Environmental and Sustainability Indicators 24 (2024) 100524

Contents lists available at ScienceDirect

Environmental and Sustainability Indicators

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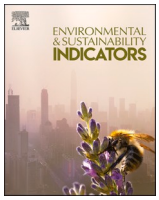

# Climate change and sustainable livelihood in south Asia: A bibliometric analysis

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ARTICLE INFO

*Keywords:*
Climate change
Sustainable livelihood
South Asia
Sustainability
Bibliometric

ABSTRACT

Climate change is a global threat and poses significant risks to sustainable livelihoods, which require immediate attention. Several review papers have highlighted the nexus between climate change and sustainable livelihoods in recent years. Still lacking, nevertheless, is a thorough bibliometrics analysis of the topic. Accordingly, the main objective of this study is to fill this gap by advancing our understanding of the previous research. For this purpose, we analyzed 1411 articles indexed in Scopus between 2004 and 2023 using Bibliometric R and VOS-viewer, two commonly used software tools for science mapping and bibliometrics analysis. This study employed a bibliometric analysis to explore the research trends, collaboration network, and thematic evaluation of papers on climate change and sustainable livelihood. The results show that, despite a consistent increase in research since 2007, the trends accelerated with the publication of the 2018 report on the assessment of climate change and sustainable livelihood. The Indian Council of Agricultural Research leads in productivity, while the USA, India, Bangladesh, and Pakistan are the most productive countries. The results offer an improved comprehension of the changing body of knowledge about climate change and sustainable livelihood research and point to new areas for investigation, making the findings a valuable resource for scholars, decision-makers, and practitioners.

## 1. Introduction

Climate change is acknowledged to be one of the critical challenges humans are facing at present (**Leal Filho et al., 2019**). It refers to the modifications in prevalent weather patterns and climatic variables, including temperature and rainfall, observed over time and space (**Tompkins and Amundsen, 2008**). Climate change is mainly caused by unrestricted greenhouse gas emissions from natural sources, such as forest fires, oceanic carbon emission, volcanism, and earthquakes (**Xi-Liu and Qing-Xian, 2018**), and human activities, such as altercation of land use land cover, energy production, industrialization, and construction work (**Tohidimoghadam et al., 2023**). The change has been amplified in recent decades due to accelerated greenhouse gas emissions by the rapidly growing population and speedy urbanization (**Satterthwaite, 2009**). Studies indicate that urban areas are the key agents of climate change by altering local ecosystems, utilizing energy, and contributing to greenhouse gas emissions (**Boyd and Ghosh, 2013**). However, the repercussions of climate change are noticed throughout the globe, making it a global concern.

Although climate change is a global concept, its consequences in the form of rising temperatures, sea levels, and extreme weather events, such as floods and droughts, are observed at regional and local scales (**Sharma & Tomar, 2010**). These adverse effects of climate change are observed in both natural and human environments (**Igben, 2021**). Among the natural environments, the impacts of climate change have been studied on coastal and marine ecosystems (**Doney et al., 2012**), riverine ecosystems (**Pletterbauer et al., 2018**) forest ecology (**Lindner et al., 2010**), freshwater ecosystem (**Döll and Zhang, 2010**), and river

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https://doi.org/10.1016/j.indic.2024.100524
Received 10 June 2024; Received in revised form 13 October 2024; Accepted 29 October 2024
Available online 30 October 2024

flow regimes (Arnell and Gosling, 2013). On the other hand, the studied impacts of climate change on human environment include crop production (Arora, 2023), agricultural practices (Chandio et al., 2020), fisheries and aquaculture (Barange et al., 2018), economy (Roson & Van der Mensbrugghe, 2012), tourism (Berrittella et al., 2006), displacement and migration (Kaczan and Orgill-Meyer, 2020), human health, including mental health (Cianconi et al., 2020) and rise in vector-borne diseases (Caminade et al., 2019), and livelihood (Funk et al., 2020).

Livelihood connotes the means of making a living. It comprises all the activities, income, and assets, including material and social resources, to fulfil the basic human needs of food, clothing, and shelter. According to Igben (2021), livelihood is a way of harnessing the environment to fulfil living needs. It can be both short and long-term. The aim of meeting the long-term needs of the population is often referred to as sustainable livelihood. The long-term aims of sustainable livelihood include coping and recovering from unprecedented stresses and shocks in future (Matovu et al., 2024). It also tries to improve the living conditions for the present and future by maintaining and enhancing the assets and capabilities without compromising the natural resources base. In this context, climate change is a threat to achieving the goal of sustainable livelihood. Studies show that climate change is adversely affecting the rural livelihood (Piya et al., 2019), especially agricultural (Dube et al., 2016), livestock (Panthi et al., 2016), and fishing (Badjeck et al., 2010; Muringai et al., 2020). It also affects the informal livelihood in urban areas (Sachikonye et al., 2016; Banu et al., 2023).

South Asia, being the world's most densely populated region, is subject to multiple challenges, including uncontrolled population growth, urbanization, food insecurity, and unemployment. Further, the recent challenges of climate change have aggravated these problems (Singh et al., 2021). Most of the population in these countries is dependent on rural agrarian livelihood or urban informal livelihood (Banu et al., 2023). Therefore, the sustainable livelihood of the large population in South Asia is under threat. Tan et al. (2021) observed South Asia has been the most focused regions in climate change related research publications in the Belt and Road Initiative (BRI) regions. However, there had been no significant review works highlighting the research trends on climate change and sustainable livelihood. Therefore, it is important to understand the current research on climate change and its impact on multi-dimensional livelihood in this region. The present study aims to investigate the available literature to assess the extent of research related to the topic.

Bibliometrics is a widely used method for evaluating and analyzing the progress in scientific research, apart from scoping or systematic reviews (Chen, 2017; Kokol et al., 2021). Analyzing the growth of research, major research issues, most cited papers in the area, national and international contributions, scientific influence, and important figures in the field are the main objectives of a bibliometric analysis (Van et al., 2018). Researchers has applied bibliometric analysis on investigating research trend and direction in climate change and related topics (Díaz Tautiva et al., 2024). However, in order to ensure best practices in metrics-based research assessment, bibliometric studies should always adhere to a set of guidelines (Ferasso and Cherobim, 2017). The current manuscript's author made every effort to make sure the study was thorough, correct, useful, legitimate, and validated by data.

Assessment of research productivity has been performed for climate change as a single topic and also has been performed out for sustainable livelihood as a single topic (Wang et al., 2018; Zhang et al., 2019). Using popular databases and search engines, including Web of Science, Scopus, and Google Scholar databases, a literature search turned up at least ten bibliometric studies on the effects of climate change on different elements of ecology, environment, and adaptation (Hou and Wang, 2021). To the best of the authors' knowledge, no study has, yet, determined research trends, created a network of collaborators, or objectively identified the most prolific authors and publications in the field of climate change and sustainable livelihood in South Asia, whereas many review articles used a subjective method to determine research themes. To find the most promising themes for climate change and sustainable livelihood, this study employed bibliometric analysis to differentiate and identify the numerous alternatives given for detecting research gaps and trends.

Bibliometric analysis of scientific literature on climate change has been published (Hou and Wang, 2021). Similarly, bibliometric analysis of scientific literature on climate change and sustainable development has been published (Baidya and Saha, 2024). None of the published bibliometric investigations analyzed literature discussing the impact of climate change or the presence of climate change and sustainable livelihood. However, for comparative purposes, few bibliometric research on livelihood were discussed. A recently published bibliometric research on Sustainable Livelihood and rural livelihood were carried using Web of Science and analyzed documents (Zhang et al., 2019; Khan et al., 2023) without specifying the keywords used to retrieve the relevant documents.

Recently published study on the impact of Climate change and sustainable development was published and analyzed the research themes of research trends, collaboration networks, and topic evaluations of climate change and sustainable development publications. The PRISMA framework was used to pick 1696 papers from the Scopus database, spanning 1992 to 2022 (Baidya and Saha, 2024). Another one recently published bibliometric research discussed the impacts of climate change on child health by reviewing 1864 related articles extracted from the Web of Science database from 2000 to 2022. The findings emphasize the growing interest in this field of study, as well as the main participants and emerging trends. The results of the study revealed can help guide future research objectives and design effective treatments to protect children from the negative consequences of climate change (Kumar et al., 2024).

This study highlights the major gaps in the body of knowledge in this area and suggests a research agenda for further study of present and upcoming climate change and sustainable livelihood issues. Which publications, authors, and countries have made the greatest contributions to climate change and sustainable livelihood? is one of the study's main research topics. What are the underlying research strands and how have important studies on the topic altered over time? What research gaps exist in the areas of sustainable livelihood and climate change throughout the study period? Which big concerns and trends are arising now or could do so in the years to come? This analysis is solely based on Scopus. Many articles on climate change and sustainable livelihood that have been published throughout the past 20 years can be found in the Scopus database.

The structure of the remaining paper is: Section 1 the concept of climate change and sustainable livelihood, Section 2 provides an explanation of the methodology used, followed by Section 3 cooperation networks tying together different yearly productivity, Asian countries, different institutions, and different scholars. Finally, the conclusion and limitation and further study is discussed in Section 4.

## 2. Literature review

The concept of sustainable livelihood emerged in the sustainable development discourse in 1991 with the work of Chambers & Conway, where they put forward the need to intensify rural economic circulation and non-farm activities to ensure sustainable livelihoods. Rapid industrialization during that time was leading to deteriorating employment, low wages, and consequently furthering the gap between rich and poor, and poverty, they stressed enhanced capability, improving equity, and increasing social sustainability for sustainable livelihood (Chambers and Conway, 1991). The idea was adopted by the United Nations Development Program (UNDP) in 1995 and the Department for International Development (DFID) in 1999, which led to the creation of the Sustainable Livelihood Framework (SLF). SLF is a holistic approach

where individuals and communities use skills, assets, and activities to confront and overcome present crises and improve future skills and assets without compromising natural resources (Merrien, 2013).

In their extensive literature review on migration and sustainable livelihood, Martin & Lorenzen (2016) pointed out that remittance from migration, intensification, and diversification of agriculture are essential for rural sustainable livelihood. Diversification of economic activities at individual and community levels is also an important element in sustainable livelihood (Saha and Bahal, 2015). One such example is enhancement and improvement in the tourism sector. Adopting diversified livelihood strategies in tourism benefits sustainable livelihood (Tao and Wall, 2009). Studies emphasized community participation in tourism for achieving sustainable livelihood (Nepal, 1997; Pasanchay and Schott, 2021). Similarly, the participation of farming communities played a significant role in ensuring sustainable livelihood in Sino-Vietnamese borderlands (Turner, 2013).

Similar cases are observed in South Asia, where climate change adversely affects the livelihood of millions. For example, coastal Bangladesh has been experiencing frequent climate extremities, such as floods, droughts, and cyclones in recent years, which pose increasing threats to agricultural productivity, resulting in higher chances of food insecurities, loans, and debts (Ahmed, 2024). Likewise, climate change has accelerated water scarcity for domestic and agricultural uses, resulting in crop failure and low productivity (Roy et al., 2024). The case study also highlighted that climate change adversely affects human and livestock health, which subsequently amplifies the impact of climate change on sustainable livelihoods. In Nepal, climate change threatens the rural livelihoods of small and subsistence farmers whose livelihoods and income are dependent on natural resources (Karki et al., 2020). Moreover, it pushes small farmers to innovate and adopt alternative adaptive practices, as is observed in West Bengal, India (Datta and Behera, 2022). However, farmers with adequate resources and assets are more capable of alternative adaptive practices than small and subsistence agricultural communities, as observed in Pakistan (Sohail et al., 2022).

In recent years, with the growing threats of climate change and its impact on livelihood, researchers have been concerned about the adverse effects of climate change on sustainable livelihood. The primary impact of climate change is rural agriculture-dependent livelihoods, especially in developing countries. For example, the study by (Dube et al., 2016) shows that climate change negatively affects agricultural productivity and hamper the biodiversity in Africa. As a result, the sustainability of agro-ecological livelihoods is threatened by climate change. Similar cases are observed in coastal Bangladesh, where frequent climate extremities, such as floods, droughts, and cyclones, pose increasing threats to agricultural productivity, resulting in higher chances of food insecurities, loans, and debts (Hoque et al., 2019; Lázár et al., 2015).

Besides agricultural livelihood, climate change is also threatening the sustainability of agro-allied livelihoods, including livestock (Panthi et al., 2016) and fishing (Badjeck et al., 2010; Muringai et al., 2020). In the study by Muringai et al. (2020), climate change has resulted in declining fish production in the small-scale fisheries of Zimbabwe. It led to declining fishery-based revenues, affecting the livelihood of the fishermen's community, and pushing them towards food insecurities. Apart from rural livelihood sustainability, climate change is also affecting urban livelihoods, especially the urban poor with informal economic activities (Sachikonye et al., 2016). The literature review corroborates the inextricable impact of climate change on sustainable livelihoods. However, most studies focus on rural, specifically agricultural livelihoods and their sustainability through different adaptive strategies.

## 3. Data and methodology

### 3.1. Database used

In order to confirm the comprehensiveness of the analysis, it is necessary for an ideal bibliometric study to retrieve relevant documents from many databases. The utilization of numerous databases is appropriate only in instances when there is a limited amount of literature available on the subject under investigation. This study searches the Scopus database for relevant documents. Because the Scopus database contains more research documents in the fields of social science and science than the Web of Science (WoS). According to a review of the literature, the Scopus database is larger and offers more features for data analysis and sorting than PubMed and WoS (Hossain & Batcha, 2021). Scopus's advanced search option was chosen since it enables the creation of extensive and complex search queries. Because bibliometric indicators and literature mapping are challenging to apply to documents retrieved from several sources, bibliometric research typically employ a single database. Scopus provides two search options: a simple search and an advanced search, both of which allow users to create lengthy, intricate search queries that will provide high-quality results. It is possible to search Scopus using phrases found in titles, titles/abstracts, journal names, author names, or affiliation names.

### 3.2. Search strategy

The second issue in any bibliometric investigation is to create a legitimate search query that produces as many papers as feasible while minimizing irrelevant (false-positive) results. The subject term was to use the title/abstract search methodology for keywords related to climate change and sustainable livelihood. In the present research, however, the authors constructed a search query for climate change by reviewing many articles published as "bibliometric analyses" or "systematic reviews". The keywords used included, (TITLE-ABS-KEY ((climate change OR global warming OR climate variability OR greenhouse gases OR carbon dioxide emissions OR climate resilience OR climate action OR climate negotiations OR carbon footprint AND TITLE-ABS-KEY (sustainable livelihood OR livelihood diversification OR rural livelihood OR urban livelihood OR poverty alleviation OR livelihood resilience OR livelihood sustainability)).

### 3.3. Inclusion and exclusion

We had to select the materials based on the set inclusion criteria to obtain those that were pertinent to the topic of climate change and sustainable livelihood. The inclusion criteria for this systematic literature review were multiple. Documents generated between 2004 and 2023 met the initial requirement for inclusion. Prior to 2004, documents were not taken into consideration for the main reason. There were not many records available before to 2004. There are four steps involved in methodically improving the documents: (1) identification, (2) screening, (3) eligibility, and (4) inclusion. Fig. 1 shows a methodical process of document refinement.

In the identification step, it is recommended that the search strategy is described in detail and then proceed to the initial search via the Scopus database. In the screening process, the initial database search yielded a total of 9062 publications.

In the eligibility process, documents generated between 2004 and 2023 met the initial requirement for inclusion. Prior to 2004, documents were not taken into consideration for the main reason. There were not many records available before to 2004. After the 85 publications were excluded because the selection period was 2004–2023. The remaining documents were 8977, 2279 documents excluded because the documents selected Articles & Review. The original search turned up 6698 items in the Scopus database after including articles, reviews, books, conference proceedings, and other research papers. Only articles and

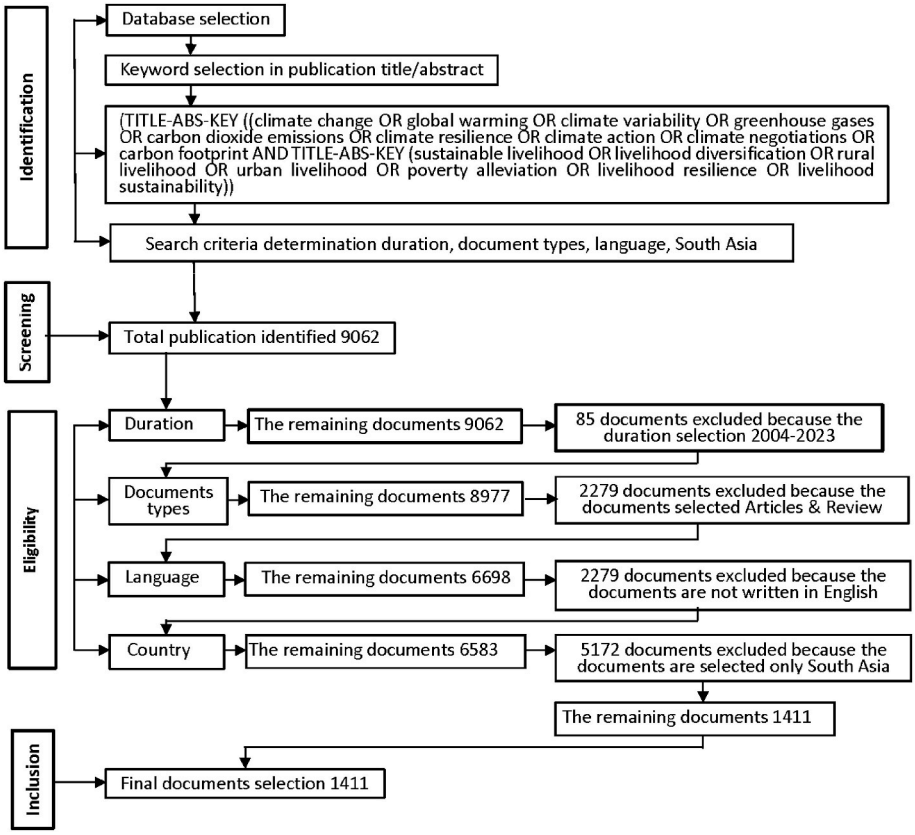


**Fig. 1.** Flowchart of systematic bibliometric analysis.

reviews remain in the impact analysis after these results were filtered. This is because such types of documents go through a rigorous review procedure that confirms the caliber of their content, especially in terms of the findings and conclusions.

In language process, out of the remaining records, 6698 and 2279 were excluded because only English was used in the writing of the paper. The next step, the southern Asian region (India, Bangladesh, Pakistan, Nepal, Sri Lanka, Bhutan, Afghanistan, and Maldives) was chosen by the researchers. Out of the remaining 6583 records, 5172 were excluded because only documents related to South Asia were selected. In the last process inclusion, 1411 articles were considered eligible for the present study.

### 3.4. Compiling the initially statistical data

Research Information System (RIS) and Comma Separated Values (CSV) are two formats that were downloaded from the Scopus database including the eligible papers. According to Naveed et al. (2023), the formats include bibliometric, abstract, and keyword information, among other essential components of data. Furthermore, the raw statistics data, including the number of document citations, author names, document titles, publication years, document sources, publishers, and document categories, could be provided via the data presentation in RIS format using the Perish or Publish (PoP) software.

### 3.5. Data analytical methods

VOS viewer 1.6.14 was used to build visualization maps of major cooccurrence keywords. The most popular articles and citations read by document, author, country, source, and institution might be displayed concurrently in the CSV data presentation created with the VOS viewer software (**Hossain & Batcha, 2021**). The VOS viewer software also showed the prevalence of keywords, clustering, and overall strength link, among other visualizations. Additionally, the researchers used **MS Excel 2019 for tables** and R Studio for data analysis and Mendeley Desktop for records and referencing.

## 4. Results

### 4.1. Distribution of publications by countries/territories

The contributions made by eight different countries filtered in publishing the retrieved documents out of 161 countries. These eight countries (South Asian) were selected for retrieved bibliographic data from 2004 to 2023 on climate change and sustainable livelihood. Fig. 2, Fig. 3 shows eight active countries being named. The sizes and colors indicate the relative ranking of the countries. India, Bangladesh, Pakistan, Nepal, Sri Lanka, Bhutan, and Afghanistan have the highest

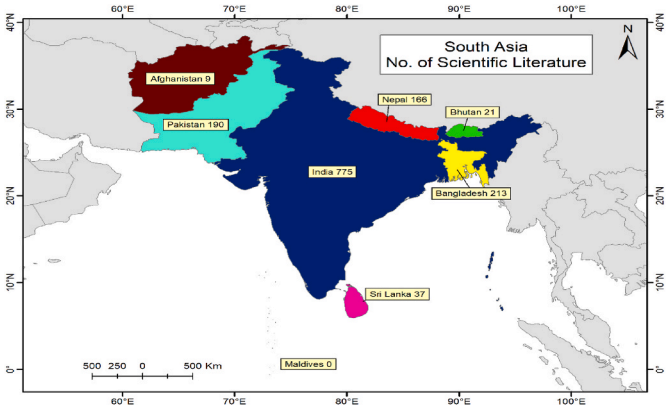


**Fig. 2.** Scientific literature collaboration by Asian country.

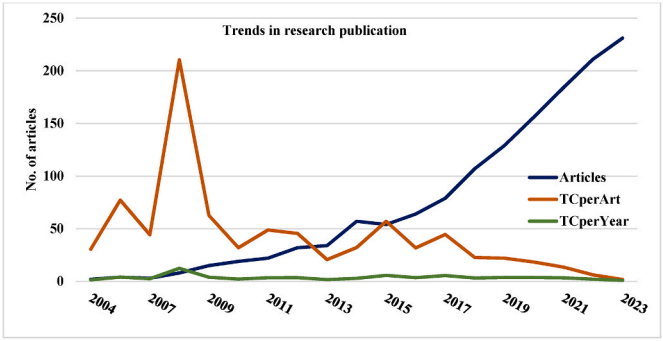


**Fig. 3.** Trends in research publication.

publication output, with 775 papers, 213 papers, and 190 papers, 166 papers, 37 papers, 21 papers, and 9 papers. The results revealed that no one author found for paper contribution form Maldives countries. **Gundimeda (2004)** found the first author from India, who worked on How 'sustainable' is the 'sustainable development objective' of CDM in developing countries like India?

### 4.2. Annual number of publications

As noted above, the final dataset for analysis consisted of 1411 documents related to climate change and sustainable livelihood taken from the Scopus databases. Research articles (n = 1266; 89.72%) and review articles (n = 145; 10.28%) made up most of the materials that were gathered. The documents that were chosen were written in English. The quantity of articles published each year is seen to be a key measure of how a field is developing. The extracted publications, which examine climate change and sustainable livelihood, span the years 2004–2023. Table 1 shows that between 2018 and 2023, the number of published papers increased dramatically. It is evident that the output of publications increased slowly between 2007 and 2017 and then drastically after that. The number of publications pertaining to climate change peaked in 2023 with 231 papers that were listed in Scopus databases. This makes speculating about potential developments in this field in the upcoming years intriguing.

Based on information that has been retrieved, **Payet & Obura (2004)** presented the first study in 2004 that examined livelihood and climate change. The findings indicate that no publications were made in 2005. There is no such explanation in the literature for the roughly one-year lapse in scholarly publication on this subject. The total number of citations per article was at its peak in 2008 and has fluctuated its allure since then. On the other hand, the total citations per year fluctuated across the year from 2000 to 2023.

### 4.3. Distribution by journals

This section highlights the most significant and active journals on climate change and sustainable livelihood. According to the Scopus dataset, 1411 documents were gathered from 542 distinct journals. The distribution of the top ten most relevant journals is shown in Table 2. According to number of publications, the distribution of articles by journal shows that Sustainability is ranked as top with 45 publications, followed by Environment, Development and Sustainability (43), and Climate and Development (34) are the most influential in the databases. Considering all the bibliometric indicators such as number of total citations Regional Environmental Change (1084) journal scored as the top source as presented in Table 2. Whereas considering the h-index and g-index Climate and Development (17) and Sustainability (24) takes 1st place.

The Bradford's Law **(Ravichandra Rao, 1998)** identifies only top thirty journal (Sustainability to Environmental Challenges in Fig. 5) as the core sources (zone 1) of climate change and sustainable livelihood research. representing 30 of journals covered by 470 of articles (see Fig. 4). The second largest zone, 116 journals, yields the next 477 articles, and the third largest zone, 396 journals, yields 8118 464 articles.

### 4.4. Analysis of highly productive and influential author

Table 3 shows the top ten most-productive authors of climate change and sustainable livelihood-related literature. Researchers from India, Bangladesh, Nepal, and Pakistan are dominated in the table. In total, 4876 author names participated in publishing the infection-related literature and single author has published 98 articles. Pandey, R, Alam GMM, and Singh, C are the three authors who have contributed most prolific author. Furthermore, Pandey, R was the most prolific contributing author in this field of study with 16 publications, 962 citations, 12 h-index, and 17. Followed by Alam GMM (number of publications 14, total citations 636, h-index 9, g-index 14) and Sing, C (number of publications 13, total citations 488, h-index 12, g-index 13). It reveals that the researcher's performance on South Asian countries, above the table four countries are listed except Sri Lanka, Bhutan, Afghanistan, and Maldives.

### 4.5. Collaboration network of author

The network of author collaboration is critical for understanding

**Table 1**
Annual number of publications over years.

| Year | Articles | Citation Per Article | Citation Per Year |
|---|---|---|---|
| 2004 | 2 | 30.5 | 1.45 |
| 2006 | 4 | 77.25 | 4.07 |
| 2007 | 3 | 44.33 | 2.46 |
| 2008 | 8 | 210.38 | 12.38 |
| 2009 | 15 | 62.6 | 3.91 |
| 2010 | 19 | 32 | 2.13 |
| 2011 | 22 | 48.77 | 3.48 |
| 2012 | 32 | 45.5 | 3.5 |
| 2013 | 34 | 20.65 | 1.72 |
| 2014 | 57 | 32.12 | 2.92 |
| 2015 | 54 | 57.02 | 5.7 |
| 2016 | 64 | 31.81 | 3.53 |
| 2017 | 79 | 44.51 | 5.56 |
| 2018 | 107 | 22.7 | 3.24 |
| 2019 | 129 | 22.02 | 3.67 |
| 2020 | 156 | 18.33 | 3.67 |
| 2021 | 184 | 13.52 | 3.38 |
| 2022 | 211 | 6.2 | 2.07 |
| 2023 | 231 | 1.77 | 0.88 |

**Table 2**
Distribution of research publication output in iournals.

| Sl. No. | Journal | Number Publications | Total Citations | h-index | g-index |
|---|---|---|---|---|---|
| 1 | Sustainability | 45 | 658 | 14 | 24 |
| 2 | Environment, Development and Sustainability | 43 | 471 | 15 | 20 |
| 3 | Climate and Development | 34 | 784 | 17 | 27 |
| 4 | Environmental Science and Pollution Research | 23 | 316 | 10 | 17 |
| 5 | Current Science | 22 | 436 | 10 | 20 |
| 6 | Regional Environmental Change | 19 | 1084 | 16 | 19 |
| 7 | Natural Hazards | 19 | 394 | 9 | 19 |
| 8 | Science of the Total Environment | 18 | 543 | 14 | 18 |
| 9 | Environmental Monitoring and Assessment | 17 | 324 | 10 | 17 |
| 10 | Ecological Indicators | 15 | 1007 | 14 | 15 |

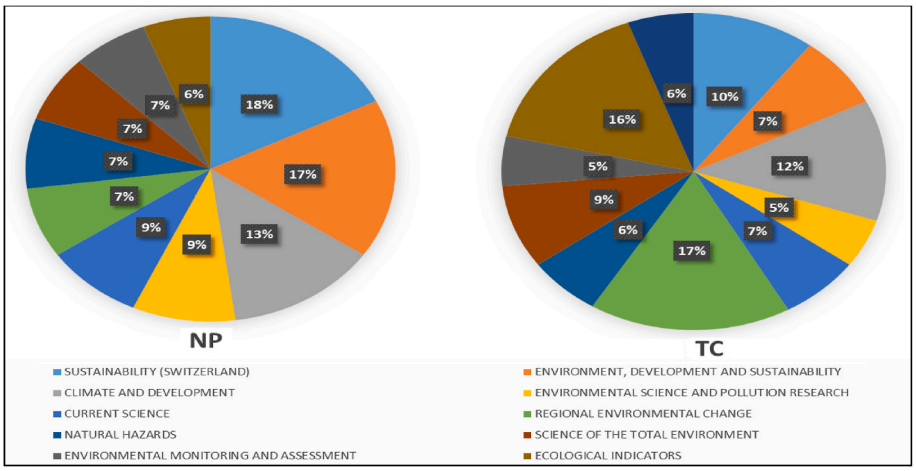


**Fig. 4.** Contribution by journals.

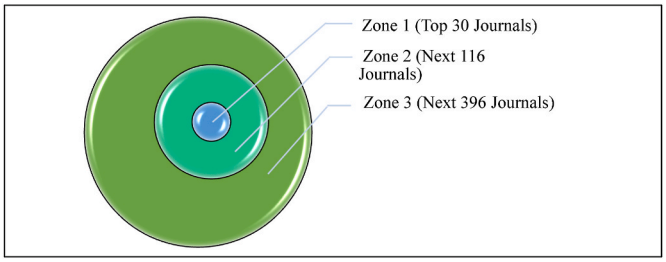


**Fig. 5.** Bradford's Law zone.

research direction in a variety of subject topics. The collaboration frequently leads to the establishment of academic centres, which promote the growth and future expansion of the study topic (**Hu et al., 2020**). The co-author network in Fig. 6 depicts the intellectual links between scholars by country. Fig. 6 illustrates which author has contributed the most and received the most citations in climate change and sustainable livelihood scientific production based on co-authorship. The size of the circle represents the number of publications by an author. The intensity of collaboration is assessed by line thickness and circle spacing. The number of documents published by authors from two or more countries determines the overall strength of a country's relationships. From 4876 distinct authors, and with the limit of an author's minimum number of papers being 5 and author's minimum number of citations being 3 and 11 clusters, met the threshold point.

In climate change and sustainable livelihood research, the four main networks emerged which is led by Pandey, R (maroon cluster), Sarkar, S (green cluster), Kumar, A (cyan cluster) and Pandey, VP (purple cluster). Within these authors, research into climate change and sustainable livelihood has increased significantly. In the collaboration network most of the authors belong to India, Bangladesh, and Pakistan. Authors in maroon cluster are concentrating their efforts on global warming and climate change are current dangers to Pacific Island states. The authors also observed on global warming and the effects of sea level rise, the vulnerability of coastal offshore, shoreline, and oceanic ecosystems must be addressed immediately (**Griggs and Reguero, 2021**; **Lu et al., 2018**).

### 4.6. *Most impactful documents*

The study of documents determines the intellectual structure of a knowledge domain by assessing the quantity and authority of cited writings. According to Scopus citation statistics, the top 10 cited documents are shown in Table 4, with total citations ranging from 771 to 246. In particular, **Zomer et al. (2008)**, **Xu et al. (2009)**, and **Rockström et al. (2017)** received 771, 695, and 616 total citations respectively and were ranked as the top three most cited articles (Table 4). According to **Zomer et al. (2008)**, carbon storage in terrestrial ecosystems through afforestation and reforestation has the potential to significantly mitigate climate change. **Xu et al. (2009)** discovered that

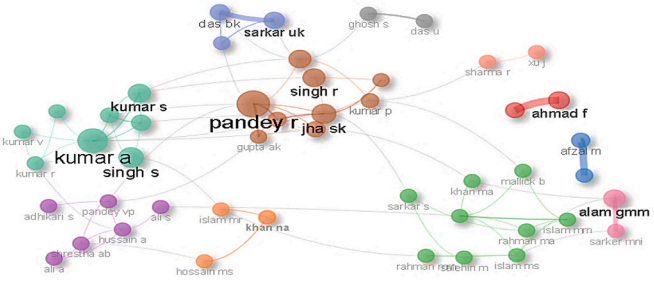


**Fig. 6.** Collaboration network by leading authors.

**Table 3**
Top 10 most productive and influential author.

| Sl. No. | Author | Organization | Publications | Citations | h-index | g-index |
|---|---|---|---|---|---|---|
| 1 | Pandey, R | Indian Council of Forestry Research and Education, Dehradun, India | 16 | 962 | 12 | 17 |
| 2 | Alam, GMM | Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh | 14 | 636 | 9 | 14 |
| 3 | Singh, C | Indian Institute for Human Settlements, Bengaluru, India | 13 | 488 | 12 | 13 |
| 4 | Sarkar, UK | National Bureau of Fish Genetic Resources, Lucknow, India | 11 | 69 | 3 | 8 |
| 5 | Ahmad F | World Agroforestry Centre, New Delhi, India | 11 | 114 | 8 | 10 |
| 6 | Goparaju L | Vindhyan Ecology and Natural History Foundation, Mirzapur, India | 11 | 100 | 7 | 10 |
| 7 | Pandey VP | Institute of Engineering, Kathmandu, Nepal | 10 | 356 | 8 | 11 |
| 8 | Das, BS | Central Inland Fisheries Research Institute, Kolkata, India | 10 | 70 | 3 | 8 |
| 9 | Ahmad, D | COMSATS University Islamabad, Vehari, Pakistan | 10 | 339 | 7 | 10 |
| 10 | Afzal, M | Preston University, Islamabad, Pakistan | 10 | 150 | 7 | 11 |

**Table 4**
Most impactful documents.

| Sl. No. | Author | Source | Document | Citations | TC per Year |
|---|---|---|---|---|---|
| 1 | Zomer et al. (2008) | Agriculture, Ecosystems and Environment | Climate change mitigation: A spatial analysis of global land suitability for clean development mechanism afforestation and reforestation | 771 | 45.35 |
| 2 | Xu et al. (2009) | Conservation Biology | The Melting Himalayas: Cascading Effects of Climate Change on Water, Biodiversity, and Livelihoods | 695 | 43.44 |
| 3 | Rockström et al. (2017) | AMBIO | Sustainable intensification of agriculture for human prosperity and global sustainability | 616 | 77 |
| 4 | Cooper et al. (2008) | Agriculture, Ecosystems and Environment | Coping better with current climatic variability in the rain-fed farming systems of sub-Saharan Africa: An essential first step in adapting to future climate change? | 575 | 33.82 |
| 5 | Biggs et al. (2015) | Environmental Science and Policy | Sustainable development and the water–energy–food nexus: A perspective on livelihoods | 572 | 57.2 |
| 6 | Creutzig et al. (2015) | GCB Bioenergy | Bioenergy and climate change mitigation: an assessment | 479 | 47.9 |
| 7 | Vermeulen et al. (2012) | Environmental Science and Policy | Options for support to agriculture and food security under climate change | 328 | 25.23 |
| 8 | Shrestha & Aryal (2011) | Regional Environmental Change | Climate change in Nepal and its impact on Himalayan glaciers | 311 | 22.21 |
| 9 | Tanner et al. (2015) | Nature Climate Change | Livelihood resilience in the face of climate change | 290 | 29 |
| 10 | Subba Rao (2006) | Environmental Geology | Seasonal variation of groundwater quality in a part of Guntur District, Andhra Pradesh, India | 246 | 12.95 |

climate change will have environmental and social consequences that will most likely raise uncertainty in water resources and agricultural production for human populations throughout Asia. The citations per year highest received by **Rockström et al. (2017)** on "Sustainable intensification of agriculture for human prosperity and global sustainability".

### 4.7. Top frequent author's keywords

In general, keywords serve to summarize the contents of a research publication while also focusing and refining the research's essential concepts. Fig. 7 depicts co-occurrence analysis, in which a pair of words appears in the author's keyword list or even in the body of the entire document within and across a particular set of published articles. An overview of the study areas in the subject of climate change and sustainable livelihoods during a specific period is given by the co-occurrence matrix or co-occurrence distribution. It adds to our understanding of the field's conceptual framework and represents the knowledge network of its scholars. The study authors used VOS viewer to visualize the links and co-occurrences of researchers chosen keywords of 54 out of 3590. The mapping of network visualization of co-occurrence of author's keywords within the period of 2004–2023 resulted in seven clusters, as depicted in Fig. 7. In the map, each keyword is represented by a circle. The diameter indicates the number of links to other keywords. Thus, a wider circle indicates more ties to other keywords. The thickness of the line between the two circles shows the frequency with which the keywords appear together.

Table 5 displays the top 54 keywords in climate change and sustainable livelihood publications that appear at least ten times. In the map, the keyword "climate change" in green color has the largest node size (n-605 occurrences). The second largest node size was "adaptation strategies" in five cluster (n- 189), and "livelihoods" in second cluster (n-166). The map of the most frequent author's keywords included the names of the following countries/regions: Bangladesh, India, Nepal, Pakistan, South Asia, Odisha, and Punjab. The researchers found the largest link strengths were "climate change," and "adaptation". **Rana (2020)** shown that adaptation and vulnerability are closely associated with the network of climate change and integrated resilience.

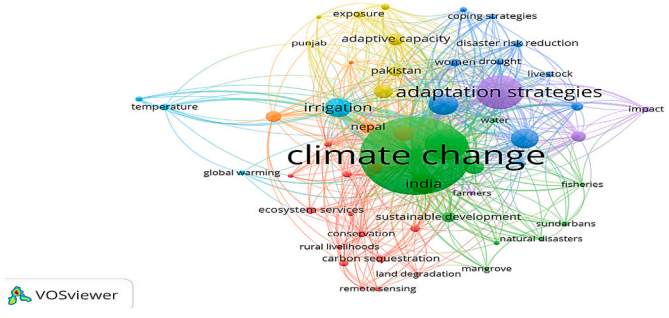


**Fig. 7.** Network visualization map of top 64 author's frequency keywords (≥10 times).

The red cluster (cluster 1) is highlighted by keywords linked to both environmental sustainability and agricultural methods, including "food security," "sustainability," "carbon sequestration," and "agroforestry." The frequent occurrence and high link strength of these terms highlight the importance of environmental stewardship and sustainable agriculture in mitigating climate change in South Asia. For example, the term "food security" has 63 occurrences and a link strength of 122, indicating that it is important to focus on maintaining dependable food systems in the event of climate disturbances (Matthews et al., 2022).

The blue cluster (cluster 2) is primarily composed of socio-economic terms, such as "resilience," "livelihoods," and "climate change." The high frequency of "Climate Change" (605 occurrences, link strength 878) illustrates how climate change has a widespread impact on many facets of South Asian life. The existence of "resilience" (56 occurrences, link strength 115) emphasizes the need of establishing adaptable abilities for sustaining livelihood across evolving environmental circumstances (Adger, 2000).

The blue cluster (cluster 3) occurrences keywords, including "disaster risk reduction," "bangladesh," and "vulnerability," highlight how vulnerable the people of south Asia are, especially in nations like Bangladesh that are extremely vulnerable to the effects of climate change. The considerable emphasis on "vulnerability" (99 occurrences, link strength 231) reflects continued worries regarding communities' capacity to endure and bounce back from climate-related disruptions.

The yellow cluster (cluster) 4 shows strategies for adaptation, with keywords including "climate change adaptation" and "adaptive capacity." The frequent occurrence of "adaptation strategies" (189 occurrences, link strength 394) emphasizes the importance of viable climate change mitigation methods, particularly in areas such as Pakistan and Punjab where climatic problems are severe.

This cluster 5 focusses (purple cluster) on the human aspect of climate change, with keywords like "perceptions" and "impact." The presence of "perceptions" (37 occurrences, link strength 75) emphasizes

**Table 5**
Top 64 Author's keywords on climate change and sustainable livelihood research.

| Sl. N. | Keyword | Frequency | Link Strength | Cluster | Sl. N. | Keyword | Frequency | Link Strength | Cluster |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Food Security | 63 | 122 | 1 | 2 | Bangladesh | 89 | 168 | 3 |
| 2 | Sustainability | 40 | 62 | 1 | 3 | Migration | 27 | 58 | 3 |
| 3 | Carbon Sequestration | 23 | 32 | 1 | 4 | Women | 26 | 51 | 3 |
| 4 | Ecosystem Services | 22 | 23 | 1 | 5 | Disaster Risk Reduction | 21 | 45 | 3 |
| 5 | Biodiversity | 21 | 39 | 1 | 6 | Drought | 19 | 38 | 3 |
| 6 | Agroforestry | 20 | 33 | 1 | 7 | Livestock | 17 | 22 | 3 |
| 7 | South Asia | 19 | 39 | 1 | 8 | Poverty | 15 | 36 | 3 |
| 8 | Conservation | 19 | 20 | 1 | 9 | Coping Strategies | 15 | 25 | 3 |
| 9 | Mitigation | 15 | 40 | 1 | 10 | Risk | 13 | 29 | 3 |
| 10 | Remote Sensing | 13 | 16 | 1 | 1 | Climate Change Adaptation | 54 | 87 | 4 |
| 11 | Rural Livelihoods | 12 | 19 | 1 | 2 | Adaptive Capacity | 47 | 98 | 4 |
| 12 | Development | 11 | 18 | 1 | 3 | Pakistan | 41 | 80 | 4 |
| 13 | Sustainable Agriculture | 11 | 14 | 1 | 4 | Exposure | 21 | 65 | 4 |
| 14 | Gis | 10 | 15 | 1 | 5 | Sensitivity | 18 | 56 | 4 |
| 15 | Land Degradation | 10 | 14 | 1 | 6 | Punjab | 11 | 27 | 4 |
| 1 | Climate Change | 605 | 878 | 2 | 7 | Livelihood Vulnerability Index | 10 | 19 | 4 |
| 2 | Livelihoods | 166 | 288 | 2 | 1 | Adaptation Strategies | 189 | 394 | 5 |
| 3 | India | 88 | 147 | 2 | 2 | Perceptions | 37 | 75 | 5 |
| 4 | Resilience | 56 | 115 | 2 | 3 | Impact | 16 | 28 | 5 |
| 5 | Sustainable Development | 34 | 44 | 2 | 4 | Farmers | 11 | 21 | 5 |
| 6 | Sundarbans | 13 | 22 | 2 | 1 | Irrigation | 85 | 172 | 6 |
| 7 | Water | 11 | 28 | 2 | 2 | Temperature | 19 | 34 | 6 |
| 8 | Natural Disasters | 11 | 24 | 2 | 3 | Global Warming | 13 | 11 | 6 |
| 9 | Odisha | 11 | 19 | 2 | 4 | Precipitation | 13 | 24 | 6 |
| 10 | Fisheries | 10 | 26 | 2 | 1 | Nepal | 42 | 67 | 7 |
| 11 | Mangrove | 10 | 15 | 2 | 2 | Himalayas | 40 | 56 | 7 |
| 1 | Vulnerability | 99 | 231 | 3 | 3 | Mountains | 10 | 23 | 7 |

the relevance of studying how communities perceive climate hazards and how this affects their readiness to embrace adaptation actions.

Cluster 6 in aqua color focusses on climate factors and water resources, as seen by phrases such as "irrigation," "temperature," and "precipitation." The prominence of "irrigation" (85 occurrences, link strength 172) emphasizes the importance of water management in maintaining productivity in agriculture in the face of climate change (Singh et al., 2021).

The focal points of cluster 7 (brown cluster) are geographic regions, including "Nepal," "Himalayas," and "Mountains." "Nepal" (42 occurrences, connection strength 67) and "Himalayas" (40 occurrences, link strength 56) are mentioned frequently, which indicates a concentrated interest in comprehending the effects of climate change in these environmentally delicate and fragile areas **(Sharma & Tomar, 2010).**

**Sub topics:** The key sub-topics under "climate change and sustainable livelihood" in South Asia are environmental sustainability, agricultural methods, and socioeconomic resilience. Socio-economic resilience, which includes ideas like "livelihoods," "resilience," and "vulnerability," is another important subtopic. This cluster highlights how crucial it is for communities to build their adaptive skills in order to endure and recover from shocks brought on by climate change. The prevalence of phrases like "disaster risk reduction" and "climate change adaptation" indicates the continuous attempts to safeguard South Asian communities that are at risk from climate change, especially in regions like Bangladesh and the Himalayan region. These sub-topics emphasize the need of establishing stable food systems and preserving biodiversity in the face of climate changes, both of which are vital for sustaining regional livelihoods.

### 4.8. Most research productivity by organization

Numerous institutions are involved in researching on climate change and sustainable livelihood. Table 6 shows the top ten active organizations. The analysis revealed that the Indian Council of Agricultural Research (n- 65 articles) and Tribhuvan University (n- 46 articles) were the top research institutions in Asia, as per selected topics. The International Centre for Integrated Mountain Development ranked first for citations and h-index (n- 2967 and 16). Overall, most of the institutions belonged to India, Bangladesh, and Nepal. Noticeably, Chinese Academy of Science (China), and University of Southern Queensland (Australia) are two top productive institutions outside of South Asia.

**Table 6**
Research productivity by organizations/institutes.

| Sl. No. | Organization/Country | Publications | Citation | h-index |
|---|---|---|---|---|
| 1 | Indian Council of Agricultural Research, India | 65 | 745 | 15 |
| 2 | Tribhuvan University, India | 46 | 820 | 16 |
| 3 | International Centre for Integrated Mountain Development, Nepal | 44 | 2967 | 27 |
| 4 | University of Dhaka, Bangladesh | 31 | 977 | 15 |
| 5 | Chinese Academy of Sciences, China | 31 | 619 | 12 |
| 6 | Indian Institute of Technology Kharagpur, India | 29 | 441 | 9 |
| 7 | University of Chittagong, Bangladesh | 26 | 225 | 11 |
| 8 | Bangabandhu Sheikh Mujibur Rahman Agricultural University, Bangladesh | 25 | 928 | 14 |
| 9 | ICAR - Indian Agricultural Research Institute, India | 25 | 233 | 9 |
| 10 | University of Southern Queensland, Australia | 25 | 898 | 14 |

## 5. Discussions

The research on changing global climate as an independent discipline started almost a century ago **(Tan et al., 2021)**, where the focus of the discussion was limited to the causes and effects of climate change **(Klingelhöfer et al., 2020)**. The interdisciplinary nature of the subject, especially its relation to sustainable livelihood, was explored much later with the dawn of the twenty-first century. The emergence of Millennium Development Goals (MDGs) in 2000 and Sustainable Development Goals (SDGs) in 2015 led researchers to expand climate change research into multiple disciplines and correlate it with different SDGs **(Hossain & Batcha, 2023)**. The present study finds that the research works highlighting the relationship between climate change and sustainable livelihood started to rise in 2012. These terms are defined as the

requirement that the environmental dimension be taken into account in all decision-making (regardless of the relevant discipline) and that there be a legal framework that allows action to be taken if this dimension is overlooked (Bowles et al., 2014; Shackleton and Shackleton, 2012; Maikhuri et al., 2013).

Climate change threatens sustainable livelihoods, especially in regions like South Asia, where large populations do not have adequate quality of life and livelihood. As the disadvantageous communities in this region rely on scarce natural resources for their sustainability climate change and its adversaries have aggravated the challenges of quality of life (Estoque et al., 2019; Albouy et al., 2016) and livelihood (Thakur and Bajagain, 2019). Although the research on climate change focusing on South Asia has increased recently, there is a lack of adequate research looking into the relationship between climate change and sustainable livelihood in this region. Hence, this bibliometric analysis tried to investigate the current state of research on the relationship between climate change and sustainable livelihood in South Asia. By identifying major themes, trends, and gaps in the literature, this study helps to improve understanding of the present state of knowledge in this critical field.

While analyzing the available scientific literature on the topic, we explored the Scopus database and found over 1411 documents related to climate change and sustainable livelihood published in the last two decades. Noticeably, over one-tenth of these documents are review articles. It is evident from the findings of Tan et al. (2021) that South Asia has been one of the most focused regions for climate change-related publications in the BRI regions. The study concerning South Asia accounted for 3.4% of the total global climate-related publications between 2013 and 2018 (Tan et al., 2021).

Within the region, India dominates other countries in research publications, followed by Bangladesh and Pakistan. The present study observed that Maldives don't have any publications on the topic. However, small island nations like Maldives are most vulnerable to climate change and related adversaries (Walshe and Stancioff, 2018). Although the research on the topic started in 2004 with two documents, the analysis also found that the annual publication output significantly increased only after 2018 (107 publications). Hence, the discussion on climate change and sustainable livelihood is new in South Asia, and there is a scope for research in the upcoming years, as the trend suggests (Fig. 2).

Furthermore, a growing number of academic journals have been actively addressing this significant issue by focusing on the investigation, analysis, and mitigation of the consequences of climate change on economic, energy environment, agriculture, etc. Various bibliometric studies that have previously been undertaken and addressed the evolution of climate change research at the worldwide level have confirmed the reality of increasing interest in climate change research (Chen et al., 2023; Hou and Wang, 2021; Sweileh, 2020).

The Bradford zone analysis revealed the top 30 journals in Zone 1 cover one-third of the total documents analyzed. Among them, Sustainability leads with 45 publications, followed by Environmental Development and Sustainability with 43 publications. However, two journals, i.e., Regional Environment Change by Springer and Ecological Indicators by Elsevier, were the most impactful, with 1084 and 1007 citations, respectively. It is evident from the analysis that few journals dominate climate change and sustainable livelihood research. The number of publication sources (journals) addressing climate change has grown significantly over time. The fact that the most prolific sources in climate change research have impact factors demonstrates the relevance of this study topic to the scientific community. Prominent publishers like Elsevier, Springer, Sage, Taylor & Francis, etc. publish most of these publications. Their identification is a huge benefit for identifying highly reliable publications (Haunschild et al., 2016).

Among the authors, researchers from India, Bangladesh, and Pakistan dominate in this context. The study found that six of the ten most productive authors are from India. The number of documents and citations is also determined by the number of authors per document and the level of global academic collaboration, both of which were high for the researched issue (Chen et al., 2023; Hou and Wang, 2021).

The current study showed that India had higher research output than China when research productivity was normalized by income and population size. India is highly populated and despite its economic growth it failed to achieve the target set in MDG regarding the reduction of hunger. The analysis revealed four main strong collaborative networks comprising authors from India, Bangladesh, and Pakistan. Overall, the dominance of researchers and institutes of three countries, i.e., India, Bangladesh, and Pakistan, in the research output can be attributed to the adoption of climate budgeting in public finances in recent years (Arora, 2023). Accordingly, high rates of scientific collaboration on climate change between the Arab world (Zyoud and Fuchs-Hanusch, 2020) and Belt and Road Initiative (Tan et al., 2021).

Based on the clusters of terms in our term map, we have identified the following main fields of climate change research: environmental sustainability and agricultural, strategies for adaptation, socio-economic terms, disaster risk reduction, human aspect of climate change, climate factors and water resources, and geographic regions. The largest cluster grouped terms related to "climate change," and "impact," which were the most occurring title words of the articles dealing with climate change research published from 1980 to 2019 in the study (Chen et al., 2023). Much emphasis has been put on understanding and conceptualizing linkages between climate change and sustainable development livelihood (Zhang et al., 2019; Chenjia et al., 2018). The most frequent keyword "climate change" found in this study is consistent with bibliometric analysis on climate change in BRI regions (Tan et al., 2021) and climate change in the Arab world literature (Zyoud and Fuchs-Hanusch, 2020).

Similarly, the study also observed that of the ten most productive institutes, four are in India, and three are in Bangladesh. Indian Council of Agriculture Research has the greatest number of publications (65). A similar pattern was observed in collaborative networks. Another noticeable finding of the present study is that two non-South Asian institutes, i.e., the Chinese Academy of Science (China) and the University of Southern Queensland (Australia), contributed significantly to climate change and sustainable livelihood in South Asia research. We observed that at least one of the authors in the collaborative networks of these documents was from South Asian countries. Besides, China's geopolitical interest in influencing South Asia is another reason Chinese institutes are productive on climate change and sustainable livelihood research in the region. The previous study, the analysis found that the University of London and University of California System were the prolific top research institutions in the world (Rana, 2020).

## 6. Research frontiers

Keywords define the central themes of the research articles. This bibliometric analysis looked deep into a total of 3590 keywords of all the articles and encountered 64 keywords with more than ten occurrences. Keywords having continuous increases in frequencies over the year determine the research frontier in the respective fields (Hou and Wang, 2021). In this context, we identified and categorized the most frequent keywords which define the research frontiers in climate change and sustainable livelihood research in South Asia. Among the countries, India emerged the most, followed by Bangladesh, Nepal, and Pakistan. It correlates with most research findings on the topic done by Indian institutes. The livelihood keyword largely focused on agriculture, farmers, rural livelihoods, livestock, and fisheries. Apart from the term climate change and livelihood (including livelihoods), the keyword bursting analysis identified adaptation, adaptive capacity, and adaptation strategies as the most frequent keywords. It indicates that most researchers are concerned about alternate adaptive strategies for sustainable livelihood to overcome climate change impacts. It allowed us to deduce the broad aspects of the impact of climate change on sustainable livelihood.

Most of the documents acknowledged that climate change threatens the objective of a sustainable livelihood globally, especially in South Asia. The impact of climate change on ecosystems, agriculture, and water resources, all of which affect millions of people's lives in the region, are important themes in these documents. The changing climate is negatively affecting rural livelihoods, particularly those related to agriculture, livestock, and fisheries. The livelihood is also related to climate change-induced poverty and migration. The keyword synthesis also reveals the adoption of resilience-building techniques and adaptive strategies to maintain livelihoods in the face of climatic (**Sarkar et al., 2019**; **Malhi et al., 2021**).

Another emerging subject in the literature is how metropolitan areas and the industrial sector affect sustainable livelihoods and contribute to climate change (**Saikanth et al., 2023**; **Fekete, 2023**). Keywords like adaptation techniques and coping strategies emphasize effective and promising measures, instruments, and technology. Achieving effective mitigation and adaptation will require adjustments to institutions, technology, individual behaviour, agricultural systems, and socioeconomic systems. Enhancing the communication between scientists and decision-makers at all societal levels is essential to bring changes. In summary, current patterns indicate that climate change and sustainable livelihood are a warning of the disastrous implications of climate change consolidation over the world. To ensure the sustainability of future generations, all citizens must make an environmental commitment.

## 7. Conclusion

The present study is the first bibliometric analysis of the research discourse on climate change and sustainable livelihood in South Asia. The main objective of this paper was to use text mining and scientific mapping technologies to produce a bibliometrics study of this extensive body of work. Because of this, unlike the conventional systematic reviews that investigate causal relationships, this paper expands on prior assessments by mapping existing science and offering performance analysis. The study analyzed the international research trends followed by researchers in the context of climate change and sustainable livelihood from the beginning of the twenty-first century until 2023. For this, it analyzed over 1400 articles from the Scopus database and concluded that the number of publications has increased in recent times as concerns over climate change have grown. The authors from India had the most publications, followed by those from Bangladesh and Pakistan. The keyword analysis indicates most research articles focused on climate change adaptation, livelihood adaptation, vulnerability, and sustainability.

Overall, this study highlights the major gaps in the body of knowledge in this area and suggests a research agenda for further study of present and upcoming climate change and sustainable livelihood issues. It identified the key players, research themes, and research gaps and the investigation furnished baseline data in this domain for scholars and policymakers. This bibliometric analysis offers insightful information about the state of research on sustainable livelihood and climate change in South Asia worldwide. It establishes the framework for upcoming multidisciplinary research and policy initiatives targeted at fostering resilience and providing sustainable livelihoods in the face of climate change by highlighting patterns, topic concentrations, and gaps in the literature. Furthermore, this will help scholars and professionals in considering the most reliable sources of research articles in bibliometric analysis.

### *7.1. Limitations and future directions*

Searching the Scopus database showed at least 1411 research related to climate change and sustainable livelihood. However, none was on sustainable livelihood under the umbrella of climate change. Therefore, the present study is the first to explore this topic from a bibliometric point of view. The present research had a few limitations. The researchers employed all potential and prospective keywords for best validity. However, missing data is still a possibility. Another limitation concerns the keywords used in the search query. The author attempted to be as comprehensive as possible, using all keywords listed in the literature that are important to climate change and sustainable livelihood. However, it is still possible to overlook some terms. Lastly, the bibliometric analysis relies on a single database, i.e., Scopus, to find relevant documents. Although Scopus is one of the largest databases, it does not include many peer-reviewed publications from Asia, Africa, Latin America, and Eastern Europe.

As a result, documents published in unindexed journals were missed. This may underestimate the output of specific countries, global areas, authors, and organizations. It applies to practically all bibliometric investigations. Other databases, such as Google Scholar, Dimension, and Web of Science, may be employed in future research to use varied review approaches to produce a more comprehensive quantitative and qualitative summary of the research front on this topic. Furthermore, future research may concentrate on the role of technology and innovation in promoting sustainable livelihoods, as well as the significance of local knowledge and community participation in adaption efforts. The continued difficulties of climate change, together with the desire for sustainable development, will continue to motivate study and policy activities in South Asia.

## CRediT authorship contribution statement

**Humood Fahm Albugami:** Writing – review & editing, Validation, Funding acquisition, Dr. **Md Kaikubad Ali:** Conceptualization. **Saddam Hossain:** Writing – original draft, Software, Methodology, Conceptualization. **Hanan Zafar:** Formal analysis, Data curation, Dr. **Naved Ahmad:** Writing – review & editing, Software, Funding acquisition.

## Contributors

It is acknowledgement that all the authors contributed equally.

## Funding

The authors extend their appreciation to the Deanship for Scientific Research, King Faisal University, Saudi Arabia for funding (Project number: KFU242266 to HAB).

## Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: NO Humood Fahm Albugami reports article publishing charge. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Acknowledgements

The authors extend their appreciation to the Deanship for Scientific Research, King Faisal University, Saudi Arabia for funding (Project number: KFU242266 to HAB). Naved Ahmad also thanks AlMaarefa University for supporting this research.

## Data availability

Data will be made available on request.

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