainable Habitat"

The higher the similarity index value, the more consistent the core themes of Indian publications on "National Mission on Sustainable Habitat" research are, while the quantity of newly developed keywords indicates that the core theme is improving, resulting in the diversification of different subthemes. With a growth rate of 144.44 percent, the number of keywords rose from 468 in 1985-2008 to 1144 in 2009-2019. More than half of the keywords from pre-mission research were integrated into Indian publications on the National Mission on Sustainable Habitat after the mission was launched.

5.4.3.1.6. Quantitative and qualitative development of themes at successive periods of Indian publication related to "National Mission on Sustainable Habitat"

During 1985-2008 a total of only 468 keywords during the before mission were observed among the total 1033 publications. The initial period has registered six themes with a DF range of 7 to 42. During this period "AQUEOUS-SOLUTIONS" was found to be the most active theme having a DF of

42 (Figure 4.4.3.1.6, Table 4.4.3.1.2). The themes "SYSTEMS" were found to come under emerging focus.

Total keywords increased by 144.44 percent after the introduction of the mission, out of a total of 18143 publications (increased by by more than 50%). During that period, the number of themes increased to 13, with a higher proportion of DF. During this time, the most active theme was "DESIGNS" with a DF of 3,471, followed by "AQUEOUS-SOLUTIONS" with a DF of 146 and "MUNICIPAL-SOLID-WASTES" with a DF of 106. (Figure 4.4.3.1.7, Table 4.4.3.1.3). The themes " ENVIRONMENTS", "ENERGY-SAVINGS" and "EFFICIENCIES were discovered to be getting more popular. The basic and transversal themes were TECHNOLOGIES" with the highest centrality value of 15.92.

5.4.3.2. Results from the Scopus publication data related to "National Mission on Sustainable Habitat"

5.4.3.2.1. Number of publications by top 30 countries related to "National Mission on Sustainable Habitat"

Using the final search string, a total of 3,23,457 publications were included in the Scopus database. Among the top 30 countries, the China is the top contributor, with 57147 publications (Figure 4.4.3.2.1). India has contributed 16651 publications to the "National Mission on Sustainable Habitat" and is ranked third in the world for "National Mission on Sustainable Habitat" publications.

5.4.3.2.2. Year-wise Growth of global and Indian publications related to "National Mission on Sustainable Habitat"

During the period 1987-2019, the compound annual growth rate (21.02 percent) of Indian publications was higher than the total global publications (Table 4.4.3.2.1). Up until 2008, when the National Mission on Sustainable Habitat was created, the CAGR (17.02 percent) of Indian publications was higher than the total global publications to the "National Mission on Sustainable Habitat". It's fascinating to note that the CAGR of Indian publications (16.22%) is also higher than the global total publications. As a result, it is possible to infer that India's " National Mission on Sustainable Habitat " initiates R&D activities on various National Mission on Sustainable Habitat targets, increasing the number of publications.

5.4.3.2.3. Total Global and Indian comparative contribution in different subject areas:

The top ten subject areas in total Indian climate change research contributed a total of 84.03 percent (normalised) which is lower than the global contribution with 85.92% . In some research fields, such as Computer Science, Chemical Engineering, Mathematics, Agricultural and Biological Sciences Medicine, Business, Management and Accounting, Biochemistry, Genetics and Molecular Biology, Immunology and Microbiology, Pharmacology, Toxicology and Pharmaceutics. India has contributed more than the global average. In certain research fields, such as Engineering, Environmental Science, Energy, Computer Science, Materials Science, Chemical Engineering, Chemistry, Physics and Astronomy, Mathematics, Social Sciences, Earth and Planetary Sciences, Agricultural and Biological Sciences, Medicine, Business, Management and Accounting, Biochemistry and so on India has contributed less than the global average.

5.4.3.2.4: Indian publication contribution related to "National Mission on Sustainable Habitat" in different research areas before and after the introduction of the mission:

Before the introduction of the " National Mission on Sustainable Habitat" the most important research areas were Engineering, Environmental Science, Energy, Chemical Engineering, Materials Science, Chemistry with over 300 publications. Following the introduction of the mission, the following research areas emerged as the most prominent, contributing over 1000 publications: Engineering, Environmental Science, Computer Science, Energy, Chemical Engineering, Materials Science

5.4.3.3. Analysis of Indian Citation Index data related to "National Mission on Sustainable Habitat"

5.4.3.3.1. Year-wise Growth of global and Indian publications related to "National Mission on Sustainable Habitat"

During the period 2005-2019, the compound annual growth rate of Indian publications was lower than that of total global publications. Before the introduction of the " National Mission on Sustainable Habitat ", the CAGR of Indian publications was quite lower than that of total global publications. While the CAGR of Indian publications from 2009 to 2019 is also lower than the global total publications, (Table 4.4.3.3.1).

5.4.3.3.2. Total Global and Indian comparative contribution in different subject areas:

The top 30 research areas of total Indian research have contributed 73.61% on the Indian "National Mission on Sustainable Habitat" related topic as compared to total global contribution of 74.86%. In some research areas, India has contributed more than the rest of the world, such as Engineering Science and Technology, Agriculture, Electrical Engineering, Energy And Fuel Science and Chemical Engineering which all deal with related to sustainable habitat technological growth (Figure 4.4.3.3.2).

5.4.3.3.3: Indian publication contribution in top 30 research areas before and after the adoption of the mission

After the introduction of the mission, the following research areas Environmental Science, Engineering Science and Technology, Biological Science, Agriculture, Chemistry, General Science and Technology, Management, Social Science, Health Science were the most important and contributed more than 150 publications.

5.4.4. National Water Mission

5.4.4.1. Results from the Web of Science data related to the "National Water Mission"

5.4.4.1.1. Number of publications related to the "National Water Mission" by top 30 countries:

The Web of Science database resulted in a total of 103673 global and 5416 Indian publications using the National Water Mission's final search string. The United States is the leading contributor to publications related to " National Water Mission " among the top 30 nations, with 25985 publications (Figure 4.4.4.1.1.). India is ranked fifth in the world in terms of the number of publications, with 5416.

5.4.4.1.2. Year-wise Growth of global and Indian publications related to "National Water Mission"

The compound annual growth rate of Indian publications was slightly lower than that of total global publications from 1987 to 2019. The CAGR of Indian publications was lower than that of total global publications before 2008. It's interesting to note that the CAGR of Indian publications between 2009 and 2019 is also lower than the global average (Table 4.4.4.1.1). As a result, it is possible to infer that India's National Water Mission initiates research and development activities on various solar mission goals, increasing the number of publications.

5.4.4.1.3. Total Global and Indian comparative contribution in top 30 research areas:

In India's overall climate change study, the top 30 research areas contributed a total of 89.99 percent (normalised), compared to 87.72 percent globally (normalised). Water Resources, Geosciences Multidisciplinary, Engineering Chemical, Agronomy, Engineering Civil, Energy Fuels, Green Sustainable Science Technology, Agriculture Multidisciplinary, Chemistry Multidisciplinary, Multidisciplinary Sciences, Biotechnology Applied Microbiology both of which are concerned with the water resources management and development to mitigate the impact of climate change., have contributed more than the global average (Figure 4.4.4.1.3).

5.4.4.1.4: Indian publication contribution in top 30 research areas before and after the adoption of the mission

After the introduction of the mission, Water Resources, Environmental Sciences, Geosciences Multidisciplinary, Agronomy, Engineering Chemical, Engineering Environmental, Engineering Civil were the most important and contributed more than 200 publications.

5.4.4.1.5. The quantitative evolution and exchange of keywords of Indian publication related to "National Water Mission"

The higher the similarity index value, the more consistent the core themes of Indian publications on "Nation Water Mission" research are, while the quantity of newly developed keywords indicates that the core theme is improving, resulting in the diversification of different subthemes. With a growth rate of 79.53 percent, the number of keywords rose from 469 in 1985-2008 to 842 in 2009-2019. More than half of the keywords from pre-mission research were integrated into Indian publications on the Nation Water Mission after the mission was launched.

5.4.4.1.6. Quantitative and qualitative development of themes at successive periods of Indian publication related to "Nation Water Mission"

During 1985-2008 a total of only 469 keywords during the before mission were observed among the total 1456 publications. The initial period has registered five themes with a fewer DF. During this period "AQUIFER" was found to be the most active theme having a DF of 81 (**Figure4.4.4.1.6**, **Table4.4.4.1.2**). The theme "FLOW" was found to come under emerging focus and also basic and transversal themes.

Total keywords increased by 79.53 percent after the introduction of the mission, out of a total of 4006 publications (increased by more than 50%). During that period, the number of themes increased to 17, with a higher proportion of DF. During this time, the most active theme was “DISTRICT” with a DF of 252 followed by “WATER-USE-EFFICIENCY” with a DF of 203, and “SOLAR-STILL” with a DF of 117 (Figure 4.4.4.1.7, Table 4.4.4.1.3). The themes MEMBRANE”, “REGION” and “LAKE” were discovered to be getting more popular. The basic and transversal themes were “HEAVY-METALS”, “MODEL” and “RIVER”.

5.4.4.2. Results from the Scopus publication data related to “Nation Water Mission”

5.4.4.2.1. Number of publications by top 30 countries related to “Nation Water Mission”

Using the final search string, a total of 2,08,795 publications were included in the Scopus database. Among the top 30 countries, the United States is the top contributor, with 48028 publications (Figure 4.4.1.2.1). India has contributed 12049 publications to the “National Water Mission” and is ranked third in the world for “National Water Mission” publications.

5.4.4.2.2. Year-wise Growth of global and Indian publications related to “National Water Mission”

During the period 1987-2019, the compound annual growth rate (11.09 percent) of Indian publications was higher than the total global publications (Table 4.4.4.2.1). Up until 2008, when the National Solar Mission was created, the CAGR (12.3 percent) of Indian publications was higher than the total global publications to the “National Water Mission.” It's fascinating to note that the CAGR of Indian publications (8.8%) is also higher than the global total publications. As a result, it is possible to infer that India's " National Water Mission Project" initiates R&D activities on various National Water Mission targets, increasing the number of publications.

5.4.4.2.3. Total Global and Indian comparative contribution in different subject areas

The top ten subject areas in total Indian climate change research contributed a total of 89.05 percent (normalised) which is similar to the global contribution. In some research fields, such as Agricultural and Biological Sciences, Engineering, Chemical Engineering, Biochemistry, Genetics and Molecular Biology, Energy, Social Sciences, Medicine, Immunology and Microbiology, Computer Science, Multidisciplinary, Business, Management and Accounting, Mathematics, Pharmacology, Toxicology and Pharmaceutics, Economics, Econometrics and Finance, Decision Sciences, India has contributed more than the global average. In certain research fields, such as Environmental Science, Earth and Planetary Sciences, Chemistry, Materials Science, Physics and Astronomy, Arts and Humanities, Veterinary, Health Professions, Neuroscience, Nursing, Dentistry, Psychology, Undefined etc., India has contributed less than the global average.

5.4.4.2.4: Indian publication contribution related to "National Water Mission" in different research areas before and after the introduction of the mission:

Before the introduction of the " National Water Mission," the most important research areas were , Environmental Science, Agricultural and Biological Sciences, Engineering, Earth and Planetary Sciences, Chemical Engineering with over 300 publications. Following the introduction of the mission, the following research areas emerged as the most prominent, contributing over 1000 publications: Environmental Science, Agricultural and Biological Sciences, Engineering, Earth and Planetary Sciences, Chemical Engineering.

5.4.4.3. Results from the Indian Citation Index data related to "National Water Mission"

5.4.3.2. Year-wise Growth of global and Indian publications related to "National Water Mission"

During the period 2005-2019, the compound annual growth rate of Indian publications was lower than that of total global publications. Before the introduction of the " National Water Mission", the CAGR of Indian publications was lower than that of total global publications. While the CAGR of Indian publications from 2009 to 2019 is lower than the global total publications, (Table 4.4.4.3.1).

5.4.4.3.2. Total Global and Indian comparative contribution in different subject areas:

The top 30 research areas of total Indian research have contributed 78.30% on the Indian "National Solar Mission" related topic as compared to total global contribution of 78.11%. In some research areas, India has contributed more than the rest of the world, such as Agriculture, Earth And Geological Science, Engineering Science And Technology, General Science And Technology, Water, Environmental Geology, Environmental Engineering, Watershed Management, Irrigation, Water Pollution, Agricultural Engineering, Environmental Pollution, Remote Sensing, Zoology, Botany, Economics, Agronomy, Environmental Protection which all deal with water resources management related technological growth (Figure 4.4.4.3.2).

5.4.4.3.3. Indian publication contribution in top 30 research areas before and after the adoption of the mission

After the introduction of the mission, the following research areas Environmental Science, Agriculture, Biological Science, Earth and Geological Science, Engineering Science and Technology, General Science and Technology, Water, Pollution, Chemistry, Social Science, Environmental Geology, Watershed Management were the most important and contributed more than 100 publications.

5.4.5. National Mission for Sustaining the Himalayan Ecosystem

5.4.5.1. Results from the Web of Science data related to the "National Mission for Sustaining the Himalayan Ecosystem"

5.4.5.1.1. Number of publications related to the "National Mission for Sustaining the Himalayan Ecosystem" by top 30 countries:

The Web of Science database resulted in a total of 15308 global and 7291 Indian publications using the National Mission for Sustaining the Himalayan Ecosystem's final search string. The India is the leading contributor to publications related to "National Mission for Sustaining the Himalayan Ecosystem " among the top 30 nations, with 7291 publications (Figure 4.4.5.1.1.).

5.4.5.1.2. Year-wise Growth of global and Indian publications related to "National Mission for Sustaining the Himalayan Ecosystem"

The compound annual growth rate of Indian publications was slightly higher than that of total global publications from 1987 to 2019. The CAGR of Indian publications was higher than that of total global publications before 2008. It's interesting to note that the CAGR of Indian publications between 2009 and 2019 is fairly higher than the global average (Table 4.4.5.1.1). As a result, it is possible to infer that India's National Mission for Sustaining the Himalayan Ecosysteminitiates research and development activities on various solar mission goals, increasing the number of publications.

5.4.5.1.3. Total Global and Indian comparative contribution in top 30 research areas:

In India's overall climate change study, the top 30 research areas contributed a total of 84.09 percent (normalised), compared to 85.22 percent globally (normalised). Environmental Sciences, Multidisciplinary Sciences, Water Resources, Remote Sensing, Agronomy, Forestry, Engineering Civil, Imaging Science, Holographic Technology, Soil Science, Agriculture Multidisciplinary, Entomology, Engineering Geological, Biotechnology Applied Microbiology, Microbiology, both of which are concerned with the Himalayan Ecosystem development to mitigate the impact climate change, have contributed more than the global average (Figure 4.4.5.1.3).

5.4.5.1.4. Indian publication contribution in top 30 research areas before and after adoption of the mission

After the introduction of the mission, Geosciences Multidisciplinary, Environmental Sciences, Multidisciplinary Sciences, Plant Sciences, Water Resources, Meteorology Atmospheric Sciences, Geography Physical were the most important and contributed more than 400 publications.

5.4.5.1.5. The quantitative evolution and exchange of keywords of Indian publication related to "National Mission for Sustaining the Himalayan Ecosystem"

The higher the similarity index value, the more consistent the core themes of Indian publications on "National Mission for Sustaining the Himalayan Ecosystem" research are, while the quantity of newly developed keywords indicates that the core theme is improving, resulting in the diversification of different subthemes. With a growth rate of 63.23 percent, the number of keywords rose from 756 in 1985-2008 to 1234 in 2009-2019. More than half of the keywords from pre-mission research were integrated into Indian publications on the National Mission for Sustaining the Himalayan Ecosystem after the mission was launched.

5.4.5.1.6. Quantitative and qualitative development of themes at successive periods of Indian publication related to "National Mission for Sustaining the Himalayan Ecosystem"

During 1985-2008 a total of only 756 keywords during the before mission were observed among the total 1895 publications. The initial period has registered six themes with DF. During this period "FOREST" was found to be the most active theme having a DF of 73 followed by "RIVER" (Figure 4.4.5.1.6, Table 4.4.5.1.2) The themes WATER" and "PLANTS" were found to come under emerging focus.

Total keywords increased by 63.23 percent after the introduction of the mission, out of a total of 18143 publications (increased by more than 50%). During that period, the number of themes increased to 17, with a higher proportion of DF. During this time, the most active theme was "CLIMATE-CHANGE," with a DF of 508 followed by "ACTIVE-TECTONICS" (Figure 4.4.5.1.7, Table 4.4.5.1.3). The themes "PLANTS", "POPULATIONS" and "DISTRICT" were discovered to be getting more popular. The basic and transversal themes were FOREST", "MODEL" and "BASIN"

5.4.5.2. Results from the Scopus publication data related to "National Mission for Sustaining the Himalayan Ecosystem"

5.4.5.2.1. Number of publications by top 30 countries related to "National Mission for Sustaining the Himalayan Ecosystem"

Using the final search string, a total of 18,181 publications were included in the Scopus database. Among the top 30 countries, the India is the top contributor, with 9388 publications (Figure 4.4.5.2.1) in "National Mission for Sustaining the Himalayan Ecosystem" publications.

5.4.5.2.2. Year-wise Growth of global and Indian publications related to "National Mission for Sustaining the Himalayan Ecosystem":

During the period 1987-2019, the compound annual growth rate (10.35 percent) of Indian publications was higher than the total global publications (Table 4.4.5.2.1). Up until 2008, when the National Mission for Sustaining the Himalayan Ecosystem was created, the CAGR (9.73 percent) of Indian publications was higher than the total global publications to the "National Mission for Sustaining the Himalayan Ecosystem." It's fascinating to note that the CAGR of Indian publications (11.67%) is also higher than the global total publications. As a result, it is possible to infer that India's " National Mission for Sustaining the Himalayan Ecosystem Project" initiates R&D activities on various solar mission targets, increasing the number of publications.

5.4.5.2.3. Total Global and Indian comparative contribution in different subject areas:

The top ten subject areas in total Indian climate change research contributed a total of 87.88 percent (normalised) which is similar to the global contribution. In some research fields, such as Agricultural and Biological Sciences, Environmental Science, Biochemistry, Genetics and Molecular, Biology, Engineering, Medicine, Multidisciplinary, Pharmacology, Toxicology and Pharmaceutics, Computer

Science, Immunology and Microbiology, Chemistry, Physics and Astronomy, Veterinary, Mathematics, Materials Science, Health Professions, India has contributed more than the global average. In certain research fields, such as Earth and Planetary Sciences, Social Sciences, Arts and Humanities, Energy, Business, Management and Accounting, Economics, Econometrics and Finance, Chemical Engineering, Decision Sciences, Neuroscience, India has contributed less than the global average.

5.4.5.2.4 Indian publication contribution related to "National Mission for Sustaining the Himalayan Ecosystem" in different research areas before and after the introduction of the mission

Before the introduction of the " National Mission for Sustaining the Himalayan Ecosystem" the most important research areas were Agricultural and Biological Sciences, Environmental Science, Earth and Planetary Sciences, Biochemistry, Genetics and Molecular Biology, Social Sciences, Engineering Multidisciplinary with over 200 publications. Following the introduction of the mission, the following research areas emerged as the most prominent, contributing over 600 publications Agricultural and Biological Sciences, Environmental Science, Earth and Planetary Sciences, Biochemistry, Genetics and Molecular Biology, Social Sciences

5.4.5.3. Results from the Indian Citation Index data related to "National Mission for Sustaining the Himalayan Ecosystem"

5.4.5.3.1. Year-wise Growth of global and Indian publications related to "National Mission for Sustaining the Himalayan Ecosystem"

During the period 2005-2019, the compound annual growth rate of Indian publications was slightly lower than that of total global publications. Before the introduction of the " National Mission for Sustaining the Himalayan Ecosystem ", the CAGR of Indian publications was also lower than that of total global publications. While the CAGR of Indian publications from 2009 to 2019 is lower than the global total publications, (Table 4.4.5.3.1).

5.4.5.3.2. Total Global and Indian comparative contribution in different subject areas:

The top 30 research areas of total Indian research have contributed 75.82% on the Indian "National Mission for Sustaining the Himalayan Ecosystem" related topic as compared to total global contribution of 75.19%. In some research areas, India has contributed more than the rest of the world, such as Agriculture, Earth And Geological Science, Engineering Science And Technology, General Science And Technology, Water, Environmental Geology, Environmental Engineering, Watershed Management, Irrigation, Water Pollution, Agricultural Engineering, Environmental Pollution, Remote Sensing, Zoology, Botany, Economics, Agronomy, Environmental Protection, which all deal with water resources management related technology growth (Figure 4.4.5.3.2).

5.4.4.3.3. Indian publication contribution in top 30 research areas before and after the adoption of the mission:

After the introduction of the mission, the following research areas Environmental Science, Agriculture, Biological Science, Earth and Geological Science, Engineering Science And Technology, General Science And Technology, Water, Pollution, Chemistry, Social Science, Environmental Geology, Watershed Management were the most important and contributed more than 100 publications.

5.4.6. National Mission for a Green India

5.4.6.1. Results from the Web of Science data related to the "National Mission for a Green India"

5.4.6.1.1 Number of publications related to the "National Mission for a Green India" by top 30 countries: "National Mission for a Green India"

The Web of Science database resulted in a total of 206003 global and 5499 Indian publications using the National Mission for a Green India's final search string. The United States is the leading contributor to publications related to " National Mission for a Green India " among the top 30 nations, with 69213 publications (Figure 4.4.6.1.1.). India is ranked 13th in the world in terms of the number of publications, with 5499.

5.4.6.1.2. Year-wise Growth of global and Indian publications related to "National Mission for a Green India"

The compound annual growth rate of Indian publications was slightly lower than that of total global publications from 1987 to 2019. The CAGR of Indian publications was slightly lower than that of total global publications before 2008. It's interesting to note that the CAGR of Indian publications between 2009 and 2019 is fairly higher than the global average (Table 4.4.6.1.1). As a result, it is possible to infer that India's National Mission for a Green India initiates research and development activities on various National Mission for a Green India goals, increasing the number of publications.

5.4.6.1.3. Total Global and Indian comparative contribution in top 30 research areas:

In India's overall climate change study, the top 30 research areas contributed a total of 89.99 percent (normalised), compared to 87.26 percent globally (normalised). Environmental Sciences, Multidisciplinary Sciences, Remote Sensing, Water Resources, Agronomy, Imaging Science Photographic Technology, Engineering Environmental, Agriculture Multidisciplinary, Energy Fuels, Engineering Electrical Electronic, Green Sustainable Science Technology, both of which are concerned with the Green India development to mitigate the impact climate change, have contributed more than the global average (Figure 4.4.6.1.3).

5.4.6.1.4. Indian publication contribution in top 30 research areas before and after adoption of the mission

After the introduction of the mission, areas Environmental Sciences, Ecology, Multidisciplinary Sciences, Biodiversity Conservation, Forestry, Plant Sciences, Geosciences Multidisciplinary, Remote Sensing were the most important and contributed more than 250 publications.

5.4.6.1.5. The quantitative evolution and exchange of keywords of Indian publication related to "National Mission for a Green India":

The higher the similarity index value, the more consistent the core themes of Indian publications on "National Mission for a Green India" research are, while the quantity of newly developed keywords indicates that the core theme is improving, resulting in the diversification of different subthemes. With a growth rate of 56.84 percent, the number of keywords rose from 651 in 1985-2008 to 1021 in 2009-2019. More than half of the keywords from pre-mission research were integrated into Indian publications on the National Mission for a Green India after the mission was launched.

5.4.6.1.6. Quantitative and qualitative development of themes at successive periods of Indian publication related to "National Mission for a Green India"

During 1985-2008 a total of only 651 keywords during the before mission were observed among the total 1400 publications. The initial period has registered eleven themes with DF. During this period

"WESTERN-GHATS" was found to be the most active theme having a DF of 82 followed by "POPULATION" (Figure 4.4.6.1.6, Table 4.4.6.1.2) The themes "CARBON" and "PLANTATIONS" were found to come under emerging focus.

Total keywords increased by 56.84 percent after the introduction of the mission, out of a total of 4130 publications (increased by more than 50%). During that period, the number of themes increased to 13, with a higher proportion of DF. During this time, the most active theme was "WESTERN-GHATS," with a DF of 329 followed by "NATIONAL-PARK" with a DF of 113 (Figure 4.4.6.1.7, Table 4.4.6.1.3). The themes "PLANTS", "AREA" and "SUNDARBANS" were discovered to be getting more popular. The basic and transversal themes "ECOSYSTEMS" appeared with the highest document citation of 3442 (DF 237) followed by "IMPACT" with document citation of 1753 (DF 112).

5.4.6.2. Results from the Scopus publication data related to "National Mission for a Green India"

5.4.6.2.1. Number of publications by top 30 countries related to "National Mission for a Green India"

Using the final search string, a total of 2,54,822 publications were included in the Scopus database. Among the top 30 countries, the United States is the top contributor, with 74372 publications (Figure 4.4.6.2.1). India has contributed 8936 publications to the "National Mission for a Green India" and is ranked third in the world for "National Mission for a Green India" publications.

5.4.6.2.2. Year-wise Growth of global and Indian publications related to "National Mission for a Green India".

During the period 1987-2019, the compound annual growth rate (12.04 percent) of Indian publications was higher than the total global publications (Table 4.4.6.2.1). Up until 2008, when the National Mission for a Green India was created, the CAGR (12.43 percent) of Indian publications was higher than the total global publications to the "National Mission for a Green India" It's fascinating to note that the CAGR of Indian publications (12.17%) is also higher than the global total publications. As a result, it is possible to infer that India's " National Mission for a Green India Project" initiates R&D

activities on various National Mission for a Green India targets, increasing the number of publications.

5.4.6.2.3. Total Global and Indian comparative contribution in different subject areas

The top ten subject areas in total Indian climate change research contributed a total of 87.04 percent (normalised) which is similar to the global contribution. In some research fields, such as Social Sciences, Biochemistry, Genetics and Molecular Biology, Engineering, Computer Science, Multidisciplinary, Energy, Immunology and Microbiology, Medicine and so on, India has contributed more than the global average. In certain research fields, such : Agricultural and Biological Sciences, Environmental Science, Earth and Planetary Sciences, Arts and Humanities, Veterinary, Neuroscience, Psychology, Undefined, Dentistry, India has contributed less than the global average.

5.4.6.2.4: Indian publication contribution related to "National Mission for a Green India" in different research areas before and after the introduction of the mission:

Before the introduction of the " National Mission for a Green India," the most important research areas were Agricultural and Biological Sciences, Environmental Science, Earth and Planetary Sciences, Social Sciences, with over 200 publications. Following the introduction of the mission, the following research areas emerged as the most prominent, contributing over 500 publications: Agricultural and Biological Sciences, Environmental Science, Earth and Planetary Sciences, Social Sciences, Engineering, Biochemistry, Genetics and Molecular Biology, Computer Science.

5.4.6.3. Results from the Indian Citation Index data related to "National Mission for a Green India"

5.4.6.3.1. Year-wise Growth of global and Indian publications related to "National Mission for a Green India"

During the period 2005-2019, the compound annual growth rate of Indian publications lower than that of total global publications. Before the introduction of the " National Mission for a Green India ", the CAGR of Indian publications was lower than that of total global publications. While the CAGR of Indian publications from 2009 to 2019 is lower than the global total publications, (Table 4.4.6.3.1).

5.4.6.3.2. Total Global and Indian comparative contribution in different subject areas:

The top 30 research areas of total Indian research have contributed 78.33% on the Indian "National Mission for a Green India" related topic as compared to total global contribution of 79.19%. In some research areas, India has contributed more than the rest of the world, such as:Forestry, Agriculture, Botany, General Science And Technology, Earth And Geological Science, Forest Botany, Natural Resources, Economic Botany, Soil Science, Zoology, Agricultural Botany, Multidisciplinary, Engineering Science And Technology, Forest Management, Management, Remote Sensing which all deal with the forest and environment-related research (Figure 4.4.6.3.2).

5.4.6.3.3. Indian publication contribution in top 30 research areas before and after the adoption of the mission

After the introduction of the mission, the following research areas Biological Science, Forestry, Environmental Science, Agriculture, Botany, Social Science, General Science and Technology, Biodiversity was the most important and contributed more than 200 publications.

5.4.7. National Mission for Sustainable Agriculture

5.4.7.1. Analysis of Web of Science publication data related to the "National Mission for Sustainable Agriculture"

5.4.7.1.1. Number of publications related to the "National Mission for Sustainable Agriculture" by top 30 countries:

The Web of Science database resulted in a total of 2,48,369 global and 13461 Indian publications using the National Mission for Sustainable Agriculture 's final search string. The United States is the leading contributor to publications related to " National Mission for Sustainable Agriculture " among the top 30 nations, with 60819 publications (Figure 4.4.7.1.1.). India is ranked fifth in the world in terms of the number of publications, with 13461.

5.4.7.1.2. Year-wise Growth of global and Indian publications related to "National Mission for Sustainable Agriculture"

The compound annual growth rate of Indian publications was slightly higher than that of total global publications from 1987 to 2019. The CAGR of Indian publications was higher than that of total global publications before 2008. It's interesting to note that the CAGR of Indian publications between 2009 and 2019 is substantially higher than the global average (Table 4.4.7.1.1). As a result, it is possible to infer that India's National Mission for Sustainable Agricultureinitiates research and development activities on various solar mission goals, increasing the number of publications.

5.4.7.1.3. Total Global and Indian comparative contribution in top 30 research areas:

In India's overall climate change study, the top 30 research areas contributed a total of 72.61 percent (normalised), compared to 74.61 percent globally (normalised). Agronomy, Water Resources, Plant Sciences, Biotechnology Applied Microbiology, Meteorology Atmospheric Sciences, Green Sustainable Science Technology, Energy Fuels, Multidisciplinary Sciences, Remote Sensing, Engineering Electrical Electronic, Engineering Chemical, Toxicology, Engineering Civil, both of which are concerned with Sustainable Agriculture development-related research to tackle climate change, have contributed more than the global average (Figure 4.4.7.1.3).

5.4.7.1.4: Indian publication contribution in top 30 research areas before and after the adoption of the mission

After the introduction of the mission, Environmental Sciences, Agronomy, Water Resources, Plant Sciences, Agriculture Multidisciplinary, Multidisciplinary Sciences, Biotechnology Applied Microbiology, Multidisciplinary Sciences, Engineering Electrical Electronic, Geosciences Multidisciplinary were the most important and contributed more than 500 publications.

5.4.7.1.5: The quantitative evolution and exchange of keywords of Indian publication related to "National Mission for Sustainable Agriculture"

The higher the similarity index value, the more consistent the core themes of Indian publications on "National Solar Mission" research are, while the quantity of newly developed keywords indicates that the core theme is improving, resulting in the diversification of different subthemes. With a growth rate of 71.99 percent, the number of keywords rose from 1203 in 1985-2008 to 2069 in 2009-2019. More than half of the keywords from pre-mission research were integrated into Indian publications on the National Mission for Sustainable Agriculture after the mission was launched.

5.4.7.1.6: Quantitative and qualitative development of themes at successive periods of Indian publication related to "National Mission for Sustainable Agriculture"

During 1985-2008 a total of only 1203 keywords during the before mission were observed among the total 2957 publications. The initial period has registered thirteen themes with DF. During this period

“ACTIVATED-CARBON” was found to be the most active theme having a DF of 64 followed by “HEAVY-METALS” with a DF of 59, “CROPPING-SYSTEMS” with a DF of 57 and “PESTICIDES” with a DF of 37 (Figure 4.4.7.1.6, Table 4.4.7.1.2) followed by “PERFORMANCES”. The themes “SYSTEMS”, “CROPS” and “PLANTS” were found to come under emerging focus.

Total keywords increased by 71.99 percent after the introduction of the mission, out of a total of 10639 publications (increased by by 50%). During that period, the number of themes increased to 28, with a higher proportion of DF. During this time, the most active theme was “CLIMATE-CHANGE,” with a DF of 321 followed by “HEAVY-METALS” with a DF of 254, “ACTIVATED-CARBON” with a DF of 240. (Figure 4.4.7.1.7, Table 4.4.7.1.3). The themes “PESTICIDES”, “PLANTS” and “FOREST” were discovered to be getting more popular. The basic and transversal themes were “YIELD” with the highest DF of 339.

5.4.7.2. Results from the Scopus publication data related to the “National Mission for Sustainable Agriculture”

5.4.7.2.1. Number of publications by top 30 countries related to the “National Mission for Sustainable Agriculture”

Using the final search string, a total of 5,06,446 publications were included in the Scopus database. Among the top 30 countries, the United States is the top contributor, with 112543 publications (Figure 4.4.7.2.1). India has contributed 36033 publications to the “National Mission for Sustainable Agriculture” and is ranked third in the world for “National Mission for Sustainable Agriculture” publications.

5.4.7.2.2. Year-wise Growth of global and Indian publications related to the “National mission for Sustainable Agriculture”

During the period 1987-2019, the compound annual growth rate (12.26 percent) of Indian publications was higher than the total global publications (Table 4.4.7.2.1). Up until 2008, when the National Solar Mission was created, the CAGR (11.5percent) of Indian publications was higher than the total global publications to the “National Solar Mission.” It's fascinating to note that the CAGR of Indian publications (13.87%) is also higher than the global total publications. As a result, it is possible to infer that India's "National Solar Project" initiates R&D activities on various solar mission targets, increasing the number of publications.

5.4.7.2.3. Total Global and Indian comparative contribution in different subject areas:

The top ten subject areas in total Indian climate change research contributed a total of 77.88 percent (normalised) which is not similar to the global contribution with 81.60% (normalized). In some research fields, such as Agricultural and Biological Sciences, Engineering, Biochemistry, Genetics and Molecular Biology, Computer Science, Energy, Chemical Engineering, Immunology and Microbiology, Business, Management and Accounting, Materials Science, Multidisciplinary, Physics and Astronomy, Pharmacology, Toxicology and Pharmaceutics, Veterinary, Mathematics, Health Professions, India has contributed more than the global average. In certain research fields, such as Environmental Science, Social Sciences, Earth and Planetary Sciences, Medicine, Economics, Econometrics and Finance, Chemistry, Arts and Humanities, Decision Sciences, India has contributed less than the global average.

5.4.7.2.4: Indian publication contribution related to the "National Mission for Sustainable Agriculture" in different research areas before and after the introduction of the mission

Before the introduction of the " National Mission for Sustainable Agriculture," the most important research areas were Agricultural and Biological Sciences, Environmental Science, Engineering, Biochemistry, Genetics and Molecular Biology, Social Sciences with over 1000 publications. Following the introduction of the mission, the following research areas emerged as the most prominent, contributing over 1500 publications: Agricultural and Biological Sciences, Environmental Science, Engineering, Biochemistry, Genetics and Molecular Biology, Social Sciences, Biochemistry, Genetics and Molecular Biology, Computer Science, Earth and Planetary Sciences, Immunology and Microbiology, Medicine.

5.4.7.3. Results from the Indian Citation Index data related to "National Mission for Sustainable Agriculture"

5.4.7.3.1. Year-wise Growth of global and Indian publications related to "National Mission for Sustainable Agriculture"

During the period 2005-2019, the compound annual growth rate of Indian publications was lower than that of total global publications. Before the introduction of the " National Mission for Sustainable Agriculture ", the CAGR of Indian publications was significantly lower than that of total global publications. While the CAGR of Indian publications from 2009 to 2019 is also lower than the global total publications, (Table 4.4.7.3.1).

5.4.7.3.2. Total Global and Indian comparative contribution in different subject areas:

The top 30 research areas of total Indian research have contributed 71.84% on the Indian "National Solar Mission" related topic as compared to total global contribution of 71.33%. In some research areas, India has contributed more than the rest of the world, such as Agriculture, General Science And Technology, Management, Botany, Agronomy, Agricultural Botany, Agricultural Economics, Agrochemicals, Horticulture, Education, Soil Science, Forestry, Agricultural Engineering, Field Crops, Crop Improvement, Zoology, Earth And Geological Science which all deal with Sustainable Agriculture growth (Figure 4.4.7.3.2).

5.4.7.3.3: Indian publication contribution in top 30 research areas before and after the adoption of the mission

After the introduction of the mission, the following research areas Agriculture, Biological Science, Environmental Science, Agronomy, Botany, Economics, Social Science, General Science and Technology, Management, Agricultural Botany, Zoology, Agricultural Economics were the most important and contributed more than 600 publications.

5.4.8. National Mission for Strategic Knowledge for Climate Change

5.4.8.1. Results from the Web of Science data related to the "National Mission for Strategic Knowledge for Climate Change"

5.4.8.1.1. Number of publications related to the "National Mission for Strategic Knowledge for Climate Change" by top 30 countries

The Web of Science database resulted in a total of 75456 global and 2442 Indian publications using the National Mission for Strategic Knowledge for Climate Change 's final search string. The United States is the leading contributor to publications related to " National Mission for Strategic Knowledge for Climate Change " among the top 30 nations, with 26513 publications (Figure 4.4.8.1.1.). India is ranked 13th in the world in terms of the number of publications, with 2442.

5.4.8.1.2. Year-wise Growth of global and Indian publications related to "National Mission for Strategic Knowledge for Climate Change"

The compound annual growth rate of Indian publications was slightly lower than that of total global publications from 1987 to 2019. The CAGR of Indian publications was quite higher than that of total global publications before 2008. It's interesting to note that the CAGR of Indian publications between 2009 and 2019 is lower than the global average (Table 4.4.8.1.1). As a result, it is possible to infer that India's National Mission for Strategic Knowledge for Climate Change initiates research and development activities on various National Mission for Strategic Knowledge for Climate Change goals, increasing the number of publications.

5.4.8.1.3. Total Global and Indian comparative contribution in top 30 research areas:

In India's overall climate change study, the top 30 research areas contributed a total of 85.62 percent (normalised), compared to 86.33 percent globally (normalised).Meteorology Atmospheric Sciences, Geosciences Multidisciplinary, Water Resources, Multidisciplinary Sciences, Energy Fuels, Engineering Civil, Remote Sensing, Agronomy, Agriculture Multidisciplinary, Engineering Electrical Electronics. both of which are concerned with Strategic Knowledge development for Climate Change to tackle climate change, have contributed more than the global average (Figure 4.4.8.1.3).

5.4.8.1.4: Indian publication contribution in top 30 research areas before and after the adoption of the mission

After the introduction of the mission, Environmental Sciences, Meteorology Atmospheric Sciences, Geosciences Multidisciplinary, Water Resources, Multidisciplinary Sciences, Engineering Civil, Ecology, Agronomy, Engineering Civil, Geography Physical were the most important and contributed more than 100 publications.

5.4.8.1.5. The quantitative evolution and exchange of keywords "National Mission for Strategic Knowledge for Climate Change"

The higher the similarity index value, the more consistent the core themes of Indian publications on "National Mission for Strategic Knowledge for Climate Change" research are, while the quantity of newly developed keywords indicates that the core theme is improving, resulting in the diversification of different subthemes. With a growth rate of 212.50 percent, the number of keywords rose from 160 in 1985-2008 to 500 in 2009-2019. More than half of the keywords from pre-mission research were integrated into Indian publications on the “National Mission for Strategic Knowledge for Climate Change” after the mission was launched.

5.4.8.1.6. Quantitative and qualitative development of themes at successive periods of Indian publication related to “National Mission for Strategic Knowledge for Climate Change”

During 1985-2008 a total of only 160 keywords during the before mission were observed among the total 206 publications. The initial period has registered only one theme with DF. During this period “CLIMATE-CHANGE” was found to be the most active theme having a DF of 56 (Figure 4.4.8.1.6, Table 4.4.8.1.2).

Total keywords increased by 212.50 percent after the introduction of the mission, out of a total of 2243 publications (increased by maximum). During that period, the number of themes increased to 7, with a higher proportion of DF. During this time, the most active theme was “CLIMATE-CHANGE,” with a DF of 816 followed by “RUNOFF” (Figure 4.4.8.1.7, Table 4.4.8.1.3). The “RIVER” and “INDEX” were discovered to be getting more popular. The basic and transversal themes were “PREDICTION”.

5.4.8.2. Results from the Scopus publication data related to “National Mission for Strategic Knowledge for Climate Change”

5.4.8.2.1. Number of publications by top 30 countries related to “National Mission for Strategic Knowledge for Climate Change”

Using the final search string, a total of 83738 publications were included in the Scopus database. Among the top 30 countries, the United States is the top contributor, with 28371 publications (Figure 4.4.1.2.1). India has contributed 3236 publications to the “National Mission for Strategic Knowledge for Climate Change” and is ranked third in the world for “National Mission for Strategic Knowledge for Climate Change” publications.

5.4.8.2.2. Year-wise Growth of global and Indian publications related to “National Mission for Strategic Knowledge for Climate Change”

5.4.1.2.2. Year-wise Growth of global and Indian publications related to "National Solar Mission"

During the period 1987-2019, the compound annual growth rate (21.02percent) of Indian publications was higher than the total global publications (Table 4.4.8.2.1). Up until 2008, when the National Solar Mission was created, the CAGR (20.07 percent) of Indian publications was lower than the total global publications to the "National Mission for Strategic Knowledge for Climate Change" It's fascinating to note that the CAGR of Indian publications (22.93%) is also higher than the global total publications. As a result, it is possible to infer that India's " National Mission for Strategic Knowledge for Climate Change Project" initiates R&D activities on various solar mission targets, increasing the number of publications.

5.4.8.2.3. Total Global and Indian comparative contribution in different subject areas:

The top ten subject areas in total Indian climate change research contributed a total of 89.51 percent (normalised) and the global contribution with 90.24% (normalised).. In some research fields, such as Engineering, Multidisciplinary, Computer Science, Medicine, Economics, Econometrics and Finance, Physics and Astronomy, Business, Management and Accounting, Materials Science, Decision Sciences, Chemical Engineering, Pharmacology, Toxicology and Pharmaceutics, Veterinary, Health Professions, Undefined, India has contributed more than the global average. In certain research fields, such as Environmental Science, Earth and Planetary Sciences, Agricultural and Biological Sciences, Social Sciences, Energy, Biochemistry, Genetics and Molecular Biology, Mathematics, Arts and Humanities, Chemistry, Immunology and Microbiology, India has contributed less than the global average.

5.4.8.2.4: Indian publication contribution related to "National Mission for Strategic Knowledge for Climate Change" in different research areas before and after the introduction of the mission

Before the introduction of the " National Mission for Strategic Knowledge for Climate Change" the most important research areas were Environmental Science, Earth and Planetary Sciences, Agricultural and Biological Sciences with over 50 publications. Following the introduction of the mission, the following research areas emerged as the most prominent, contributing over 100 publications: Environmental Science, Earth and Planetary Sciences, Agricultural and Biological

Sciences, Engineering, Social Sciences, Computer Science, Multidisciplinary, Energy, Medicine, Biochemistry, Genetics and Molecular Biology.

5.4.8.3. Results from the Indian Citation Index data related to "National Mission for Strategic Knowledge for Climate Change"

5.4.8.3.1. Year-wise Growth of global and Indian publications related to "National Mission for Strategic Knowledge for Climate Change"

During the period 2005-2019, the compound annual growth rate of Indian publications was lower than that of total global publications. Before the introduction of the " National Mission for Strategic Knowledge for Climate Change ", the CAGR of Indian publications was significantly lower than that of total global publications. While the CAGR of Indian publications from 2009 to 2019 is higher than the global total publications, (Table 4.4.8.3.1).

5.4.8.3.2. Total Global and Indian comparative contribution in different subject areas:

The top 30 research areas of total Indian research have contributed 75.40% on the Indian "National Mission for Strategic Knowledge for Climate Change" related topic as compared to total global contribution of 75.41%. In some research areas, India has contributed more than the rest of the world, such as Agriculture, General Science and Technology, Agricultural Meteorology, Botany, Meteorology, Forestry, Management, Economics, Agronomy, Agricultural Botany, Zoology, Education, Soil Science and Chemistry. (Figure 4.4.8.3.2).

5.4.8.3.3: Indian publication contribution in top 30 research areas before and after adoption of the mission

After the introduction of the mission, the following research areas Agriculture, Environmental Science, Biological Science, General Science and Technology, Earth and Geological Science, Agricultural Meteorology, Botany, Meteorology, Forestry, Social Science, Management were the most important and contributed more than 90 publications.

5.5. Evaluation of the comparative evolving trends of the research area and research topic

5.5.1. Results from Web of Science database

5.5.1.1. Period-wise growth of the number of the research area of total global publications on "Climate Change":

With a compound period-wise growth rate of 18.12 percent, the number of research areas of the total global publications increased from 88 in the beginning (1985-1989) to 239 in the last period (2015-2019). During the second cycle (1990-1994), the main diversification in research areas of total global climate change research was accelerated, with a growth rate of 127.27 percent.

5.5.1.2. Period-wise comparative growth of the number of research area among top 20 countries:

The Group's average number of research areas was increased from 10.6 during the initial period (1985-1989) to 181.55 during the last period (2015-2019) with a CPGR of 60.54%. India's number of research areas was increased from 7 during the initial period (1985-1989) to 177 during the last period (2015-2019) with a CPGR of 71.32 %. Seven to ten countries have contributed to more research areas than the group average number of research areas during different periods. During the years 1990-1994, 1995-1999, 2005-2009, and 2010-2014, there was a substantial diversification of research areas in Indian publications. Climate change research has been conducted in 243 research areas worldwide. During the total periods, India contributed to 200 research areas, and during the most recent period, India contributed to 177 research areas, putting it in ninth place (Table 4.5.1.1).

5.5.1.3. Total Global and Indian comparative contribution in top 30 research areas :

Total global research on Climate Change has been performed in 242 research areas. The top 30 research areas of total global research on climate change have contributed 79.09% cumulatively. India has contributed to 200 research areas during total periods. The top 30 research areas of total Indian research on climate change have contributed 79.26 % cumulatively. India has contributed at a higher proportion than the global in some research areas namely: Energy fuel, Water resource, Agronomy, Engineering Electrical Electronics, Green sustainable, Remote sensing those are mainly deal with the mitigation and adaptive measures of climate change.

5.5.1.4. Period-wise growth of top 30 research areas of global and total Indian publications:

Remote Sensing (312.63 %), Evolutionary Biology (293.65 %), Construction Building Technology (257.54 %), Engineering Electrical Electronic (255.91 %), Engineering Environmental (232.74 %), Marine Freshwater Biology (220.83 %), Environmental Studies (217.01 %), Biodiversity Conservation (212.65 %), Public Environmental Occupational Health (212.44 %), Energy Fuels (203.44 %), Ecology (197.89 %), Engineering Civil (196.90 %), Plant Sciences (194.69 %), Soil Science (183.96 %), Agriculture Multidisciplinary (182.49 %) are some of the research areas of global publications that have contributed at higher CPGR than the average CPGR of total global publications (181.19 percent).

Computer Science Theory Methods (421.71 %), Engineering Electrical Electronic (258.40 %), Engineering Civil (219.70 %), Agriculture Multidisciplinary (190.81 %), Ecology (174.32 %), Geochemistry Geophysics (172.04 %), Forestry (161.37 %), are some of the research areas of Indian publications that contributed higher CPGR than the average CPGR of total Indian publications (136.56 percent). The following research areas of Indian publications have contributed with higher CPGR than the global CPGR namely: Agriculture Multidisciplinary, Computer Science Theory Methods, Engineering Electrical Electronic, Forestry, Geochemistry Geophysics, Meteorology Atmospheric Sciences, Palaeontology.

5.5.1.5. Comparative evolving trend of top 30 research areas among top 20 countries:

Compared to the top 20 nations, India contributed more publications in the following research areas: Engineering Electrical Electronic (Rank-3), Multidisciplinary Sciences (Rank-8), Energy Fuels (Rank-9) and Remote Sensing (Rank-9) over time. Except for Multidisciplinary Sciences (Rank-8) and Energy Fuels (Rank-9) in the top ten research areas of global cumulative publications, India did not perform well. Meteorology Atmospheric Sciences, Water Resources and Energy Fuels ranked 9th and 10th, respectively, among the top 20 countries during the recent period, and these research areas also ranked in the top ten research areas of global cumulative publications.

5.5.1.6. Period-wise research themes and research topic analysis of Indian research Publications on "Climate Change"

5.5.1.6.1. Quantitative evolution of keywords

There was no important keyword to designate the research theme during the initial period (1985-1989) in Indian climate change research, which totaled 11 publications. With a CPGR of 80.15 percent, the number of keywords increased from 114 in the second era to 2163 in the third. At each time interval, the proportion of new keywords in Indian climate change research has decreased (77 percent during 1995-1999, 66.27 percent during 2000-2004, 61.7 percent during 2005-2009, 51.39 percent during 2010-2014, 26.59 percent during 2015-2019).

5.5.1.6.2. Thematic evolution

In the case of Indian climate change research, seven themes namely “OCEANS”, “PLANTS”, “ECOSYSTEMS”, “SIMULATIONS”, “INFECTIONS”, “SEA-SURFACE-TEMPERATURES” and “SOILS” have solid links with the themes of the next period that indicates the continuity of the associated keywords vis-à-vis topics. Some of these themes have appeared during the next period like “SEDIMENTS”, “SIMULATIONS”, “SOILS”. During 1995-1999 the new themes have appeared like “SENSITIVITIES”, and “STABLE-ISOTOPES” represent transition themes that shared the main topics. Although these themes have not appeared during the next period.

During 2000-2004 the new themes have appeared like “RECORDS”, “MODELS”, “CLIMATE-CHANGES”, “CARBONATES”, “GENERAL-CIRCULATION-MODELS”, “DEPOSITS”, “AEROSOLS” and “PADDY-FIELD” represent transition themes that shared the main topics. “CLIMATE-CHANGES” themes have appeared throughout the successive period from 2000-2004 to 2015-2019.

During 2005-2009 six themes namely “CLIMATE-CHANGES”, “CLIMATES”, “SENSITIVITIES”, “METHANE-EMISSIONS”, “INDIAN-MONSOONS”, “WESTERN-GHATS” have solid links with the themes of the next period that indicates the continuity of the associated keywords vis-à-vis topics.

During 2010-2014 eight themes namely “GLOBAL-WARMING-POTENTIALS”, “CLIMATE-CHANGES”, “CLIMATES”, “BASINS”, “INTENSITIES”, “MASS-BALANCES” have solid links with the themes of the next period. In this period “SEA-SURFACE-TEMPERATURES” again appeared after 1990-1994 and “SIMULATIONS” appeared after 1995-1999.

During 2010-2014, three themes “CLIMATE-CHANGES”, “GLOBAL-WARMING-POTENTIALS”, “MASS-BALANCES” have appeared as transition themes among these 21 have shared the main topics with the themes of the last period (2015- 2019). It has been observed that the themes "SIMULATIONS" have shared main topics and sub-topics only with the following themes "INDIAN-SUMMER-MONSOONS" and "UNCERTAINTIES" during the last period. The themes have acted as a thematic bridge those have received topics from the previous period as well as shared its main topics of the next period "EMISSIONS" to "ENERGIES", "INTENSITIES" to "TROPICAL-CYCLONES" and "SEA-SURFACE-TEMPERATURES" to "INDIAN-SUMMER-MONSOONS".

5.5.1.6.3. Continuity of themes

It has been observed that none of the themes were omnipresent in every period and that most of the themes had newly arisen in each period (Figure4.5.1.10). A very few themes have appeared at intervals although, their document frequency and citation impact were found to be very low. The theme "CLIMATE-CHANGES" was the main theme during the 2000-2004 period which has appeared throughout the last period. The themes "CLIMATES" have appeared during 2005-2009 which has appeared throughout the last period and "GLOBAL-WARMING-POTENTIALS" have appeared during the last two periods.

Figure4.5.1.10 illustrates how the themes are distributed at successive periods (from 1990-1995 to 2015-2019) of Indian research Publications on "Climate Change".

5.5.1.6.4. Quantitative and qualitative development of themes at successive periods

There were not enough keywords which are required to designate particular research themes during 1985-1989. The second period (1990-1994) has registered eleven themes with very lower DF. During this period "SEDIMENTS" was found to be the most active theme having a DF of 2 (Figure 4.5.1.10, Table 4.5.1.10) followed by "CONTINENTAL-MARGINS" with DF of 2. The themes "SEA-SURFACE-TEMPERATURES" were found to come under emerging focus.

The third period (1995-1999) has registered eight themes with a higher DF than the previous period. During this period "STABLE-ISOTOPES" was found to be the most active theme having a DF of 10 (Figure 4.5.1.11, Table 4.5.1.12). The theme "STABLE-ISOTOPES" was positioned in the top-right quadrant with the highest centrality value (48.26) indicating itself as the most important and well-connected theme with other keywords vis-à-vis themes.

The fourth period (2000-2004) has also registered eight themes with a higher DF than the previous period. During this period “RECORDS” was found to be the most active theme having a DF of 43 followed by “CARBONATES” with DF (11) (Figure 4.5.1.12, Table 4.5.1.14) followed by “CARBONATES”. The themes “AEROSOLS” were found to come under emerging focus. The theme “CLIMATE-CHANGES” and “MODELS” appeared in the bottom-right quadrant as basic and transversal themes.

The fifth period (2005-2009) has registered eleven themes with much higher DF than the previous period. During this period “SENSITIVITIES” was found to be the most active theme having a DF of 29 followed by “METHANE-EMISSIONS” with DF (18) (Figure 4.5.1.13, Table 4.5.1.16). The themes “HIMALAYAS” were found to come under emerging focus. The theme “CLIMATES” appeared in the bottom-right quadrant as basic and transversal themes with highest DF (84), highest document citations (4217) and also with the highest centrality value (12.38) followed by “CLIMATE-CHANGES” DF (70), document citations (3920) and centrality value (10.45) during this period.

The sixth period (2010-2014) has registered twelve themes with the increased DF within a range of 6 to 379. During this period “CLIMATE-CHANGES” was found to be the most active theme having a DF of 379 (Figure 4.5.1.14, Table 4.5.1.17). The theme “CLIMATE-CHANGES” received maximum document citations (14,836) and was positioned in the top-right quadrant with the highest centrality value (14.72) indicating itself as the most important and well-connected theme with other keywords vis-à-vis themes. The themes “SEA-SURFACE-TEMPERATURES”, “WESTERN-GHATS” and “DEPTHS” were found to come under emerging focus. The theme “CLIMATES”, “SIMULATIONS” and “BASINS” appeared in the bottom-right quadrant as basic and transversal themes.

The last period (2015-2019) has registered 21 themes with the maximum DF within a range of 6 to 1114. During this period “CLIMATE-CHANGES” was also found to be the most active theme having a DF of 1,114 (Figure 4.5.1.15, Table 4.5.1.19). The theme “CLIMATE-CHANGES” received maximum document citations (18,452). Another themes “GLOBAL-WARMING-POTENTIALS”, “INDIAN-SUMMER-MONSOONS”, “UNCERTAINTIES” and “GREENHOUSE-GAS-EMISSIONS” was positioned in the top-right quadrant. The themes “HAZARDS”, “STABLE-ISOTOPES”, “ARTIFICIAL-NEURAL-NETWORKS” and “ABIOTIC-STRESSES” were found to come under emerging focus. The theme "GREENHOUSE-GAS-EMISSIONS", "ENERGIES", "AEROSOLS", "FORESTS", "WATERS" and "EVENTS" appeared in the bottom-right quadrant as basic and transversal themes.

5.5.2. Results from Scopus database:

5.5.2.1. Comparative total global and Indian contribution in different subject areas:

India has contributed 83.34 % of total Indian publications in the global top 10 research areas (85%. India has contributed at a higher proportion than the global in some research areas namely: Engineering, Energy, Biochemistry, Genetics & Molecular Biology, Computer Science, Multidisciplinary, Physics and Astronomy, Materials Science, Chemical Engineering which are mainly deal with the mitigation and adaptive measures of the climate change. India has contributed at a lower proportion than the global in some research areas namely: Environmental Science, Earth and Planetary Sciences, Agricultural & Biological Sciences, Social Sciences, Medicine and Business, Management & Accounting which are mainly deal with the causal factor identification and impact assessment of the climate change (Figure 4.5.2.1).

5.5.2.2. Period-wise growth of top 30 research areas of Indian publications:

Some of the research areas of Indian publications contributed at higher CPGR than the CPGR of total Indian publications (111.37 %) (Figure 4.5.2.2 & Figure 4.5.2.2) namely: Computer Science (240.81 %), Economics, Econometrics and Finance (225.25 %), Decision Sciences (198.75 %), Mathematics (196.85 %), Business, Management and Accounting (189.20 %), Biochemistry, Genetics and Molecular Biology (150.53 %), etc.

5.5.2.3. Comparative Evolving trend of different subject areas among top 20 countries:

Throughout the periods, in the following subject areas namely Computer Science (Rank-3), Chemical Engineering (Rank-3), Veterinary (Rank-3), Pharmacology, Toxicology and Pharmaceutics (Rank-3), Engineering (Rank-4) and Materials Science (Rank-5), and Energy (Rank-7) India cumulatively contributed more publications and placed better as compared with the top 20 countries. In the top ten subject areas of global cumulative publications, India ranked better in the following three subject areas Computer Science (Rank-3), Engineering (Rank-4), Energy (Rank-7). During the last period, Computer Science ranked 2nd, Engineering ranked 3rd and Energy ranked 6th among the top 20 countries and these subject areas are also positioned in the top ten subject areas of global cumulative publications.

5.5.2.4. Evolving Trends of research topics vis-à-vis keywords of Indian research publications on "Climate Change" during successive periods

Throughout the periods "Climate Change" has appeared in the top five keywords excluding "India". During the last period, "Climate Change" has appeared as the most frequent keyword. "Global Warming," "Greenhouse Gases," and "Solar Energy" all emerged with rising frequency and rank as the periods progressed. During the years 2000-2004, "Carbon Dioxide" and "Sustainable Development" appeared in the top 50 charts, and their frequency and ranking grew over time. Between 2005 and 2009, "Weather Forecasting" entered the top 50 list for the first time. The words "fossil fuels," "climate modelling," and "energy efficiency" first appeared between 2010 and 2014. Some keywords, such as "Economics," "Trend Analysis," and others, have remained in the top 50 list over the last few months.

5.5.3. Results from Indian citation index database

5.5.3.1. Total Global and Indian comparative contribution in different subject areas:

The top 30 research areas of total Indian research on climate change have contributed 70.04 % cumulatively as compared to the total global research on climate change (79.09%) cumulatively. India has contributed at a higher proportion than the global in some research areas namely: Agriculture, General Science and Technology, Botany, Engineering Science and Technology, Meteorology and Agricultural Meteorology. India has contributed a lower proportion than the global in some research areas namely: Environmental Science, Biological Science, Earth and Geological Science, Ecology and Environment, Economics etc. are mainly deal with the causal factor identification and impact assessment of climate change (Figure 4.5.3.1).

5.5.3.2. Evolving trend of top 30research areas during successive periods of Indian research:

Some of the research areas of Indian publications have contributed at higher CPGR than the average CPGR of total Indian publications (87.42 %) namely Pharmacology and Pharmaceutical Science (383.05 %), Business and Marketing(182.84 %), Education (153.31 %), Economics (138.37 %), Management (133.93 %), Business Management (117.94 %), Multidisciplinary (110.26 %), Social

Science (108.99 %), Chemistry (97.30 %), Dairying, Dairy, Animals and Animals Produce (93.31 %), Engineering Science and Technology (93.06 %) and Botany (88.00 %).

5.5.3.3. Most frequent research topics vis-à-vis keywords during successive periods of Indian research:

Throughout the periods “Climate Change”, “Global warming” and “India” have appeared as the top three keywords indicated that the research works were performed on those research topics focusing on the Indian context. The following keywords namely “Rainfall”, “Climate”, “Environment”, “Agriculture”, “Remote sensing”, “Carbon sequestration”, “Rice”, “GIS”, “Drought”, “Conservation”, “Mitigation”, “Diversity”, “Adaptation”, “Food security”, Precipitation etc. also appeared throughout the periods with increasing frequency at successive periods. Between 2010 and 2014, the words "management," "Himalaya," "Effect," "Simulation," and "Himalaya" appeared in the top 50 list, and their frequency and rank increased with at successive period. “Elevated CO2,” “Heat stress,” “Renewable energy,” “Development,” “Livestock,” and “Carbon stock” all made the top 50 list in the latest period.

5.6 Inter-relationship among the carried-out research topics and country-specific socio-economic & environmental problems

5.6.1. Inter-relationship of CO_2 emission and publications of top 20 countries based on the number of publications from Scopus

Based on the number of publications in the Scopus database, the top 20 countries account for around 73.59 percent of total global accumulated CO2, with an average of 3.68 percent (Figure 4.6.1). India came in seventh place, accounting for 3.08 percent of total global CO2 emissions from 1990 to 2017. The top 20 countries emit an average of 8.24 metric tons of CO2 per capita. With a value of 1.73 metric tons per capita, India is the lowest per capita CO2 emitting nation among the top 20 countries. The number of publications (both from the WoS and Scopus databases) and the share of global total CO2 emissions by the top 20 countries have a strong positive association (r=0.93). Based on the number of publications from the Web of Science and Scopus databases from 1985 to 2019, India was ranked 13th and 9th, respectively.

5.6.2. Total Greenhouse gas emission % change from 1990 of the top 20 countries based on the number of publications from Scopus

The top 20 countries' cumulative greenhouse gas emission percent change from 1990 is about 27.47 percent (Figure 4.6.2). Denmark leads the list with a negative acceleration of -25.91 percent, followed by the United Kingdom (-24.63 percent), Germany (-24.23 percent), Russian Federation (-21.99 percent), Sweden (-14.78 percent), the Netherlands (-12.74 percent), and so on. However, several countries have seen positive acceleration in terms of greenhouse gas emission reductions, with China leading the way with a value of 219.95 percent, led by South Korea (122.62 percent). With a positive acceleration value of 116.44 percent, India came in third.

5.6.3. Inter-relationship of CO2 emission and GDP of top 20 countries

Total CO2 emissions and GDP current prices (2018) in billions of US dollars have a strong positive correlation (r=0.82) (Figure 4.6.3). In 2018, four countries emitted more CO2 than the group average in tons, with India being the third most emitting country with 2591323.74 kilotons. China (9956568.523 kilotons) and the United States (5424881.502 kilotons) are the top two emitters, respectively. In terms of GDP, four countries, namely the United States, China, Japan, and Germany, contributed more than the group's average GDP. India came in seventh position with a GDP contribution of 2718.732 billions of dollars in current prices (2018).

5.6.4. Inter-relationship of publications, GERD in % of GDP and GERD in billions of US dollar of top 20 countries

The number of publications from both databases had no association (r=0.03) with GERD as a percentage of GDP (Figure 4.6.4). With a value of 0.62, India is the last country with a higher GERD as a percentage of GDP than the group average (2.46 percent). Figure 4.6.5 depicts the relationship between Gross Research and Development Spending in Billions of US Dollars (GERD in Billions of US Dollars) and Publication Share Percentage (The World Bank, 2015). The GERD PPP in billions of dollars and the number of publications from both databases had a strong positive correlation (0.85), according to the findings.

5.6.5. Comparative analysis of electricity production from coal sources and fossil fuel energy Consumption of top 20 countries

Eight countries have a higher percentage of electricity output from coal sources than the group average, with India having the highest percentage (75.31%), followed by China (70.31%), Australia (62.87%), and so on (Figure 4.6.6). Coal-fired electricity generation accounts for less than 1% of total electricity generation in Switzerland and Norway. Twelve countries consume a higher percentage of fossil fuel resources than the rest of the group. With 94.41 percent of overall energy consumption, Japan came out on top, followed by Australia (93.39 percent), the Russian Federation (92.14 percent), and so on. India was ranked 11th in this parameter, with a value of (73.58 percent of total) for the percentage of electricity generated from coal sources.

5.6.6. Comparative analysis of renewable energy Consumption of top 20 countries

Eight countries use a higher percentage of renewable energy than the group as a whole (Figure 4.6.7). With 57.77 percent of overall energy consumption, Norway came out on top, followed by Sweden (53.25 percent), Brazil (43.79 percent), Finland (43.24 percent), and so on. India was ranked fifth in terms of renewable energy usage, with 36.02 percent. Renewable energy consumption accounts for less than 10% of overall final energy consumption in the United States, the United Kingdom, Australia, Japan, the Netherlands, Russia, and South Korea.

5.6.7. Comparative analysis of the land area and forest cover of top 20 countries

Seven countries have a higher forest cover percentage than the 37.68 percent average for the group (Figure 4.6.8). With a forest cover of 23.83 percent of total land, India ranked 15th. Finland was first on the list, with 73.10 percent forest cover, followed by Sweden (68.92 percent), Japan (68.46 percent), South Korea (63.35 percent), Brazil (58.93 percent), and so on. Seven countries have a higher forest cover in sq km than the community average of 10449724.54 sq km, based on total forest coverage. India came in seventh with a forest area of 12475033.97 square kilometers and a total land area of 12475033.97 square kilometers.

5.6.8. Comparative analysis of the number of patent publications and number of research publications on climate change from WoS and Scopus

The World Intellectual Property Organization (WIPO) registered a total of 19634 global and 545 Indian patent publications using the search string up to March 2021. During 2019, the highest global patent publication was 1710, and Indian patent publication was 66 (Figure 4.6.9). The number of global and Indian patent publications had a strong positive correlation (r=0.92). The number of research publications (both from WoS and Scopus databases) and the number of global patent publications had a strong positive correlation (r=0.97) (Figure 4.6.10).

Between 1985 and 2019, the total number of Indian patent publications was 438, while the total number of Indian research publications on total "Climate Change" was 14663 and 24865, according to Web of Science and Scopus, respectively (Figure 4.6.11). There was no patent publication on "Climate Change" from India prior to 2005. However, there was a strong positive association (r=0.95) between the number of publications (from both the WoS and Scopus databases) and the number of Indian patent publications.

On climate change, four countries have more patent publications than the group average. With 5494 patent publications, China took first place, followed by Japan (2,415), the United States of America (2,040), and so on (Figure 4.6.12). In both the WoS-149215 and Scopus-186066 databases, the United States had the most publications, followed by China (WoS-58608 & Scopus-71360). With 554 patent publications, India came in fifth place. The number of publications (both from WoS and Scopus databases) and the number of patent publications in the top 20 countries had a lower positive correlation (r=0.45).

5.6.9. Comparative analysis of patent publications from the WIPO GREEN Database

On the WIPO GREEN database, five countries have more patent publications than the group (top 30) average. With 1305 patent publications in the WIPO GREEN database, the United States tops the list, followed by Japan (961). Similarly, the United States was the country with the most publications in both databases (WoS-149215 & Scopus-186066), followed by China (WoS-58608 and Scopus-71360). According to the WIPO GREEN index, India is ranked 14th with 34 patent publications. The number of publications (both from WoS and Scopus databases) and the number of patent publications from the WIPO GREEN database of the top 30 countries had a moderate positive correlation (r=0.71).

The patent publications by different categories are Energy, Solar, Pollution & Waste, Product, materials and processes, Farming & Forestry, Building & Construction, Water, Transportation, etc. USA registered the highest position in the total number of patent publication and also registered the highest position in five different categories like Energy (621), Solar (229), Pollution & Waste (275), Farming & Forestry (196), Transportation (44), Japan registered the highest position in two different categories like Product, materials, and processes (299), Building & Construction (73) and Israel registered the highest position in only Water (59) categories from the WIPO GREEN database. . India registered different positions by different categories from the WIPO GREEN database such as Energy-9th, Solar-9th, Pollution & Waste-17th, Product, materials and processes-6th, Farming & Forestry-16th, Building & Construction-23rd, Water-9th, Transportation-8th (Table 4.6.1) with very few numbers of patent.

Chapter 6

Findings/Summary and recommendations

Findings/Summary and Recommendations

India held 13th rank by contributing 14532 publications i.e., 2 % (normalised) of the total global publications in the Web of Science database. During the last 5-year period India secured 10th position by contributing 8140 publications during the last periodwith a CPGR of 200.74% (WoS).India held 9th rank by contributing 24865 publications i.e., 2.66 % (normalised) of the total global publications. India achieved 8th position during the last five-year period (2015-2019) by contributing 13197 publicationswith a CPGR of 112.73% (Scopus).India has contributed to the total global publications at a higher proportion of publications in the Scopus database than that of the publications in the Web of Science database. Therefore, it is suggested to give more importance on climate change research for the betterment of this field of research and to reach paritywith the top countries.

India ranked 15th position by involving 6588 and 7915organizations respectively in the Web of Science and Scopus database. There were no Indian organisations in the global top 30 and top 100 organisations. India ranked 16th position by involving 24689 authors during the last five-yearperiodwith a CPGR of 243.61 %. The participation of more authors from more organisations will accelerate the growth of publications and will be helpful to address various issues related to climate change.

Top 30 source titles or journals have published 15.93 % of the total Indian research on climate change which is lower than the total global share (22.21). India has contributed at a higher proportion than the global in some low-impact journals (IF range 2-5). India has contributed at a lower proportion than the global in some high-impact journals namely Nature, Science. Similar trends were observed from the Scopus database. Revealed information about the top 30 journals will help to design new research work and this work to be published in a high-impact journal.

India rankedthe last and 17thposition in WoS and Scopus respectively based on average citation during the last two consecutive periods. India ranked 19thand 29th during the last period among the top 20 and top 30countries. India ranked 19th and 21st position during the last three periods based on the h-index.

India also ranked last based on the average impact factor of country-specific top 100 journals and its individual publications of the top 20 countries with very lower value as compared to the others (WoS). India ranked better in the below one and no IF categories from both of the databases. The number of not cited publications of both global and Indian publications from the Indian Citation Index were increased at successive periods. Therefore, the citation impact of the Indian publication was very poor as compared to the top countries. It is recommended that the quality of research work on climate change should be improved to be published in high-impact journals.

India ranked in the 15^{th} position among the top 20 countries during the last periodbased on research collaboration. The average citations of the collaborative publications with the top 20 India's collaborating countries were about two times greater than that of the average citations of total Indian publications. Therefore, it is suggested that more research collaboration with those countries will elevate the impact of the Indian research publications.

India ranked $4^{th}$and 3rd with 20686 and 25933publications related to the "National Solar Mission" from WoS and Scopus respectively. India ranked $4^{th}$and $3^{rd}$with 20686 and 25933publications related to the "National Solar Mission" from WoS and Scopus respectively. India ranked $3^{rd}$with 10239 and 19094publications related to the "National Mission for Enhanced Energy Efficiency" from WoS and Scopus respectively. India ranked $7^{th}$and 3^{rd} with 7187 and 16651publications related to the "National Mission on Sustainable Habitat" from WoS and Scopus respectively. India ranked $5^{th}$and 3rd with 5416 and 12049publications related to the "National Water Mission" from WoS and Scopus respectively. India ranked 1^{st} with 9388 and 25933publications related to the "National Mission for Sustaining the Himalayan Ecosystem" from WoS and Scopus respectively. India ranked 13^{th} and $10^{th}$with 5499 and 8936publications related to the "National Mission for a Green India" from WoS and Scopus respectively.India ranked 5^{th} and 3^{rd} with 13461 and 36033publications related to the "National Mission for Sustainable Agriculture" from WoS and Scopus respectively.India ranked $13^{th}$and $10^{th}$with 2442 and 3236publications related to the "National Mission for Strategic Knowledge for Climate Change" from WoS and Scopus respectively.India is the leading country for all the missions from the Indian Citation Index. Although, the CAGR was lower for all the missions after the introduction of the missions as compared to the total global publications.

The study on the different National Missions also shows that the publication growth rate after the introduction of the missions was higher than the total global publications related to different missions from both the WoS and Scopus database except for the National Water Mission and National Mission forStrategic Knowledge for Climate Change from WoS.The maintenance of the research activity related to the different missions is suggested and some extra attention should be taken for the following missions namely "National Water Mission", "National Mission for Sustainable Agriculture" and "National Mission forStrategic Knowledge for Climate Change". Further in-depth bibliometric and scientometric analysis for all the missions is required to identify the major contributors for different bibliometric parameters, citation impact, research collaboration along with the innovation study through in-depth patent analysis.

Throughout the periods. in the following research areas namely Engineering Electrical Electronic (Rank-3), Multidisciplinary Sciences(Rank-8), Energy Fuels (Rank-9) and Remote Sensing (Rank-9) India cumulatively contributed more publications as compared with the top 20 countries. India did not rank better in the global top ten research area except Meteorology Atmospheric Sciences, Water Resources and Energy Fuels. It is suggested that Indian researchers should also perform better in the global top research areas.

In all environmental and socioeconomic parameters India performed a balanced role. Although some care should be taken like the reduction of electricity generation from coal source, more power consumption from renewable sources and promotion of more afforestation to increase forest cover as compared to the others.

Indian patent publications were recorded with 545 number of patent publications since 2006 and registered 5th position. India registered 14th position with 34 patent publications from the WIPO GREEN database. Finally, it is also suggested to accelerate the innovation on green technology to mitigate the impact of climate change.

Research Summary

Contribution of India on Climate Change Research in Comparison with Major Countries: A Bibliometric Study of 30 years (1987-2016), by Dr. Ajoy Mallik. Dinabandhu Mahavidyalaya, Bongaon, North 24 Parganas, West Bengal 743235. 2018-2020

This work provides a quantitative and qualitative analysis of the contribution of Indian climate change research in comparison with top 20 countries reflected in the publication output recorded in Web of Science, Scopus and Indian Citation Index. This study identified quantitative contributions by different bibliometric parameters (organisations, authors, journals) and their rank among the top 20 countries. This study also evaluates the comparative impact of the carried-out research by top 20 countries through citation analysis. The contribution and impact of the Indian collaborative research was also quantified. Most proficient collaborative countries, organizations and authors of Indian climate change research were identified. The impacts of the implications of the "Eight national Mission" were quantified covering publication from WoS, Scopus and Indian Citation Index. The leading research areas of the individual missions were also recognized. Evolving trends of research areas and research themes of Indian climate change were identified. The comparative interrelationship study for various environmental parameters, publications and patents were carried out among the top 20countries. India held 13th, 9th rank by contributing 14532, 24865 publications in WoS and Scopus respectively. There were only 9 Indian organisations in the top 500 global organization's list. The citation impact of Indian publications was the lowest among the top 20countries. The Indian collaborative research improved the quality of Indian publications. The individual mission related publications attained higher acceleration than the total global publications after introductions except the National Water Mission from WoS.India has contributed at a higher proportion than the global in some research areas namely: Energy fuel, Water resource, Agronomy, Engineering Electrical Electronics, Green sustainable, those are mainly deal with the mitigation and adaptive measures of climate change. During the last period "Climate-Changes" was the most active theme followed by "Global-Warming-Potentials", "Indian-Summer-Monsoons", "Uncertainties" and "Greenhouse-Gas-Emissions". In all environmental and socioeconomic parameters India performed a proportionate role.

Patent analysis showed that more acceleration of innovation on the green technology is required to mitigate the impact of climate change.

End Project Deliverables:

The project has been completed accomplishing the project's objectives. In short, the project work revealed the followings:

Total global and Indian publications on Climate Change have been quantified from WoS, Scopus and Indian Citation Index. Comparative quantification of publications and different bibliometric parameters (organizations, authors, source titles, meeting abstract, funded research) among the top 20 countries revealed India's rank in different bibliometric parameters during total timespan and progressive rank during successive periods from the three databases.

Qualitative study through comparative citation analysis explored that the Indian publications received lower impacts as compared with the other countries among the top 20 countries in respect to the average citation, h-index, calculated 5 year's Impact Factor, top 100 journals distributions among different IF categories.

Research collaboration study identified the most collaborative countries, Indian and International organizations, authors. This study also revealed that multinational collaborative publications received more citation impact as compared to the Indian publications without multinational collaboration.

Analysis of individual National Missions from WoS, Scopus and Indian Citation Indexexhibited that almost all the Missions had a positive impact on the research publications as the adoption of individual missions accelerated the publication growth.

Inter-relationship study among carried-out research topics and country-specific socio-economic & environmental problems revealed various correlation among various parameters. A strong positive correlation was observed between number of publications and number of patents.

One manpower as Junior Research Fellow has been trained in this project. Two research publications have been prepared which would be published in International Journals.Some research infrastructures have been developed in the host Institute.

How the outcome of this project will be beneficial for various stakeholders

The quantitative and qualitative analysis of Indian research contribution on Climate Change will be helpful towards future policy formulation for the further advancement in this field. This study also identified the top 100 journals of global publications in Climate Change that might be influential to design new research methodology and for the communications of the completed research work to be published to improve the publication quality. As the Climate Change research is a multinational issue therefore, collaboration is the uttermost need in this field. Therefore, the findings from the evaluation of research collaboration will be helpful to identify the most prolific countries, organisations and authors of various proficiencies for research collaborations. Research evaluation related to eight different National Mission on Climate Change highlighted various strengths and lacunas which will be deliverable towards the policy formulations for successful R&D management for individual National Missions. Although some in-depth study is also needed for individual National Missions. Evolving trends analysis of the research area and research topic of total Climate Change revealed various research areas and themes of Indian Climate Change research which are well developed and which are required to be developed further.

Rationale about taking the two databases (WoS and Scopus)

The Expert Committee on Bibliometrics in its 1st meeting on 20-21 April, 2018 at Hyderabad also recommended to align the project with national goal on climate change covering Indian journals by using Indian Citation Index. Alongside, it had been mentioned in the limitation of the study that the publication data will also be collected from Scopus database along with the Web of Science and Indian Citation Index and a comparative analysis will also be performed to visualise the actual data coverage. Therefore, the study was performed mainly based on Web of Science database and compared with Scopus and Indian Citation index. The comparative analysis of the publication output among these databases explored some valuable information regarding Indian research performance in holistic manner. Thereby, this study covered the all-inclusive information about the research performance on "Climate change" and will be useful for future research policy formulation.

The variation of scores/results from these databases

The detailed comparative analysis of different parameters has been represented and discussted above. Some variations of scores and results have been observed from the above study. The tabales represented below are self explanatory regaring the variation of scores and results obsereved from various data basees.

Table 6.1: Number of publications of the total global, top 20 countries and India; India's rank in different databaeses during different period and total 35-year time span.

		Total	1985-1989	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014	2015-2019	CPGR %
WoS	Global publication	466426	808	10697	22783	35914	65395	128169	205135	151.63
	Group average	28508	32.3	489.55	1167.75	2017.65	3818.9	7824.75	13157.1	172.26
	Indian Publication	14532	11	194	387	576	1439	3883	8140	200.75
	Inadi's Rank	13	9	10	15	18	14	14	10	13
Scopus	Global publication	649544	9071	16933	29355	50867	98783	181803	262732	75.24
	Group average	35341.55	280.9	577	1323.2	2518.35	5154.6	10110.35	15071.1	94.20
	Indian Publication	24865	148	266	500	952	2385	6677	13197	112.73
	Inadi's Rank	9	9	10	15	15	13	10	8	8
ICI	Global publication	19690	-	-	-	-	1420	3437	4988	87.42
	Indian Publication	15496	-	-	-	-	1145	2742	3861	83.63
	Inadi's Rank	1	-	-	-	-	1	1	1	1

Table 6.3: Number of publications, Sum of the Times Cited, h-index, Average Citations per Item, No Citation % of the publications came from the collaboration with top 20 Countries, collaboration with rest of the Countries and total India publication from WoS and Scopus.

		Collaboration with top 20 Countries	Collaboration with rest of the Countries	Total of India
Web of Science	Number of publications	4022	639	14663
	Sum of the Times Cited	163396	13554	321021
	h-index	167	60	188
	Average Citations per Item	40.62	21.21	21.893
	No Citation %	5.2	9..86	13.45
SCOPUS	Number of publications	6555	1062	24856
	Sum of the Times Cited	207746	16709	439132
	h-index	178	60	208
	Average Citations per Item	31.69	15.73	17.66
	No Citation %	12.68	17.89	36.37

Table 6.4: Global and Indian CAGR after adoption of Indian National Mission on Climate Change and India's rank in different national mission from Wos, Scopus.

National Action Plan on Climate Change (NAPCC)		Web of Science		Scopus		Indian Citation Index
		CAGR After Indian Mission	India's rank	CAGR After Indian Mission	India's rank	CAGR After Indian Mission
National Solar Mission	Global Publication	12.48%	5th	12.89%	3rd	10.45%
	Indian Publication	20.77%		25.77%		8.78%
National Mission for Enhanced Energy Efficiency	Global Publication	12.79%	3rd	13.79%	3rd	10.46%
	Indian Publication	21.40%		26.83%		9.42%
National Mission on Sustainable Habitat	Global Publication	14.66%	7th	10.86%	3rd	15.37%
	Indian Publication	17.33%		16.22%		13.83%

National Water Mission	Global Publication	11.91%	5th	8.30%	3rd	4.48%
	Indian Publication	11.17%		8.80%		3.09%
National Mission for Sustaining the Himalayan Ecosystem	Global Publication	10.57%	1st	10.30%	1st	3.18%
	Indian Publication	11.73%		11.67%		2.39%
National Mission for a “Green India”	Global Publication	7.58%	13th	10.26%	10th	3.54%
	Indian Publication	10.76%		12.17%		1.97%
National Mission for Sustainable Agriculture	Global Publication	9.70%	5th	9.20%	3rd	5.98%
	Indian Publication	11.47%		13.87%		4.55%
National Mission on Strategic Knowledge for Climate Change	Global Publication	26.71%	13th	12.15%	10th	15.14%
	Indian Publication	25.10%		22.93%		18.14%

References

Ahern M, Kovats RS, Wilkinson P, Few R. etal. Global health impacts of floods: epidemiologic evidence. Epidemiologic Reviews. 2005;27:36–46.

Alley RB, Marotzke J, Nordhaus WD, Overpeck JT. etal. Abrupt climate change. Science. 2003;299(5615):2005-2010.

Attri SD, Rathore LS. Simulation of impact of projected climate change on wheat in India. International Journal of Climatology. 2003;23(6): 693-705.

Bellard C, Bertelsmeier C, Leadley P, Thuiller W. etal. Impacts of climate change on the future of biodiversity. *Ecology Letters.* 2012;15:365–377.

Bjurstro¨m A, Polk M. Climate change and interdisciplinarity: a co-citation analysis of IPCC Third Assessment Report. Scientometrics. 2011a;87:525–550.

Bjurstro¨m A, Polk M. Physical and economic bias in climate change research: a scientometric study of IPCC Third Assessment Report. Climatic Change. 2011b;108:1–22

Both C, Bouwhuis S, Lessells CM, Visser ME. Climate change and population declines in a long distance migratory bird. Nature. 2006;441(7089):81-83.

Brenkert AL, Malone EL. Modelling vulnerability and resilience to climate change: A case study of India and Indian states. Climatic Change. 2005;72(12):57-102.

Bush KF, Luber G., Kotha SR, Dhaliwal RS. etal. Impacts of Climate Change on Public Health in India: Future Research Directions. Environmental Health Perspectives. 2011;119(6):765-770.

Byjesh K, Kumar SN, Aggarwal PK. Simulating impacts, potential adaptation and vulnerability of maize to climate change in India. Mitigation and Adaptation Strategies for Global Change. 2010;15(5):413-431.

Chattopadhyay N, Hulme M. Evaporation and potential evapotranspiration in India under conditions of recent and future climate change. Agricultural and Forest Meteorology. 1997;87(1):55-73.

Chen IC, Hill JK, Ohlemüller R, Roy DB, Thomas CD. Rapid range shifts of species associated with high levels of climate warming. Science. 2011;333:1024–26.

Cobo MJ, Lo´pez-Herrera AG, Herrera-Viedma E, Herrera F. An approach for detecting, quantifying and visualizing the evolution of a research field: A practical application to the fuzzy sets theory field. J Inform. 2011;5(1):146-66. Available from: DOI: 10.1016/j.joi.2010.10.002

Cobo MJ, López-Herrera AG, Herrera-Viedma E, Herrera F. Sci MAT: A New Science Mapping Analysis Software Tool. Journal of the American Society for Information Science and Technology. 2012;63(8):1609-30.

Cramer W, Bondeau A, Woodward FI, Prentice IC. Global response of terrestrial ecosystem structure and function to CO2 and climate change: results from six dynamic global vegetation models. Global Change Biology. 2001;7(4):357-373.

Crowley TJ. Causes of climate change over the past 1000 years. Science. 2000;289(5477):270-277.

da Silva LBL, Alencar MH, de Almeida AT. Multidimensional flood risk management under climate changes: Bibliometric analysis, trends and strategic guidelines for decision-making in urban dynamics Source. International Journal of Disaster Risk Reduction. 2020;50:101865

Dash SK, Hunt JCR. Variability of climate change in India. Current Science. 2007;93(6):782-788.

Dash SK, Jenamani RK, Kalsi SR, Panda SK. Some evidence of climate change in twentieth century India. Climatic Change. 2007;85(34):299-321.

Davarazar M, Jahanianfard D, Sheikhnejad Y et al. Underground carbon dioxide sequestration for climate change mitigation - A scientometric study. Journal of CO2 Utilization. 2019;33:179-188. Available from: doi:10.1016/j.jcou.2019.05.022.

Demiroglu OC, Hall CM. Geobibliography and Bibliometric Networks of Polar Tourism and Climate Change Research. *Atmosphere*. 2020;11(5):498. Available from: doi:https://doi.org/10.3390/atmos11050498

Dhiman RC, Pahwa S, Dhillon GPS, Dash AP. Climate change and threat of vector borne diseases in India: are we prepared? Parasitology Research. 2010;106(4):763-773.

Dickinson RE, Cicerone RJ. Future global warming from atmospheric trace gases. Nature. 1986;319:109-115

Edmonds JA, Rosenberg NJ. Climate change impacts for the Conterminous USA: an integrated assessment summary Climate Change. 2005;69:151–62

Edwards M, Richardson AJ. Impact of climate change on marine pelagic phenology and trophic mismatch. Nature.2004;430(7002): 881-884.

Einecker R, Kirby A. Climate Change: A Bibliometric Study of Adaptation, Mitigation and Resilience. Sustainability. 2020;12(17):6935.

Emanuel K. Increasing destructiveness of tropical cyclones over the past 30 years. Nature. 2005;436:686–8.

Fischer G, Shah M, Tubiello FN and van Velhuizen H. Socio-economic and climate change impacts on agriculture: an integrated assessment, 1990–2080. Phil. Trans. R. Soc. B. 2005;360:2067–83.

Gadgil S. Climate-change and agriculture - an Indian perspective. Current Science. 1995;69(8):649-659.

Garfield E. From bibliographic coupling to co-citation analysis via algorithmic historio-bibliography. Drexel University, Philadelphia, PA. 2001;27:1-45

Garg A, Dhiman RC, Bhattacharya S, Shukla PR. Development, Malaria and Adaptation to Climate Change: A Case Study from India. Environmental Management. 2009;43(5):779-789.

Giorgi F, Lionello P. Climate change projections for the Mediterranean region. Global and Planetary Change. 2008;63(23): 90-104.

Giorgi F. Climate change hotspots. Geophysical Research Letters. 2006;3(8): 101029

Guhathakurta P, Sreejith OP, Menon PA. Impact of climate change on extreme rainfall events and flood risk in India. Journal of Earth System Science. 2011;120(3):359-373.

Hainesa A, Kovatsa RS, Campbell-Lendrumb D, 7 Corvalan C. Climate change and human health: Impacts, vulnerability and public health. Public Health. 2006;120:585–596

Hamers L, Hemeryck Y, Herweyers G, Janssen M, Keters H, Rousseau R, et.al. Similarity measures in scientometric research: The Jaccard index versus Salton’s cosine formula. Inform Process Manage. 1989;25(3):315-18. Available from: DOI: 10.1016/0306-4573(89)90048-4

Hannah L, Roehrdanz PR, Ikegami M, Shepard AV, et.al. Climate change, wine, and conservation. Proceedings of the National Academy of Sciences. 2013;110(17):6907–12

Haunschild R, Bornmann L, Marx W. Climate Change Research in View of Bibliometrics. PLoS One. 2016;11(7):e0160393. Available from: doi:10.1371/journal.pone.0160393.

Hoegh-Guldberg O, Bruno JF. The Impact of Climate Change on the World's Marine Ecosystems. Science. 2010;328(5985):1523-28

Huang L, Chen K, Zhou M. Climate change and carbon sink: a bibliometric analysis *Environmental Science* and *Pollution Research*. 2020;27(8):8740-8758. Available from: doi:10.1007/s11356-019-07489-6.

Hulme M., Jenkins GJ., Lu X., et al. Climate change scenarios for the United Kingdom: the UKCIP02 scientific report. Norwich: Tyndall Centre for Climate Change Research, School of Environmental Sciences, University of East Anglia. 2002.

Indian Citation Index. http://www.indiancitationindex.com/ici.aspx. Retrieved from: December 2019 to February 2020 and October 2020 to December 2020.

IPCC (Intergovernmental Panel on Climate Change Working Group 2) 2001 Climate Change 2001: Impacts, Adaptation and Vulnerability IPCC Working Group 2

Iwasaki S, Razafindrabe BHN, Shaw R. Fishery livelihoods and adaptation to climate change: a case study of Chilika lagoon, India. Mitigation and Adaptation Strategies for Global Change. 2009;14(4):339-355.

Jeroen CJM. van den Bergh. A third option for climate policy within potential limits to growth. Nature Climate Change. 2017;7:107–112

Kapila RV, Haszeldine RS. Opportunities in India for Carbon Capture and Storage as a form of climate change mitigation. Greenhouse Gas Control Technologies 9 Book (Eds:Gale J; Herzog H; Braitsch J) Series: Energy Procedia. 2009;1(1): 4527-4534.

Karl TR, Trenberth KE. Modern Global Climate Change. Science. 2003;302:1719-1723.

Kaul M, Mohren GMJ, Dadhwal VK. Carbon storage versus fossil fuel substitution: a climate change mitigation option for two different land use categories based on short and long rotation forestry in India. Mitigation and Adaptation Strategies for Global Change. 2010;15(4):395-409.

Kovats RS, Bouma MJ, Hajat S, Worrall E, Haines A. El Niño and health. Lancet. 2003;362(9394):1481-9. doi: 10.1016/S0140-6736(03)14695-8. PMID: 14602445.

Lal M, Cubasch U, Perlwitz J. etal. Simulation of the Indian monsoon climatology in ECHAM3 climate model: Sensitivity to horizontal resolution. International Journal of Climatology. 1997;17(8):847-858.

Lal R. Soil carbon sequestration to mitigate climate change. Geoderma. 2004;123(12):1-22.

Li F, Zhou H, Huang DS, & Guan P. Global Research Output and Theme Trends on Climate Change and Infectious Diseases: A Restrospective Bibliometric and Co-Word Biclustering Investigation of Papers Indexed in PubMed (1999-2018). International journal of environmental research and public health. 2020;17(14):5228. Available from: doi:https://doi.org/10.3390/ijerph17145228

Li X, Li Y, Li G. A scientometric review of the research on the impacts of climate change on water quality during 1998-2018. *Environmental Science* and *Pollution Research*. 2020 May;27(13):14322-14341. Available from: doi: 10.1007/s11356-020-08176-7.

Lima CO, Bonetti J. "Bibliometric analysis of the scientific production on coastal communities' social vulnerability to climate change and to the impact of extreme events," Natural Hazards: Journal of the International Society for the Prevention and Mitigation of Natural Hazards, Springer; International Society for the Prevention and Mitigation of Natural Hazards, 2020;102(3):1589-1610.

Loarie SR, Duffy PB, Hamilton H, Asner GP, Field CB, Ackerly DD. The velocity of climate change. Nature. 2009;462(7276):1052-5. doi: 10.1038/nature08649. PMID: 20033047.

Mall RK, Aggarwal PK. Climate change and rice yields in diverse agro environments of India. I. Evaluation of impact assessment models. Climatic Change. 2002;52(3):315-330.

Marx W, Haunschild R, Thor A, Bornmann L. Which early works are cited most frequently in climate change research literature? A bibliometric approach based on Reference Publication Year Spectroscopy. Scientometrics. 2017;110(1):335-353. Available from: doi:10.1007/s11192-016-2177-x.

Meehl GA, Covey C, Delworth T, Latif M. et al. The WCRP CMIP3 multimodel dataset A - new era in climate change research. Bulletin of the American Meteorological Society. 2007;88(9):1383-1394.

Meng S, Xiong D. Review and Exploration of China Subtropical Climate Change Research Based on Scientometric Analysis. Tropical Conservation Science. 2018;11. Available from: doi:10.1177/1940082918806795.

Menzel A, Sparks TH, Estrella N, Koch E. et al. European phenological response to climate change matches the warming pattern. Global Change Biology. 2006;12(10):1969-1976.

Moss RH. et al. The next generation of scenarios for climate change research and assessment.

Noji EK. The public health consequences of disasters. Prehosp Disaster Med. 2000 ;15(4):147-57. PMID: 11227602.

O'Brien K, Leichenko R, Kelkar U, Venema H. et al. Mapping vulnerability to multiple stressors: climate change and globalization in India. Global Environmental Change human and Policy Dimensions. 2004;14(4):303-313.

Omoregbe O, Mustapha AN, Wilckens RS, El-Kharouf A, Onyeaka, H. Carbon capture technologies for climate change mitigation: A bibliometric analysis of the scientific discourse during 1998–2018. Energy Reports. 2020;6:1200-1212.

Our World in Data. https://ourworldindata.org/charts. Retrieved from: January 2020

Pal I, AlTabbaa A. Trends in seasonal precipitation extremes an indicator of 'climate change' in Kerala, India. Journal of Hydrology. 2009;367(12):62-69.

Parikh J, Gokarn S. Climate change and India energy policy options: New perspectives on sectoral CO_2 emissions and incremental costs. Global Environmental Change. 1993;3(3):276-281. Available from: https://doi.org/10.1016/0959-3780(93)90044-L.

Parmesan C. Ecological and evolutionary responses to recent climate change. Annual Review of Ecology Evolution and Systematics. 2006;37:637-669.

Parmesan C., Yohe G. A globally coherent fingerprint of climate change impacts across natural systems. Nature. 2003;421(6918):37-42.

Parry M, Rosenzweig C, Livermore M. Climate change, global food supply and risk of hunger. Philosophical Transactions of the Royal Society B: Biological Sciences.2005;360:2125–38.

Patz JA, Campbell-Lendrum D, Holloway T, Foley JA. Impact of regional climate change on human health. Nature. 2005;438(7066):310-7. doi: 10.1038/nature04188. PMID: 16292302.

Pearson RG, Dawson TP. Predicting the impacts of climate change on the distribution of species: are bioclimate envelope models useful? Global Ecology and Biogeography. 2003;12(5):361-371.

Popp A, Dietrich JP, Lotze-Campen H, Klein D. et al. The economic potential of bioenergy for climate change mitigation with special attention given to implications for the land system. Environmental Research Letters. 2011;6(3):034017.

Rana IA. Disaster and climate change resilience: A bibliometric analysis. International Journal Of Disaster Risk Reduction. 2020;50:101839.

Rao PG, Kelly PM, Hulme M. Recent Climatic Change, Greenhouse Gas Emissions and Future Climate: The Implications for India. *Theoretical and Applied Climatology.* 1996;55:41-64.

Ravindranath NH, Chaturvedi RK, Joshi NV, Sukumar R. et al. Implications of climate change on mitigation potential estimates for forest sector in India. Mitigation and Adaptation Strategies for Global Change. 2011;16(2) SI:211-227.

Ravindranath NH, Joshi NV, Sukumar R, Saxena A. Impact of climate change on forests in India. Current Science. 2006;90 (3)354-361.

Ravindranath NH, Sukumar R. Climate change and tropical forests in India. Climatic Change. 1998;39 (23):563-581.

Rootzen JM, Berndes G, Ravindranath NH, Somashekar HI. et al. Carbon sequestration versus bio-energy: A case study from South India exploring the relative land use efficiency of two options for climate change mitigation. Biomass & Bioenergy. 2010; 34(1):116-123.

Rosenzweig C, Parry ML. Potential impact of climate change on world food supply. Nature. 1994;367(6459):133–138.

Saseendran SA, Singh KK, Rathore LS, Singh SV, Sinha SK. Effects of climate change on rice production in the tropical humid climate of Kerala, India. Climatic Change. 2000;44 (4):495-514.

Sathaye J, Shukla PR, Ravindranath NH. Climate change, sustainable development and India: Global and national concerns. Current Science. 2006;90(3):314-325.

Scopus. https://www.scopus.com/home.uri. November 2019 to January 2021.

Semenza JC, Hall, DE, Wilson DJ, Bontempo BD. et al. Public Perception of Climate Change Voluntary Mitigation and Barriers to Behavior Change. American Journal of Preventive Medicine. 2008;35(5):479-487.

Singh BB, Sharma R., Gill JPS, Aulakh RS, Banga HS. Climate change, zoonoses and India. Revue Scientifique et Technique office International des Epizooties. 2011;30(3):779-788.

Singh P, Kumar N. Impact assessment of climate change on the hydrological response of a snow and glacier melt runoff dominated Himalayan River. Journal of Hydrology. 1997;193(1-4):316-350.

Sinha SK, Swaminathan MS. Deforestation, climate change and sustainable nutrition security: A case study of India. Climatic Change. 1991;19(1):201–209.

Solomon S, Plattner GK, Knutti R, Friedlingstein P. Irreversible climate change due to carbon dioxide emissions. Proceedings of the National Academy of Sciences of the United States of America. 2009;106(6):1704-1709.

Stanhill, G. The Growth of Climate Change Science: A Scientometric Study. Climatic Change. 2001;48:515–524. Available from: doi:*https://doi.org/10.1023/A:1010721600896*

Stott PA, Stone DA, Allen MR. Human contribution to the European heat wave of 2003. Nature. 2004;432:610–4.

Sukumar R, Suresh HS, Ramesh R. Climate change and its impact on tropical montane ecosystems in southern India. Journal of Biogeography. 1995;22(23):533-536.

Sweileh WM. Bibliometric analysis of peer-reviewed literature on climate change and human health with an emphasis on infectious diseases. Global Health. 2020;16(1):44. Available from: doi:10.1186/s12992-020-00576-1.

The World Bank. https://www.worldbank.org. Retrieved from: July 2020

Tijssen RJW, Raan AFJ. Mapping co-word structures: A comparison of multidimensional scaling and LEXIMAPPE. Scientometrics. 1989;15(3-4):283-95. Available from: DOI: 10.1007/BF02017203

United Nations Framework Convention on Climate Change. https://unfccc.int. Retrieved from: January 2020

Vass KK, Das MK, Srivastava PK, Dey S. Assessing the impact of climate change on inland fisheries in River Ganga and its plains in India. Aquatic Ecosystem Health & Management. 2011;12 (2):138-151.

Vedwan N, Rhoades RE. Climate change in the Western Himalayas of India: a study of local perception and response. Climate Research. 2001;19(2):109-117.

Walther GR, Post E, Convey P, Menzel A. et al. Ecological responses to recent climate change. Nature. 2002;416(6879):389-395.

Wang B, Pan SY, Ke RY, Wang K, Wei YM. An overview of climate change vulnerability: A bibliometric analysis based on Web of Science database. Natural Hazards. 2014;74:1649-1666. Available from: doi:10.1007/s11069-014-1260-y.

Wang B, Zhao Y. A bibliometric analysis of climate change adaptation based on massive research literature data. Journal of Cleaner Production. 2018;199.Available from: doi:10.1016/j.jclepro

Web of Science. https://login.webofknowledge.com. Retrieved from: November 2019 to January 2021.

Webster PJ, Holland GJ, Curry JA, Chang HR. (2005) Changes in tropical cyclone number, duration, and intensity in a warming environment. Science. 2005;309:1844–6.

WIPO GREEN.https://www3.wipo.int/wipogreen/en. Retrieved from: November 2020

World Intellectual Property Organization. https://www.wipo.int/patentscope/en. Retrieved from: November 2020

Wu F, Geng Y, Tian X, Zhong S, Wu W, Yu S, Xiao S. Responding climate change: A bibliometric review on urban environmental governance. Journal of Cleaner Production. 2018;204. Available from: doi:10.1016/j.jclepro.2018.09.067.

Zorner RJ, Trabucco A, Bossio DA, Verchot LV. Climate change mitigation: A spatial analysis of global land suitability for clean development mechanism afforestation and reforestation. Agriculture Ecosystems & Environment. 2008;26(12):67-80.

Zyoud SH, Fuchs-Hanusch D. Mapping of climate change research in the Arab world: a bibliometric analysis. *Environmental Science* and *Pollution Research*. 2020;27(3):3523-3540. Available from: doi:10.1007/s11356-019-07100-y.

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Citation:

The report may be cited as DST (2016): Report on “Contribution of India on Climate Change Research in Comparison with Major Countries: A Bibliometric Study of 30 years (1987-2016)”; Dr. Ajoy Mallik, Dinabandhu Mahavidyalaya. New Delhi, Govt. of India

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