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 CO2 emissions (%), CO2 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 CO2 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.