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Bibliometric analyses of climate change study in Central Asia between 1990–2022

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Abstract: Climate change is an important issue in all areas of research. Central Asia is one of the most sensitive regions to the effects of climate change. Several studies were conducted in arid and semi-arid regions of Central Asia to provide a sustainable future in the region. To gain a better understanding of the study domains, bibliometric analyses were performed on climate change papers published in Central Asian countries. All publications between 1990–2022 were downloaded and reviewed from the Scopus database. Results showed a significant increase in publication between 2011 and 2022. Kazakhstan, China, and Uzbekistan are leading countries with the number of top institutions, which are publishing research related to climate change issues. Nearly 40% of citations were attributed to publications in *Nature Climate Change* and *Philosophical Transactions of the Royal Society B: Biological Sciences*.

Keywords: climate change; review; bibliometric method; trend of publication; Scopus; Central Asia.

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Biographical notes: Makhliyo Nasirova is a PhD student and a Professor Assistant at the EcoGIS Center of the Tashkent Institute of Irrigation and Agricultural Mechanization Engineers, National Research University, where she teaches the basics of Geographic Information Systems in Environmental Science. Her research focuses on evaluating climate change's impact on natural resources. She is a co-author of the chapters 'Surface water resources' and 'Local and national institutions and policies governing water resources management' in the book *The Aral Sea Basin Water for Sustainable Development in Central Asia*. Her research interests include downscaling of climate data, mapping of climate indicators and crop modelling.

1 Introduction

Central Asia is one of the vulnerable regions to the impacts of climate change (Djumaboev et al., 2019) and water scarcity is predicted (IPCC, 2014; Rakhmatullaev and Abdullaev, 2014) in the region where changes in flow dynamics in transboundary and local rivers have been elaborated due to the growth of irrigated agriculture and population (Kodirov and Gapparov, 2020; Abuduwaili et al., 2019; Cherednichenko et al., 2017; Rumbaur et al., 2015).

Furthermore, the comprehensive Intergovernmental Panel on Climate Change (IPCC) assessment reports have been published on a regular basis since 1988, identifying findings of the consequences of climatic change to the scientific community (IPCC, 2017). As a result, more researchers are attempting to study climate change issues at both the local (Hamidov et al., 2020; Mamadjanova and Leckebusch, 2022), and regional levels (Xenarios et al., 2018; Liu et al., 2020). Since impacts are linked with the geographic and climatic characteristics of the regions (Agrawal, 2008), several studies were conducted in arid and semi-arid regions of Central Asia to provide a sustainable future in the region (Sommer et al., 2013; Rakhmatullaev and Abdullaev, 2014; Gulakhmadov et al., 2020).

Assessment of climate change based on rainfall-runoff erosivity (Gafforov et al., 2021) and groundwater response to climate change (Hamidov et al., 2020), as well as the role of political institutions and society in the determinants of climate change policies were studied with the cooperation of international experts (Obydenkova and Salahodjaev, 2017). While irrigated agriculture, adaptive capacity, and collaboration in water management are important for the region's economy (Kuchkarov, 2018), many studies report on the region's limited adaptive capacity and suggest cooperation on extreme events as well as collective action in water management (Stucker et al., 2012; Stulina and Eshchanov, 2013; Barrett et al., 2017; Siegfried et al., 2012) and in land using (Christmann et al., 2014).

In order to assess the risk of formation of droughts and wet events for the administrative decision-making in the sectors of water management, energy, agriculture and other economic sectors, in the sphere of climate modelling, the weather research and forecasting (WRF) model SL-AV global semi-Lagrangian model, general circulation models scenarios, hydrological model, namely the soil and water assessment tool (SWAT), remote sensing data and GIS modelling, the bio-economic farm model was applied in the region (Yunicheva et al., 2020; Kulikovaa et al., 2017; Andrei et al., 2008; Rakhimova et al., 2020; Finaev et al., 2016).

Furthermore, researches related to impacts of climate change on the transformation of wetland ecosystem (Mukhitdinov et al., 2020), mountain ecosystem, particularly flora and fauna diversity change (Imanberdieva et al., 2018; Dimeyeva et al., 2015; Bobojonov and Aw-Hassan, 2014; Morgounov et al., 2018; Seim et al., 2016; Groll et al., 2016), glaciers (Agal'tseva et al., 2011; Podrezova and Pavlova, 2017; Glazirin and Semakova, 2019), which shows positive trend of glaciation shrinkage were conducted in the region.

Schumacher et al. (2018) studied high-mountains zones where the ecosystem-based adaptation approach was tested based on identifying key vulnerabilities of people and the ecosystem. Another adaptation option in mountainous areas is based on the establishment of mountain climate change observatories and the inventorying of promising adaptive actions in the condition of capacity building and PES funding (Kohler et al., 2016).

Several studies suggest adaptation actions such as the development of water-saving irrigation technologies to ensure a high yield, and use of improved collector-drainage water for irrigation in the arid zones were implemented (Khamidov and Khamraev, 2020; Salokhiddiov et al., 2020; Khamidov et al., 2020).

Extending the fields in specific research causes problems with the overall overview of accomplished studies. Bibliometrics, scientometrics, and informetrics are examples of metrics studies. All these studies were focused on gaining an understanding of the dynamics of disciplines as reflected in the production of their literature (Yang et al., 2020; Hood and Wilson, 2001). Informetrics is defined as application of mathematical models in the study of scientific information (Chellappandi and Vijayakumar, 2018; Yang et al., 2020), while scientometric study quantitative aspects of science. Bibliometric analysis is an efficient tool, which allows a better overview of the entire research field by analysing large volumes of scientific data (Haunschild et al., 2016; Donthu et al., 2021). Pritchard coined the term bibliometrics in 1969 to describe the application of mathematical and statistical methods to books and other forms of communication. Bibliometric involves the quantitative analyses of scientific books, articles or documents. Bibliometric study can be applied to evaluate the productivity of individual researchers, journals, countries, or any other levels of performance. The publications to be analysed in a bibliometric study can be obtained from a multidisciplinary database such as the ISI Web of Science (WoS), Scopus, or Google Scholar, which collects publications from a variety of disciplines (Andrés, 2009).

The previous bibliometric studies conducted by several researchers on the climate were dedicated to the whole world, and not on a regional level (Haunschild et al., 2016; Wang et al., 2018; Sweileh, 2020; Di Matteo et al., 2018).

Haunschild et al. (2016) analysed the growth of the overall publication output related to the global warming issue and of major subfields between 1980 and 2014 in the WoS database. The authors also examined the topical shifting of the climate change relevant research by title word analysis. Finally, most contributing journals and countries and their overall citation impact were identified (Haunschild et al., 2016).

Wang et al. (2018) applied the bibliometric method to analyse a situation and development trends, including the total numbers of publications, their geographical distribution, productive journals, authors and institutions, and most cited articles. In addition, the degree of academic collaboration and national comprehensive research strength were also measured and analysed. Word-clustering analysis, frequency analysis, co-occurrence, and network analyses were performed on high-frequency keywords in this area to identify hot research topics. In this research publications related to climate change adaptation were included (Wang et al., 2018).

Another study concentrated on bibliometric analyses of papers dedicated to climate change vulnerability assessment. The most commonly occurring research terms and their interrelationships were studied in this study, and the most relevant research terms in terms of co-cited publications papers were analysed (Di Matteo et al., 2018).

In the context of agro-climatic conditions of Central Asia, analyses of conducted studies at the local level are important by generating national adaptation and mitigation strategies. To assess the productive conditions in climate change-related publications in Central Asia, bibliometric analyses are required. Therefore, the main objective of this study is to analyse the overall development conditions of climate change areas of research from 1990 to 2022 in Central Asia through the use of the bibliometric method.

The following specific objectives were formulated for the study aiming to illustrate the time evolution and relative importance of specific research areas:

- 1 study of the temporal trend of publications of climate change
- 2 identify contributing journals, authors, and institutions to develop climate change publications
- 3 analyse citation impacts of the journals and keywords of publications.

2 Methods and materials

To explore the climate change issues in five countries of Central Asia (Kazakhstan, Kyrgyz Republic, Tajikistan, Turkmenistan, and Uzbekistan), 1006 articles from the Scopus database were downloaded and analysed based on the bibliometric method. It was decided to utilise Scopus database publications in this study due to its advantages, such as the availability of functions for analysing and sorting data compared to WoS and Google Scholar (Sweileh, 2020; Falagas et al., 2008; Harzing and Alakangas, 2016). The keywords ‘climate change’ and ‘global warming’ were used to search publications from all subject areas of Scopus database. The simplest approach was to apply the title/abstract search methodology for keywords related to ‘climate change’ and ‘global warming’. Due to the high proportion of irrelevant documents produced by this method, we excluded 501 publications after filtering keywords and reviewing abstracts from the downloaded Scopus database. Publications from 1990 to 2022 were included regardless of the language of the publications.

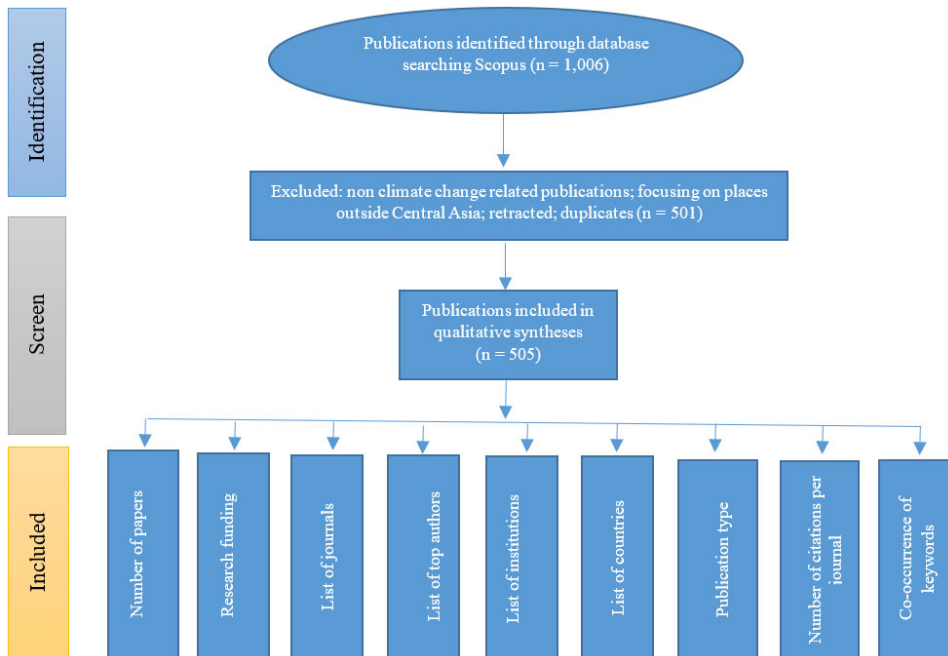
In this study, the technique of bibliometric analyses consists of two categories (performance analysis and science mapping), which are reported by Donthu et al. (2021) (Table 1). A database of 505 peer-reviewed publications was created for the analysis of the number of publications by year, funding details of publications, the name of the journal, the number of publications and relevant CiteScore values of journals, the list of top authors, institutions, and countries, citation of the publications, and keyword co-occurrence. A flowchart shows a diagrammatic representation of the step-by-step approach of this research (Figure 1).

Table 1 The bibliometric analysis toolbox

<i>Bibliometric analysis</i>		
<i>Main techniques</i>		<i>Enrichment techniques</i>
<i>Performance analysis</i>	<i>Science mapping</i>	<i>Network analysis</i>
<i>Publication related metrics:</i>	<i>Citation related metrics:</i>	<i>Visualisation:</i> • VOSviewer
• Total publications	• Total citations	
• Number of contribution authors		
<i>Citation analysis:</i>	<i>Co-word analysis:</i>	
• Most influential publications	• Written content (words)	

Source: Adapted by author

Figure 1 Flowchart of the research analysis based on the bibliometric method (see online version for colours)



3 Results and discussion

3.1 Temporal trend of published publications

The number of publications is the primary indicator used to assess the development trend in a particular field. Results show that a total of 505 publications between 1990–2022 focused on climate change issues in Central Asia (Figure 2). There are no publications published on climate change in 1990 and 1991. The number of publications remained steady between 1992–2004. The trend of published articles depicted that nearly 91% of publications were published after 2010. During this time, the trend increased slightly, with the most papers published in 2020, 2021. It is noted that the number of publications decreased in 2018 and 2022, rapidly. So far, the number of publications papers on climate change peaked in 2021, with 89 papers in the Scopus database, accounting for 18% of total publication.

There are several possible explanations for these results. One of the reasons could be a funding rate of the research in the field. Figure 3 illustrated the role of research funding in the trend of climate change publications. Our findings revealed that the observed increase in funding could be attributed to the growth in publications after 2012. It is notable that the trend of publications between 2012–2022 changed according to the funding rate.

Figure 2 Number of the publications with the climate change theme arranged by the year (see online version for colours)

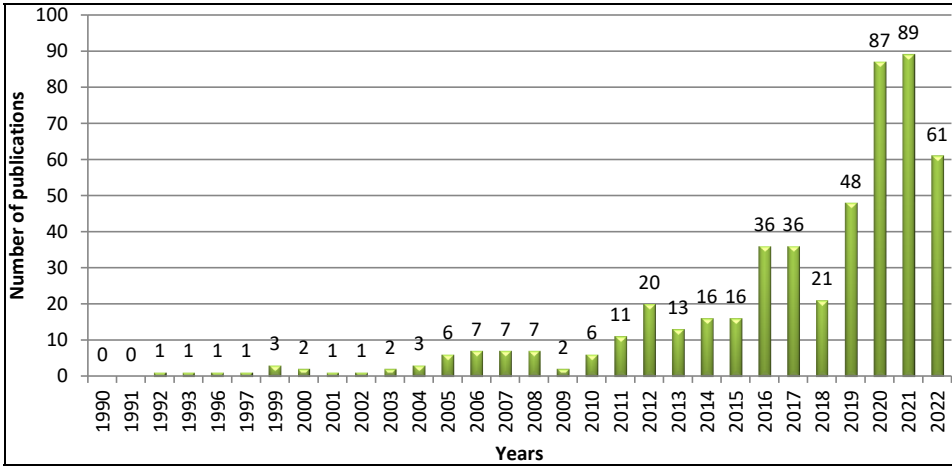
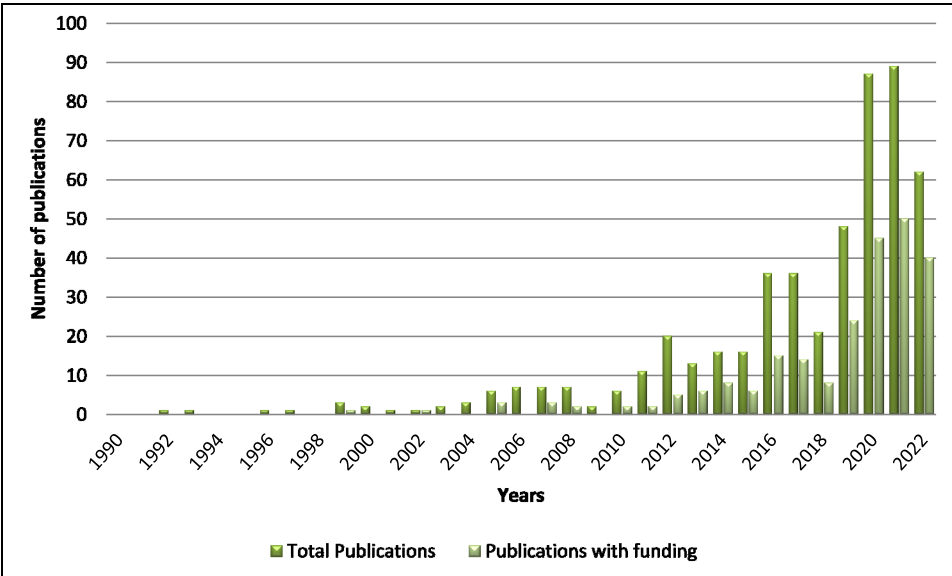


Figure 3 The research funding and number of the climate change publications with the climate change theme (see online version for colours)



3.2 Journals on climate change

Selecting an appropriate journal for publication is critical. Awareness about top journals in a certain field is important for researchers (Knight and Steinbach, 2008). Table 2 shows that a total of 143 journals published climate change issues in Central Asia during the last 32 years in the Scopus database. Approximately, 28% of papers were published in the first 15 journals (Figure 4).

Table 2 Journals publishing climate change papers during the period 1990–2022

<i>Source title</i>	<i>Number</i>
<i>IOP Conference Series: Earth and Environmental Science</i>	22
<i>E3S Web of Conferences</i>	18
<i>Water (Switzerland)</i>	17
<i>Sustainability (Switzerland)</i>	12
<i>International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM</i>	10
<i>IOP Conference Series: Materials Science and Engineering</i>	8
<i>PLoS One</i>	7
<i>Science of the Total Environment</i>	7
<i>Environmental Research Letters</i>	6
<i>Mountain Research and Development</i>	6
<i>Quaternary Science Reviews</i>	6
<i>Forests</i>	5
<i>Global and Planetary Change</i>	5
<i>International Journal of Geoinformatics</i>	5
<i>Renewable Energy</i>	5
<i>Agriculture, Ecosystems and Environment</i>	4
<i>Arabian Journal of Geosciences</i>	4
<i>Cotton, Water, Salts and Soums: Economic and Ecological Restructuring in Khorezm, Uzbekistan</i>	4
<i>Environmental research</i>	4
<i>International Environmental Agreements: Politics, Law and Economics</i>	4
<i>Journal of Cleaner Production</i>	4
<i>NATO Science for Peace and Security Series C: Environmental Security</i>	4
<i>The Aral Sea Basin: Water for Sustainable Development in Central Asia</i>	4
<i>Annals of Glaciology</i>	3
<i>Data</i>	3
<i>Energy</i>	3
<i>Environmental Science and Policy</i>	3
<i>Environmental Science and Pollution Research</i>	3
<i>International Journal of Biometeorology</i>	3
<i>International Journal of Climatology</i>	3
<i>Journal of Arid Land</i>	3
<i>Journal of Atmospheric and Solar-Terrestrial Physics</i>	3
<i>Remote Sensing</i>	3
<i>Springer Water</i>	3
<i>Agricultural and Forest Meteorology</i>	2
<i>Agricultural Water Management</i>	2
<i>Agroecology and Sustainable Food Systems</i>	2

Table 2 Journals publishing climate change papers during the period 1990–2022 (continued)

<i>Source title</i>	<i>Number</i>
<i>AIP Conference Proceedings</i>	2
<i>Scientific Data</i>	2
<i>Sustainable Energy in Kazakhstan: Moving to Cleaner Energy in a Resource-Rich Country</i>	2
<i>Water Resources Development and Management</i>	2
<i>Water Science and Technology</i>	2
<i>Water, Air, and Soil Pollution</i>	2
<i>Agricultural Systems</i>	1
<i>12th International Multidisciplinary Scientific GeoConference and EXPO – Modern Management of Mine Producing, Geology and Environmental Protection, SGEM 2012</i>	1
<i>2017 International Siberian Conference on Control and Communications, SIBCON 2017 – Proceedings</i>	1
<i>2021 6th International Conference on Smart and Sustainable Technologies, SpliTech 2021</i>	1
<i>2022 IEEE Global Humanitarian Technology Conference, GHTC 2022</i>	1
<i>40th Asian Conference on Remote Sensing, ACRS 2019: Progress of Remote Sensing Technology for Smart Future</i>	1
<i>ACM International Conference Proceeding Series</i>	1
<i>Advances in Experimental Medicine and Biology</i>	1
<i>Advances in Materials Science and Engineering</i>	1
<i>Advances in Space Research</i>	1
<i>Aerosol and Air Quality Research</i>	1
<i>Agriculture (Switzerland)</i>	1
<i>Agronomy</i>	1
<i>Allergy: European Journal of Allergy and Clinical Immunology</i>	1
<i>American Journal of Applied Sciences</i>	1
<i>Annual Review of Environment and Resources</i>	1
<i>Applied Sciences (Switzerland)</i>	1
<i>Applied Solar Energy (English translation of Geliotekhnika)</i>	1
<i>Applied Water Science</i>	1
<i>Arabian Journal of Chemistry</i>	1
<i>Archaeologische Mitteilungen aus Iran und Turan</i>	1
<i>Atmospheric Environment</i>	1
<i>Atmospheric Research</i>	1
<i>Atomic Energy</i>	1
<i>Austrian Journal of Earth Sciences</i>	1
<i>Big Data</i>	1
<i>BMC Proceedings</i>	1
<i>Case Studies in Construction Materials</i>	1

Table 2 Journals publishing climate change papers during the period 1990–2022 (continued)

<i>Source title</i>	<i>Number</i>
<i>Catena</i>	1
<i>Chemical Engineering Transactions</i>	1
<i>Chemosphere</i>	1
<i>Climate Change Adaptation Strategies – An Upstream-Downstream Perspective</i>	1
<i>Climate Change Economics</i>	1
<i>Climate Change Impacts on High-Altitude Ecosystems</i>	1
<i>Journal of Environmental Informatics</i>	1
<i>Journal of Climate</i>	1
<i>Journal of Environmental Management and Tourism</i>	1
<i>Journal of Glaciology</i>	1
<i>Journal of Hydrology: Regional Studies</i>	1
<i>Journal of Marine Systems</i>	1
<i>Journal of Paleolimnology</i>	1
<i>Journal of Plankton Research</i>	1
<i>Journal of Renewable and Sustainable Energy</i>	1
<i>Journal of Solar Energy Engineering, Transactions of the ASME</i>	1
<i>Journal of the Royal Society Interface</i>	1
<i>Journal of Water and Climate Change</i>	1
<i>Journal of World Energy Law and Business</i>	1
<i>JPT, Journal of Petroleum Technology</i>	1
<i>Kyrgyzstan: Political, Economic and Social Issues</i>	1
<i>Land</i>	1
<i>Land Degradation and Development</i>	1
<i>Lecture Notes in Energy</i>	1
<i>Lecture Notes in Networks and Systems</i>	1
<i>Led i Sneg</i>	1
<i>Mathematical Problems in Engineering</i>	1
<i>Medicina (Lithuania)</i>	1
<i>Microorganisms</i>	1
<i>Molecular Physics</i>	1
<i>Nanoscience and Nanotechnology – Asia</i>	1
<i>Natural Resources: Economics, Management and Policy</i>	1
<i>Nursing Forum</i>	1
<i>Open Access Macedonian Journal of Medical Sciences</i>	1
<i>Oxidation Communications</i>	1
<i>Pakistan Journal of Zoology</i>	1
<i>Peatland Restoration and Ecosystem Services: Science, Policy and Practice</i>	1
<i>PeerJ Computer Science</i>	1

Table 2 Journals publishing climate change papers during the period 1990–2022 (continued)

<i>Source title</i>	<i>Number</i>
<i>Perspectives in Plant Ecology, Evolution and Systematics</i>	1
<i>International Astronautical Federation – 55th International Astronautical Congress 2004</i>	1
<i>Philosophical Transactions of the Royal Society B: Biological Sciences</i>	1
<i>Physica A: Statistical Mechanics and its Applications</i>	1
<i>Plant Science Today</i>	1
<i>PLoS Medicine</i>	1
<i>PLoS Neglected Tropical Diseases</i>	1
<i>Society and Natural Resources</i>	1
<i>Society of Petroleum Engineers – SPE EuropEC – Europe Energy Conference featured at the 83rd EAGE Annual Conference and Exhibition, EURO 2022</i>	1
<i>Society of Petroleum Engineers – SPE Russian Petroleum Technology Conference 2021, RPTC 2021</i>	1
<i>Voprosy Prakticheskoi Pediatrii</i>	1
<i>Waste Management and Research</i>	1
<i>Water for Food Security: Challenges for Pakistan</i>	1
<i>Water Research</i>	1
<i>Atmosphere</i>	2
<i>Biodiversity and Conservation</i>	2
<i>Climate and Development</i>	2
<i>Climate Dynamics</i>	2
<i>Climatic Change</i>	2
<i>Earth Surface Processes and Landforms</i>	2
<i>Energies</i>	2
<i>Environment International</i>	2
<i>Environmental Crises in Central Asia: From Steppes to Seas, from Deserts to Glaciers</i>	2
<i>Environmental Earth Sciences</i>	2
<i>Environmental Science and Engineering</i>	2
<i>Frontiers in Earth Science</i>	2
<i>Frontiers in Energy Research</i>	2
<i>Geography, Environment, Sustainability</i>	2
<i>Geomagnetism and Aeronomy</i>	2
<i>Geoscientific Instrumentation, Methods and Data Systems</i>	2
<i>Global Change Biology</i>	2
<i>Green Energy and Technology</i>	2
<i>Heredity</i>	2
<i>Holocene</i>	2
<i>Human Ecology</i>	2

Table 2 Journals publishing climate change papers during the period 1990–2022 (continued)

<i>Source title</i>	<i>Number</i>
<i>IAHS-AISH Publication</i>	2
<i>InterCarto, InterGIS</i>	2
<i>International Geoscience and Remote Sensing Symposium (IGARSS)</i>	2
<i>International Journal of Energy Economics and Policy</i>	2
<i>International Journal of Environmental Research and Public Health</i>	2
<i>International Journal of Water Resources Development</i>	2
<i>Journal of Arid Environments</i>	2
<i>Journal of Environmental Management</i>	2
<i>Journal of Geophysical Research Atmospheres</i>	2
<i>Journal of Hydrology</i>	2
<i>Materials</i>	2
<i>Mitigation and Adaptation Strategies for Global Change</i>	2
<i>Nature Climate Change</i>	2
<i>News of the National Academy of Sciences of the Republic of Kazakhstan, Series of Geology and Technical Sciences</i>	2
<i>Optics InfoBase Conference Papers</i>	2
<i>Permafrost and Periglacial Processes</i>	2
<i>Proceedings of SPIE – The International Society for Optical Engineering</i>	2
<i>Climate Policy</i>	1
<i>Climate Change Management</i>	1
<i>Crustaceana</i>	1
<i>Dendrobiology</i>	1
<i>Dendrochronologia</i>	1
<i>Earth and Planetary Science Letters</i>	1
<i>Earth Science Frontiers</i>	1
<i>Earth System Dynamics</i>	1
<i>Earth Systems and Environment</i>	1
<i>Earth's Cryosphere</i>	1
<i>Eastern-European Journal of Enterprise Technologies</i>	1
<i>Ecological Engineering</i>	1
<i>Ecology and Evolution</i>	1
<i>Ecology, Environment and Conservation</i>	1
<i>Economic Growth and Wellbeing: Evidence from the Belt and Road Initiative Countries</i>	1
<i>Ekologia Bratislava</i>	1
<i>Ekoloji</i>	1
<i>Ekonomicheskaya Politika</i>	1
<i>Electrical Engineering</i>	1
<i>Energy and Fuels</i>	1

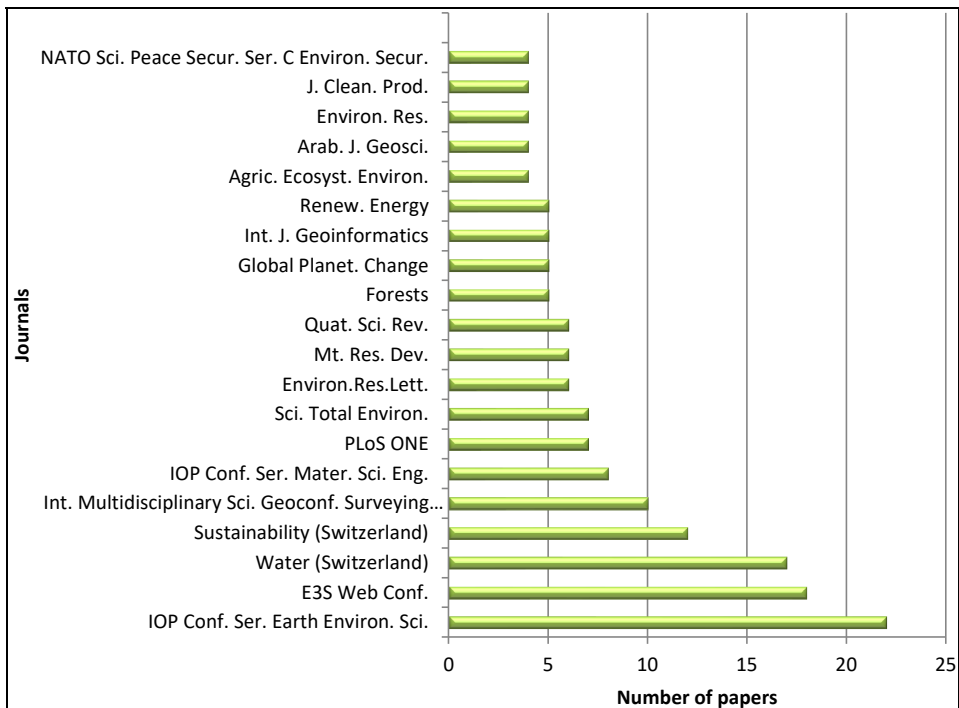
Table 2 Journals publishing climate change papers during the period 1990–2022 (continued)

<i>Source title</i>	<i>Number</i>
<i>Energy Engineering: Journal of the Association of Energy Engineering</i>	1
<i>Energy Policy</i>	1
<i>Energy Reports</i>	1
<i>Energy Strategy Reviews</i>	1
<i>Engineering for Rural Development</i>	1
<i>International Journal of Engineering Research and Technology</i>	1
<i>International Journal of Environment and Sustainable Development</i>	1
<i>International Journal of Environmental Research</i>	1
<i>International Journal of GEOMATE</i>	1
<i>International Journal of Plant Production</i>	1
<i>International Journal of Renewable Energy Development</i>	1
<i>International Journal of Renewable Energy Research</i>	1
<i>Irrigation and Drainage</i>	1
<i>Irrigation Science</i>	1
<i>Izvestiya Akademii Nauk, Seriya Geograficheskaya</i>	1
<i>Izvestiya Rossiiskoi Akademii Nauk. Seriya Geograficheskaya</i>	1
<i>Journal of Advanced Research in Dynamical and Control Systems</i>	1
<i>Journal of Agronomy and Crop Science</i>	1
<i>Journal of Asian Earth Sciences</i>	1
<i>Procedia Computer Science</i>	1
<i>Proceedings of the 5th International Disaster and Risk Conference: Integrative Risk Management – The Role of Science, Technology and Practice, IDRC Davos 2014</i>	1
<i>Proceedings of the International Association of Hydrological Sciences</i>	1
<i>Proceedings of the International Symposium on Dams in the Societies of the 21st Century, ICOLD-SPANCOLD – Dams and Reservoirs, Societies and Environment in the 21st Century</i>	1
<i>Proceedings of the Royal Society B: Biological Sciences</i>	1
<i>Producing Fuels and Fine Chemicals from Biomass Using Nanomaterials</i>	1
<i>Soil Biology and Biochemistry</i>	1
<i>South African Journal of Industrial Engineering</i>	1
<i>Sovremennye Problemy Distantionnogo Zondirovaniya Zemli iz Kosmosa</i>	1
<i>Springer Climate</i>	1
<i>Stochastic Environmental Research and Risk Assessment</i>	1
<i>Studia Quaternaria</i>	1
<i>Sustainable Cities and Society</i>	1
<i>Sustainable Civil Infrastructures</i>	1
<i>Sustainable Water Resources Management</i>	1
<i>Symmetry</i>	1
<i>Technology in Society</i>	1

Table 2 Journals publishing climate change papers during the period 1990–2022 (continued)

Source title	Number
<i>Tellus, Series B: Chemical and Physical Meteorology</i>	1
<i>TNC 2015 – Connected Communities</i>	1
<i>Tree Physiology</i>	1
<i>Trees – Structure and Function</i>	1
<i>Turkish Journal of Agriculture and Forestry</i>	1
<i>Vegetation of Central Asia and Environs</i>	1
<i>Vestnik Moskovskogo Universiteta, Seriya 5: Geografiya</i>	1
<i>Quarterly Journal of International Agriculture</i>	1
<i>Quaternary Research</i>	1
<i>Regional Sustainability</i>	1
<i>Remote Sensing of Environment</i>	1
<i>Renewable and Sustainable Energy Reviews</i>	1
<i>Research in Globalization</i>	1
<i>Research in Social Problems and Public Policy</i>	1
<i>Research Journal of Pharmaceutical, Biological and Chemical Sciences</i>	1
<i>Riparian Zones: Characteristics, Management Practices and Ecological Impacts</i>	1
<i>Routledge Handbook of Environmental Conflict and Peacebuilding</i>	1
<i>Russian Geology and Geophysics</i>	1
<i>Russian Journal of Non-Ferrous Metals</i>	1
<i>Science</i>	1
<i>Science Bulletin</i>	1
<i>Scientific Reports</i>	1
<i>Water Resources</i>	1
<i>Water Resources Protection</i>	1
<i>Wiley Interdisciplinary Reviews: Water</i>	1
<i>World Applied Sciences Journal</i>	1
<i>Zeitschrift für Gefässmedizin</i>	1
<i>Zolotoordynskoe Obozrenie</i>	1

The results reveal that there has been a marked growth in the number of papers after the appearance of opportunity in publishing proceedings with the IOP Conference Series. The top journals are IOP Conference Series: Earth and Environmental Science, E3S Web of Conferences, *Water* (Switzerland), *Sustainability* (Switzerland) and International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM. If we analyse the relevant CiteScore of journals and number of publications, we can see the possibility that a journal publishing a larger number of papers has a smaller CiteScore. For instance, the CiteScore of the top publisher (with the 22 publication) IOP Conference Series: Earth and Environmental Science is 0.6, whereas the *Journal of Cleaner Production* with a cite score 15.8 published only four papers between 1990–2022 (Figure 5).

Figure 4 Top journals publishing climate change papers (see online version for colours)

3.3 Top authors on climate change

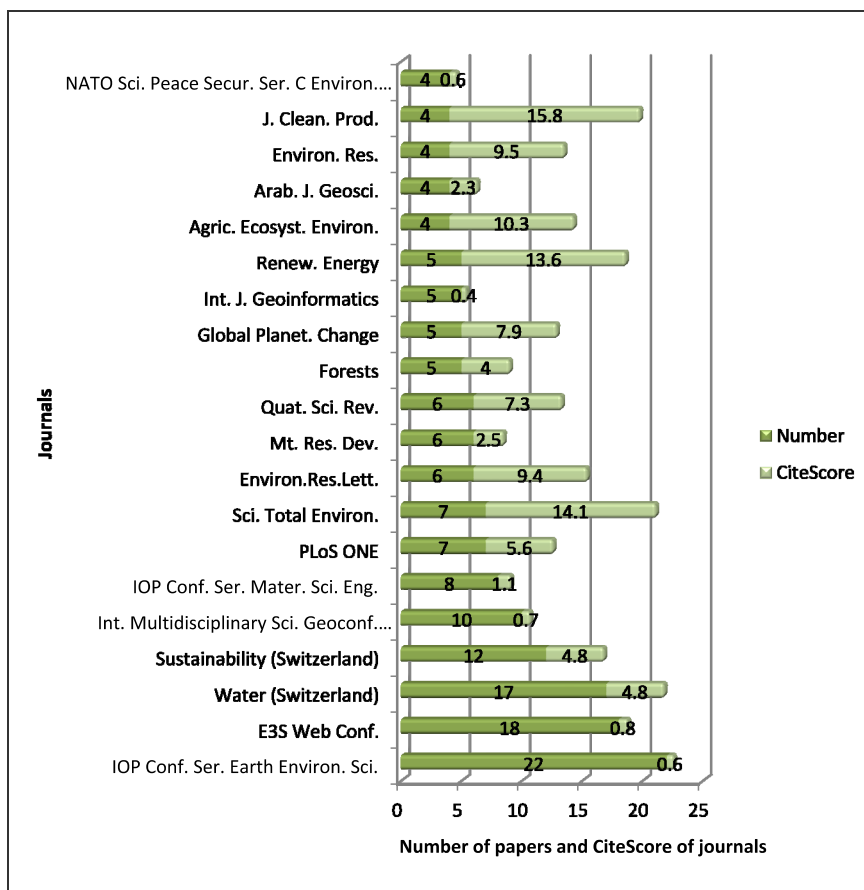
A total of 2,944 authors were identified during the analyses of publications. The top 24 authors (at least with five publications) are included in Figure 6. The top 24 authors have contributed 30% of the publications. Author X. Chen and J. Abuduwaili have the highest number of publications (almost 2%), followed by S. Yu, J.P.A. Lamers, T. Liu, and H. Shang (more than 1.5%), and Y. Chen, G. Issanova, R. Zhang, A. Gafurov, C. Martius, S.A. Memon, A. Gulakhmadov, Q. He, S. Khasanov, R. Kulmatov, Y. Li, L. Qin, L. Rojas-Solórzano, R. Satylkanov, N. Thevs, R. Usubaliev, Y. Yuan, and T. Zhang (near 1%). Only 3% of papers published were written by a single author, while 10% of papers published were written by two authors, and others' authors were more than two authors. Furthermore, the findings highlight another point: the majority of the authors of the published papers are from other regions.

3.4 Top institutions and countries on climate change

In terms of high-yield institutions, Figure 7 represents the top 21 productive institutions in respect to the number of publications. The results indicate that Tashkent Institute of Irrigation and Agricultural Mechanization Engineers, National Research University in Uzbekistan (NRU TIAME, Uzbekistan; 10% of the total publications) is the top institute publishing on climate change related issues followed by Al Farabi Kazakh National University (KAZNU, Kazakhstan), Nazarbayev University in Kazakhstan and Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences (XIEG, CAS; 9.5%

of the total publications). University of Chinese Academy of Science (UCAS, China) and Research Center for Ecology and Environment of Central Asia (RCEECA, China) with (5.5%) and (3.5%) rank third and fourth, respectively. Overall, researchers from five institutions in Uzbekistan (15% of the total publications) and Kazakhstan (24% of the total publications), four institutions in China (20% of the total publications), two institutions in Kyrgyzstan and Germany (4% and 3% of the total publications, respectively), and one institution in USA (3% of the total publications), Tajikistan and Russian (2% of the total publications) worked on the climate change specific issues. These findings highlight that local institutions are more active in terms of climate change study in Central Asia. One of the possible reasons may be data availability in the region. However, China's contribution is significant to compare it with other countries.

Figure 5 Number of papers and CiteScores of journals (see online version for colours)

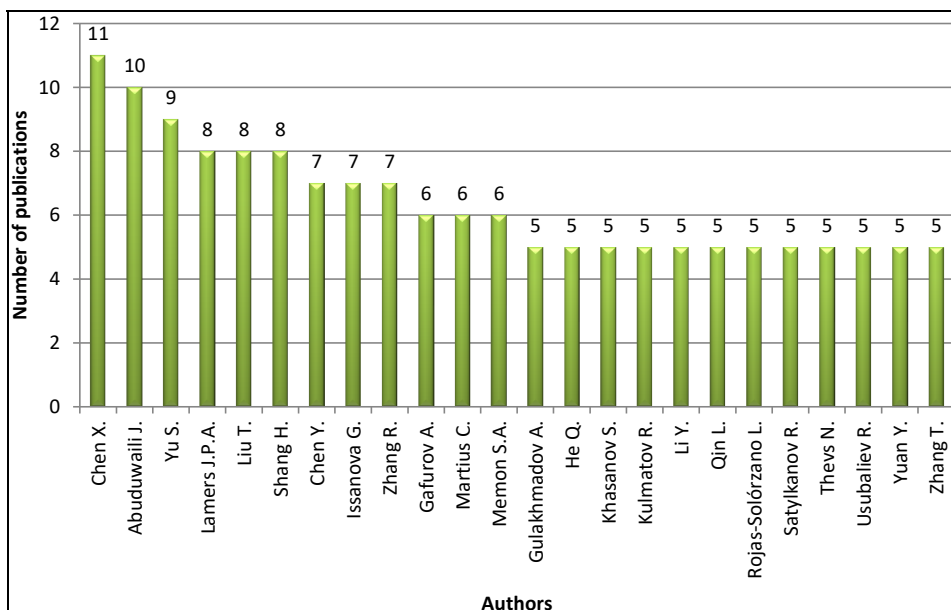


3.5 Publication type on climate change

The authors present their research findings in several ways. Figure 8 displays the distribution of publication types, including research articles, book chapters, conference papers, reviews, and other types of publications (letter, data paper, and note). These five

publication types constituted the selected database for bibliometric analysis in this research. It should be noted that 92% of conference papers began to be published after 2000 (with the exception of one conference paper), and over 10% of them are a contribution of IOP Conference Series Proceedings and E3S Web of Conferences. Results show that most (except one book chapter) book chapters have been issued after 2008 in the Scopus database. Approximately, three of a quarter of the publication type is a research article.

Figure 6 Authors of climate change publications for the period 1990–2022



3.6 Top cited journals on climate change

Citation to the papers means importance and quality of the research (Christmann and Aw-Hassan, 2011, 2012; Sommer et al., 2013; Siegfried et al., 2012; Li et al., 2015). The results of the analyses show that 505 papers received 11,853 citations in 284 journals. We have illustrated the top 29 journals, which were cited more than 100 times between 1990–2022. Nearly, 33% of citations were given to the papers in the first five journals: *Nature Climate Change*, *Philosophical Transactions of the Royal Society B: Biological Sciences*, *Journal of Glaciology*, *Journal of Geophysical Research Atmospheres* and *Global and Planetary Change* (Figure 9). The percentage of citations shared by all top journals is 8%.

3.7 Co-occurrence of keywords

Keywords describe the essence of the study since authors use keyword selection to highlight the essential elements of their research. In total, 3,666 keywords were extracted from the 505 publications. Overlay visualisation is generated for keywords with the co-occurrence of at least ten, including 92 keywords based on the VOSviewer software

(Figure 10). *Climate change* was the most frequently used keyword (63%) followed by *Kazakhstan* (17%) and *Central Asia* (13%), *global warming* (12%), *Kyrgyzstan* (8%) and *rivers* (7%). The figure shows the keyword remote sensing appeared after the year 2017. Keywords related to the energy sector, such as fossil fuels, energy use, and energy efficiency, were included in the papers published by the end of 2019. Furthermore, rivers, water management, and water reservoir supply, water user association, and water resources are among the top 10 terms. According to the keyword analysis, it is clear that more publications are dedicated to the problem areas of agriculture and water resources in Central Asia. IPCC reported a projected increase in water demand in most Asian countries due to the irrigated agriculture and population growth (IPCC, 2014). Cluster analysis is performed on the co-occurrence of keywords with a frequency ≥ 10 . There are 92 keywords clustered into five categories. A cluster includes a research theme in which one or more research topics can be identified. Cluster 1 includes keywords related to the changes in climatic factors. Cluster 2 presents changes in water resources and agriculture. Cluster 3 mainly focuses on human activity and ecosystem. In cluster 4 collected greenhouse emissions and energy. The last cluster contains keywords linked with adaptation management.

Figure 7 Contributed institutions to the publications of climate change (see online version for colours)

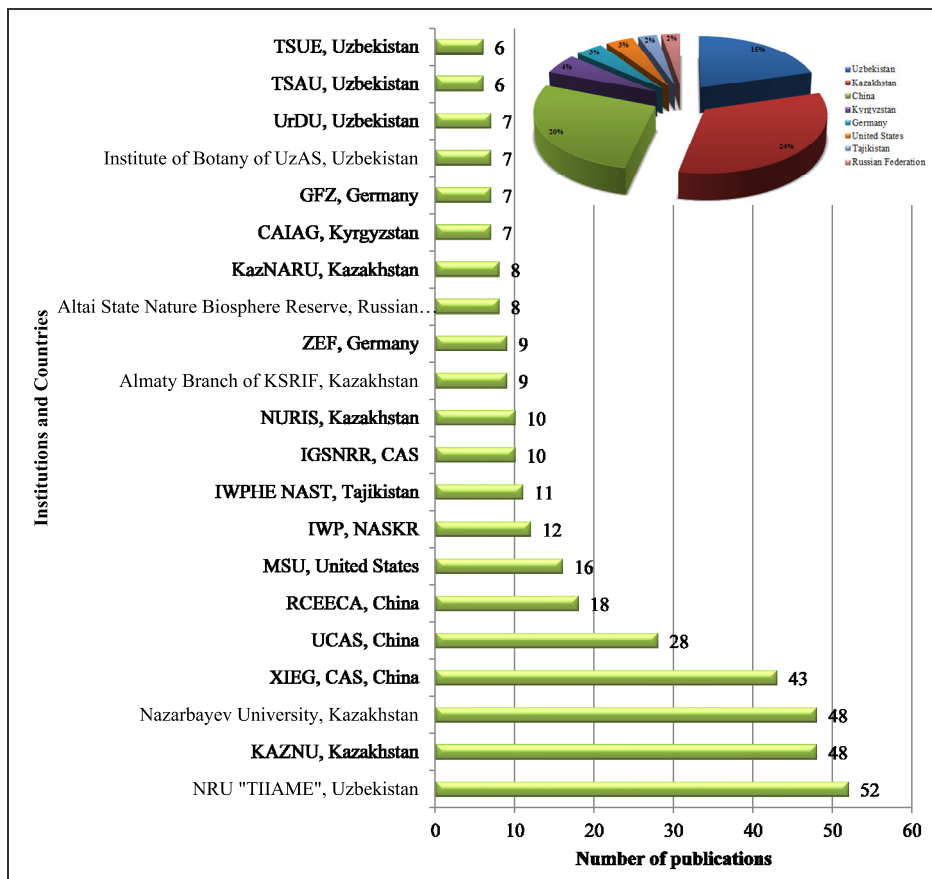


Figure 8 Type of publications during the period 1990–2022 (see online version for colours)

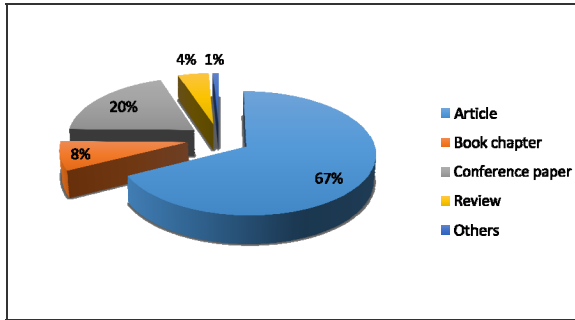
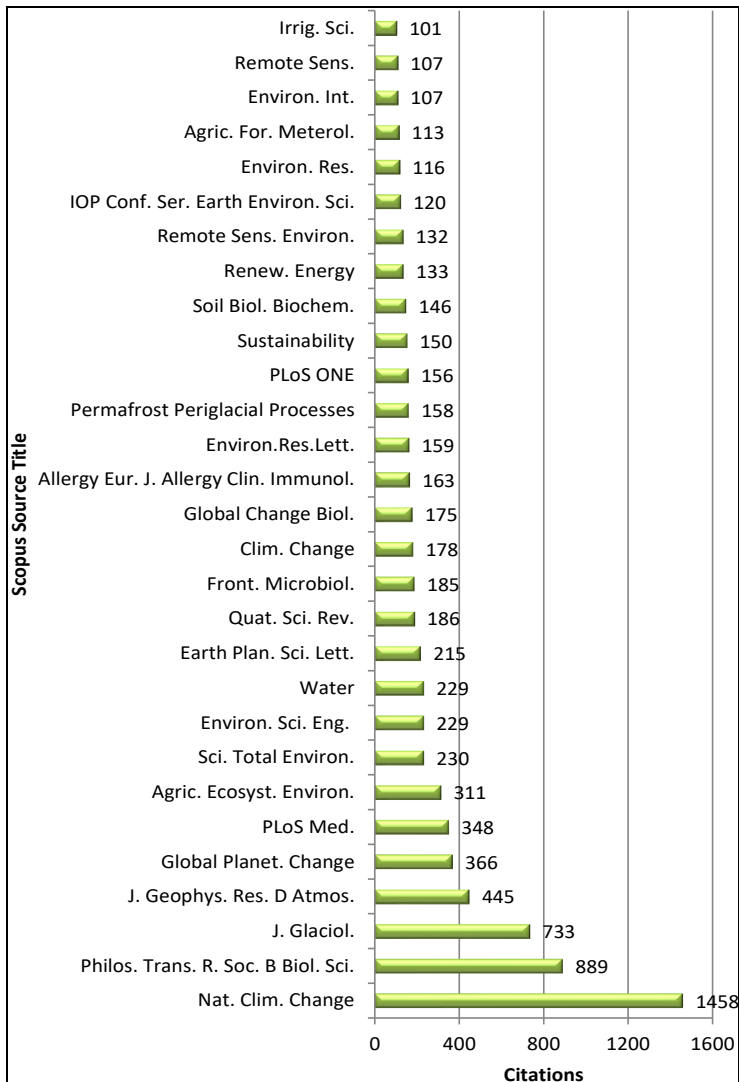


Figure 9 Citations of journals (see online version for colours)



More recent studies have confirmed that journals *Quaternary Science Reviews*, *Global and Planetary Change* (Haunschild et al., 2016), *Sustainability* (Switzerland), *Water* (Switzerland) (Sweileh, 2020; Suhaimi and Mahmud, 2022), *Plos One*, and *Environmental Research Letters* (Wang et al., 2018) were considered as the top journals for publishing in the field of climate change. Consistent with past research findings, we discovered that the aforementioned publications were included in 21 top journals.

Several studies have found that research on climate change is quantitatively dominated by the USA and UK in the first two positions (Wang et al., 2018; Haunschild et al., 2016; Sweileh, 2020; Suhaimi and Mahmud, 2022). Whereas in our findings, ranking of USA is in the sixth position. Furthermore, in our case, China makes a significant contribution compared to worldwide bibliometric analyses (Haunschild et al., 2016; Wang et al., 2018; Suhaimi and Mahmud, 2022).

There is a large volume of published studies describing keyword clustering and frequency analysis. The top listed keyword *climate change* was recorded in our analyses as well (Wang et al., 2018; Einecker and Kirby, 2020; Sweileh, 2020; Suhaimi and Mahmud, 2022). As this study is focused on a regional publications, the name of the regions is also one of the keywords with high frequency. As a result, in our study, Kazakhstan has the highest frequency while China has the highest frequency in worldwide analysed bibliometric studies (Wang et al., 2018). The frequency of the other keywords such as terms linked with water resources and extreme events is consistent with findings of past studies. However, co-occurrence of some keywords linked with adaptation, mitigation or vulnerability, is low in comparison to other studies (Wang et al., 2018; Einecker and Kirby, 2020; Sweileh, 2020).

5 Conclusions

Based on the Scopus database, a detailed analysis was conducted for the overall development conditions of climate change research in Central Asia from 1990 to 2022 using bibliometric analyses. The key conclusions are as follows:

- The publications on climate change emerged after 1991 in Central Asia. The number of publications remained steady between 2000–2004. However, it increased by six times in 2022 compared to 2011.
- However, IOP Conference Series: Earth and Environmental Science, E3S Web of Conferences dominated as the two top climate change journals, the CiteScore of these journals are low to compare others. While the journals with lower ranking such as *Water* (Switzerland) and *Sustainability* (Switzerland) have much higher CiteScore.
- The top 24 writers accounted for 30% of all publications. Only 4% of articles were produced by a single author, 10% by two authors, and the remainder by more than two authors.
- Among the top productive institutions, Tashkent Institute of Irrigation and Agricultural Mechanization Engineers, National Research University in Uzbekistan (10% of the total publications) has published the most papers in fields related to climate change followed by Al Farabi Kazakh National University, Nazarbayev University in Kazakhstan and Xinjiang Institute of Ecology and Geography, Chinese

Academy of Sciences (9.5% of the total publications). These findings highlight that local institutions are more active in terms of climate change study in Central Asia. One of the possible reasons may be data availability in the region.

- The distribution of publication types includes research articles (67%), conference papers (20%), book chapters (8%), reviews (8%) and others (letter, note, and data paper) (1%).
- Climate change was the most frequently used keyword (63%) co-occurrences in the publications, followed by *Kazakhstan* (17%) and *Central Asia* (13%), *global warming* (12%), *Kyrgyzstan* (8%) and *rivers* (7%). However, co-occurrence of some keywords linked with adaptation, mitigation, or vulnerability, were low in comparison to other studies.

Notably, this study has some limitations. First, while Scopus is a widely used literature database with a broad coverage of numerous fields, many publications, particularly those with a local or regional concentration, are not indexed in this database and so are not considered in our analysis. Second, this study does not cover the most recent research on climate change. Third, our analysis offers a macro-level perspective of climate change research. It does not provide a detailed understanding of the sub-topics in climate change research at the micro-level. A more in-depth understanding will necessitate a combination of bibliometric analysis and a thorough reading of the literature.

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