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THE POTENTIAL OF SCIENTOMETRIC ANALYSIS FOR STUDYING CLIMATE CHANGE ISSUES: A CASE STUDY OF UKRAINE

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Abstract. *Research on climate change is critically important due to its widespread impacts on ecosystems, economies, and social structures. Climate change, including rising temperatures, rising sea levels, extreme weather events, and droughts, is already causing significant harm to people, biodiversity, and the environment, highlighting the need for research to develop strategies for adaptation and mitigation. Furthermore, understanding the underlying mechanisms of climate change processes is essential for predicting future consequences and creating effective policies and technologies. These efforts are crucial for reducing greenhouse gas emissions, transitioning to renewable energy, and preventing natural disasters.*

In addition, climate change research plays a vital role in global scientific and political discussions, influencing the formation of agreements and laws that support sustainable development and environmental protection. Scientific knowledge aids in informed decision-making at international, national, and local levels, contributing to the creation of social support strategies, especially for vulnerable populations such as impoverished regions and small island nations.

This study utilizes bibliometric analysis to examine the research landscape of climate change, highlighting key research areas, identifying gaps in knowledge, and determining priority fields for further study. Bibliometrics also helps assess the interdisciplinary nature of climate change, spanning various disciplines from ecology to social sciences, and it provides insights into the contributions of scientific research to achieving the Sustainable Development Goals. This approach enhances the understanding of the geographical aspects of climate change research and supports the formation of scientific priorities while improving the impact of research on practical solutions.

Data from the Scopus platform on publications related to climate change adaptation, disaster risk reduction, sustainable agricultural practices, and the circular economy were analyzed. A total of 1,689 documents were identified between 1991 and 2024, and descriptive statistics were performed. The study employs structural scientometrics, using bibliometric links, co-citation analysis, and mapping cognitive structures to provide a comprehensive overview of the evolution of climate change research. The findings show that scientific interest in climate change has significantly increased since 2010, marking a turning point in global awareness and research efforts.

Keywords: *Scientometric Analysis, Climate Change, Ukraine.*

INTRODUCTION

Research on climate change is of paramount importance for several reasons. Firstly, climate change impacts all aspects of life on Earth, ranging from natural ecosystems to economies and social structures. The increase in temperature, rising sea levels, droughts, extreme storms, and other climate-related consequences are already causing significant harm to people, flora, and fauna, making such research crucial for developing strategies for adaptation and damage mitigation [1].

Secondly, climate change research helps to better understand the mechanisms behind

these processes and to predict their future consequences. This enables timely development and implementation of effective policies and technologies aimed at mitigating the effects of climate change, particularly through reducing greenhouse gas emissions, transitioning to renewable energy sources, and preventing natural disasters.

Moreover, climate change research is an important tool for scientific and political discussions that contribute to the formation of global agreements and laws that support sustainable development and environmental protection. Scientific knowledge about climate change allows for more informed decision-making at the levels of international organizations, governments, and local communities.

Furthermore, climate change is not just an environmental issue but also a social and economic one. Different segments of the population, especially vulnerable groups such as poor regions or small island nations, suffer the consequences of climate change much more severely. Research on these phenomena facilitates more effective planning of social support strategies and the provision of viable living conditions for people worldwide [2].

Thus, climate change research is essential for understanding global processes, developing strategies to combat climate change, and ensuring a sustainable future for the planet and all its inhabitants.

Bibliometric analysis provides extensive opportunities for exploring and addressing the issue of climate change. By using this approach, scientific knowledge can be systematized, key research areas can be identified, gaps in science can be pinpointed, and priority fields for further study can be established. Bibliometrics enables an assessment of the interdisciplinary nature of climate change, as these issues encompass various fields of knowledge, from ecology to social sciences. It also helps to identify leading researchers and scientific institutions, as well as to evaluate the impact of scientific work on political decisions and technological innovations [3]. Moreover, bibliometric tools allow for the determination of the contribution of research to achieving the Sustainable Development Goals and contribute to a better understanding of the geographical aspects of climate change research. As a result, bibliometrics is an effective tool for examining trends, forming scientific priorities, and enhancing the influence of research on practical solutions in the fight against climate change.

MATERIALS AND METHODS

The data from the Scopus platform on the number of publications related to climate change adaptation, disaster risk reduction, sustainable agriculture practices, and the circular economy were used. Descriptive statistics were performed on studies published between 1991 and 2024. During this period, 1,689 document results were found using these keywords.

Scientometrics is regarded as one of the most significant disciplines within the sciences, defined as an informational process carried out through the quantitative study of science. For the purposes of this study, we adopt the epistemological understanding of science, which encompasses the overall development of the system under analysis, focusing on interrelationships and disciplinary structures. Structural scientometrics, as a component of this field, was approached using bibliometric links, co-citation analysis, and mapping cognitive structures of scientific perceptions.

The goal of this process is to provide an objective overview of how science evolves over time, how it assesses timeliness by identifying key topics of interest in academic work, and how it efficiently organizes research systems, activities, management, and productivity.

The term «bibliometrics» was first coined by Alan Pritchard in 1969 and is considered a statistical and mathematical method focused on books and publications, which is also regarded as a branch of scientometrics[4]. In this study, search results from the Scopus database were exported into text format, including scientific articles on the topics of climate change adaptation, disaster risk reduction, sustainable agricultural practices, and the circular economy. Using the keywords extracted from the database, we obtained unique insights into the publications in Ukraine related to these subjects.

RESULTS

The analysis of trends in scientific research related to climate change issues is one of the key tasks of bibliometrics. With powerful tools for gathering and analyzing data on publications, citations, authors, and institutions, bibliometrics allows not only tracking the quantity of scientific works in a particular field but also determining the qualitative aspects of the research [5].

Firstly, analyzing publication activity helps to understand how the scientific community's interest in climate change has evolved over time. For example, it is possible to trace which aspects of this issue were prioritized in the past, how the focus of contemporary research has shifted, and which directions have potential for further development. Such data reveal patterns in scientific activity: periods of increased publication activity often correlate with the emergence of new methodologies, breakthrough technologies, or global events (such as international climate agreements).

In the case of Ukraine (Fig. 1), a significant increase in the number of articles addressing climate change issues begins only in 2010 (16 articles compared to one in 1991 or 1993).

Furthermore, by using scientometric tools, it is possible to explore emerging topics. For example, modern machine learning and text analysis technologies allow publications to be automatically classified by key themes, enabling the identification of the most discussed issues, such as the impact of climate change on biodiversity, climate scenario modeling, or renewable energy research.

An especially important aspect is identifying topics that are developing most dynamically. These are the areas that are just beginning to gain scientific attention but already show high rates of growth in publication and citation numbers. Such «hotspots» in science indicate potential breakthroughs that could significantly change approaches to solving climate change-related issues.

For instance, in the field of climate change research, the subject areas exhibit varying degrees of focus, each contributing a unique perspective to understanding and addressing the complex challenges posed by climate change. Environmental Science, with the highest number of publications (288), is the central field, reflecting its pivotal role in understanding the direct impacts of climate change on ecosystems, environmental processes, and mitigation strategies. Close behind, Earth and Planetary Sciences (207 publications) plays an important role by investigating the physical processes affecting

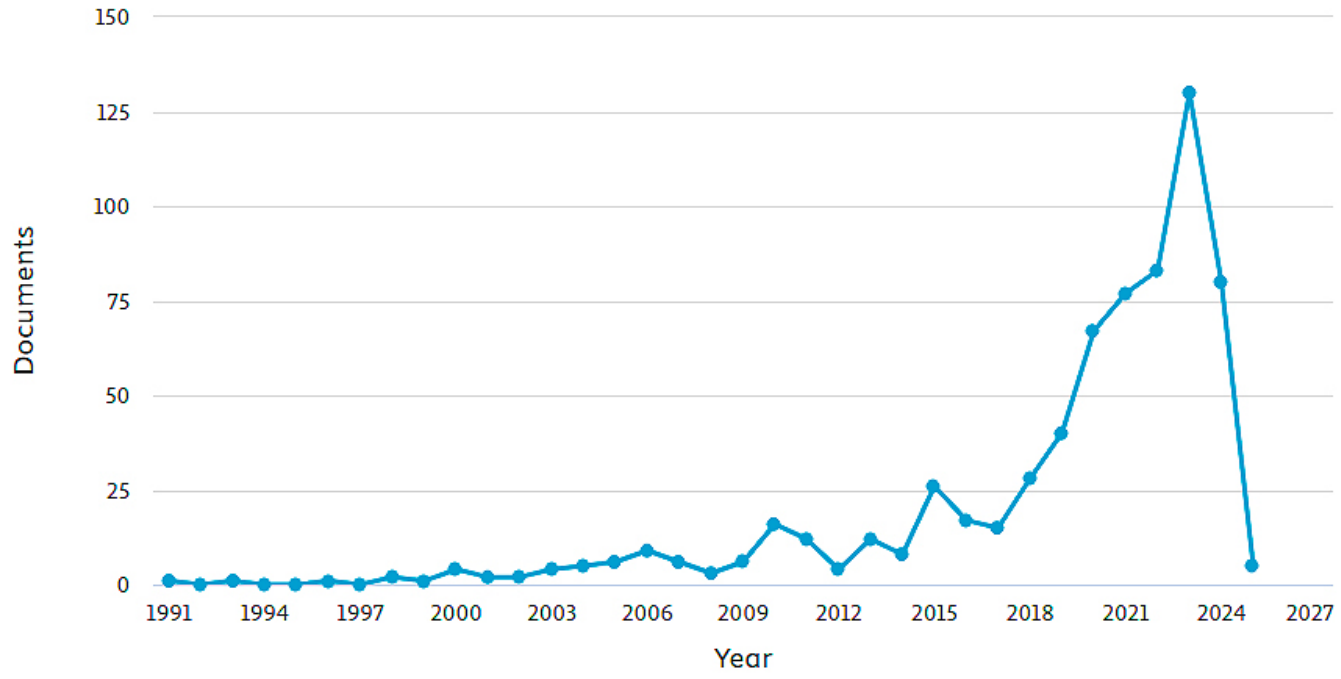

Fig. 1. Dynamics of publications by Ukrainian researchers on climate change (1991–2023)

the Earth, such as atmospheric dynamics and ocean currents, both crucial for climate modeling and predicting future scenarios (Fig. 2).

Agricultural and Biological Sciences (166 publications) highlight the growing recognition of the profound effects climate change has on agriculture and biodiversity. Researchers in this area are increasingly focused on how climate variations affect crop yields, biodiversity, and overall food security, making this a vital area of concern. Engineering (117 publications) underscores the importance of technological solutions, with research focusing on climate adaptation technologies, sustainable infrastructure, and green innovations aimed at reducing emissions and enhancing resilience.

The contributions from Nursing (2 publications), Health Professions (1 publication), Neuroscience (1 publication), Psychology (1 publication), and Veterinary (1 publication) are smaller but still significant, focusing on the human and animal health implications of climate change. These fields address issues such as the physical and mental health consequences of climate change, particularly in vulnerable populations, and the impact on animal species and ecosystems.

Overall, the distribution of research across these subject areas reflects the diverse and interconnected nature of climate change challenges. The leading fields like Environmental Science, Earth and Planetary Sciences, and Energy showcase the centrality of understanding the scientific and technological aspects of climate change. Meanwhile, the growing presence of disciplines such as Social Sciences, Economics, and Decision Sciences highlights the increasing recognition of the need for interdisciplinary solutions that address not only the scientific but also the social, economic, and policy-related dimensions of climate change.

At the same time, scientometrics enables the identification of knowledge gaps. For example, regions or aspects of climate change that remain under-researched due to limited resources or data access. This is particularly important for science policy, as such findings can be used to adjust funding or direct resources toward addressing the most urgent or under-explored issues [6].

Thus, analyzing research trends through scientometrics is a powerful tool for forming a comprehensive understanding of the state of scientific activity in the field of climate change. It allows for the comprehension of the dynamics

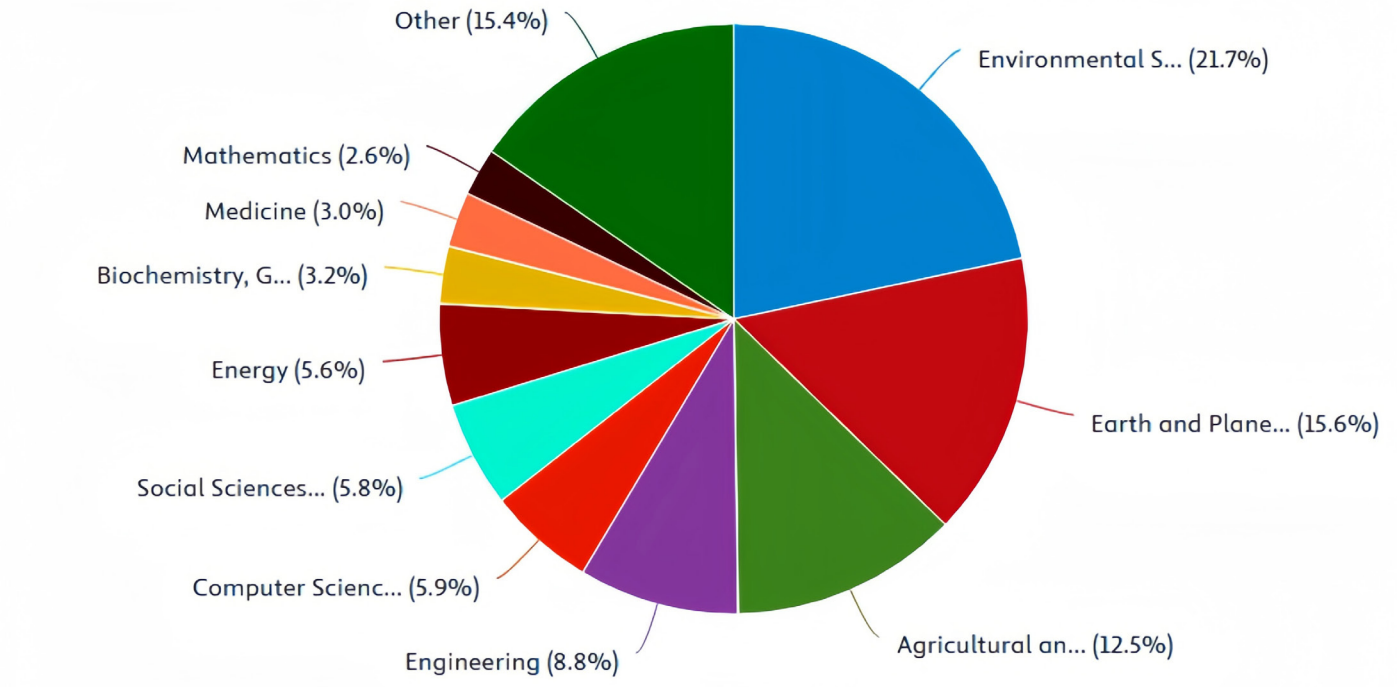

Fig. 2. Documents by subject area

of the subject's development, forecasting future trends, efficiently directing resources toward key issues, and providing strategic support for the most promising areas.

The assessment of interdisciplinarity is a crucial aspect of studying climate change issues, as this global challenge spans a wide range of scientific disciplines and requires the integration of knowledge from different fields. Through scientometrics, it is possible to gain deeper insights into how various scientific areas collaborate to create innovative solutions and identify potential intersection points that remain insufficiently explored.

One of the key advantages of scientometric data is the ability to analyze co-authorship patterns in scientific publications. For example, research with authors from different disciplines, such as ecology and economics or engineering and social sciences, indicates an interdisciplinary approach to solving climate change issues. This type of analysis allows us to identify the most active research groups working at the intersection of fields and explore how they combine their expertise to achieve common goals.

Scientometrics also enables the analysis of publication topics related to climate change in the context of interdisciplinarity. Modern analytical tools allow for the classification of scientific works by keywords, themes, or citations, providing the opportunity to track how certain concepts or technologies migrate between disciplines. For instance, one can detect how engineering methods for assessing greenhouse gas emissions are applied in ecological research, or how economic models are used to forecast the socio-economic impacts of climate change.

An important aspect is also the evaluation of the impact of interdisciplinary research. Scientometrics allows us to measure how such works are cited across other scientific fields, serving as an indicator of their significance and influence on the broader scientific community. For example, studies exploring the relationship between renewable energy sources and economic policy may be cited in both the energy sector and economics, highlighting their interdisciplinary nature and practical value.

Furthermore, the analysis of scientometric data enables the assessment of interactions between institutions working on climate change issues. For example, it is possible to determine how universities, research institutes, and industrial partners collaborate to jointly develop new technologies or adaptation strategies. This information is valuable not only for understanding the structure of scientific cooperation but also for identifying key centers that promote knowledge integration and innovation development.

Ultimately, interdisciplinarity in climate change research is fundamental to creating innovative solutions that address both technical and socio-economic aspects of the problem. Scientometric analysis helps not only to assess the current level of knowledge integration but also to identify new opportunities for cross-sector collaboration, which is a crucial step in addressing the global challenges posed by climate change.

Identifying leading researchers and institutions is one of the key aspects of scientometric analysis, which helps understand who is setting the agenda in climate change research. This process contributes to the identification of scientific leaders, the creation of effective partnerships, and the development of global-level cooperation.

Scientometric tools allow for the analysis of performance indicators of individual researchers and institutions, such as the number of publications, citation index, impact of works in key journals, and collaboration with other organizations. Databases such as Scopus or Web of Science, along with specialized analytical platforms like SciVal or InCites, are used for this purpose. Through these tools, one can identify researchers whose works are most cited in the field of climate change, as well as those making significant contributions to the development of new research directions.

Scientometric analysis also allows for the identification of institutions that are leaders in the field. These could include universities, research centers, government organizations, or international institutions. For example, an analysis of the number of publications or the ratio of quality

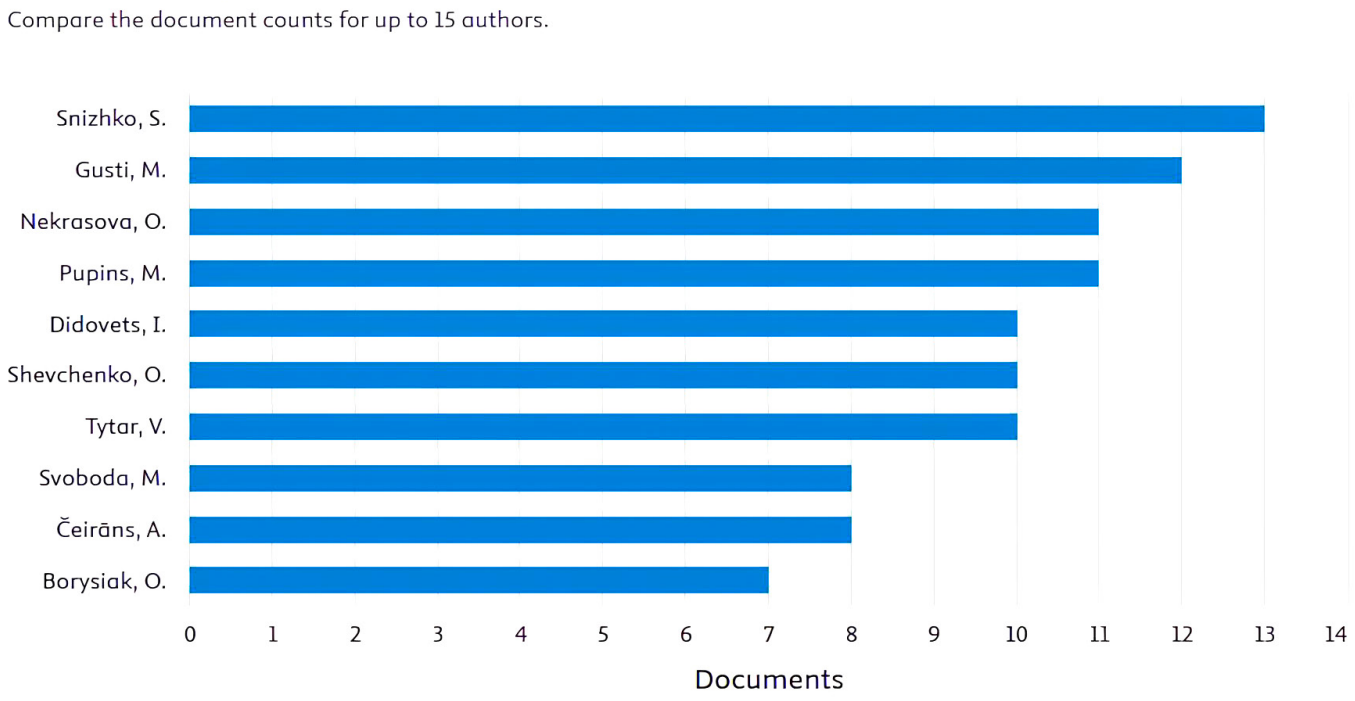

Fig. 3. Documents by authors

to quantity in research can highlight institutions that are actively engaged in climate research and attract significant funding. Additionally, the level of their collaboration with other institutions, such as international universities or non-governmental organizations, can also be assessed.

Identifying leading researchers and institutions has great practical significance. It helps in building scientific consortia for addressing global challenges together. For example, if a group of researchers working on climate change adaptation is identified, cooperation can be initiated between them and institutions involved in developing technologies for reducing greenhouse gas emissions. This approach allows for the integration of expertise from different fields, creating interdisciplinary platforms for innovation.

Moreover, identifying leading scientists contributes to the search for potential mentors for young researchers and strengthens the human resources capacity in the field of climate research. For example, young scientists can collaborate with leaders, learn from their experience and methodologies, which will help foster the development of new generations of climate experts.

In our case, however, researchers from institutions of the National Academy of Sciences of Ukraine often affiliate themselves with the Academy as a whole rather than with specific research institutions. This presents a challenge for analysis, as it becomes difficult to accurately identify the contributions of individual institutions within the Academy. Many researchers in Ukraine are more likely to emphasize their affiliation with the broader Academy rather than specifying their particular institution, which may lead to a lack of detailed data for scientometric analysis at the institutional level.

This situation complicates the process of identifying leading institutions, as the contributions of individual research centers may be masked by the general affiliation with the Academy. As a result, we may face challenges in tracking collaborative networks, funding sources, and research outputs linked to specific institutions. Additionally, it may hinder the ability to assess the impact of certain institutions on the development of climate research, as the data may not fully reflect the institutional differences within the broader structure of the National Academy of Sciences. This issue highlights the need for more granular data collection and clearer institutional affiliations in order to better understand the contributions of specific re-

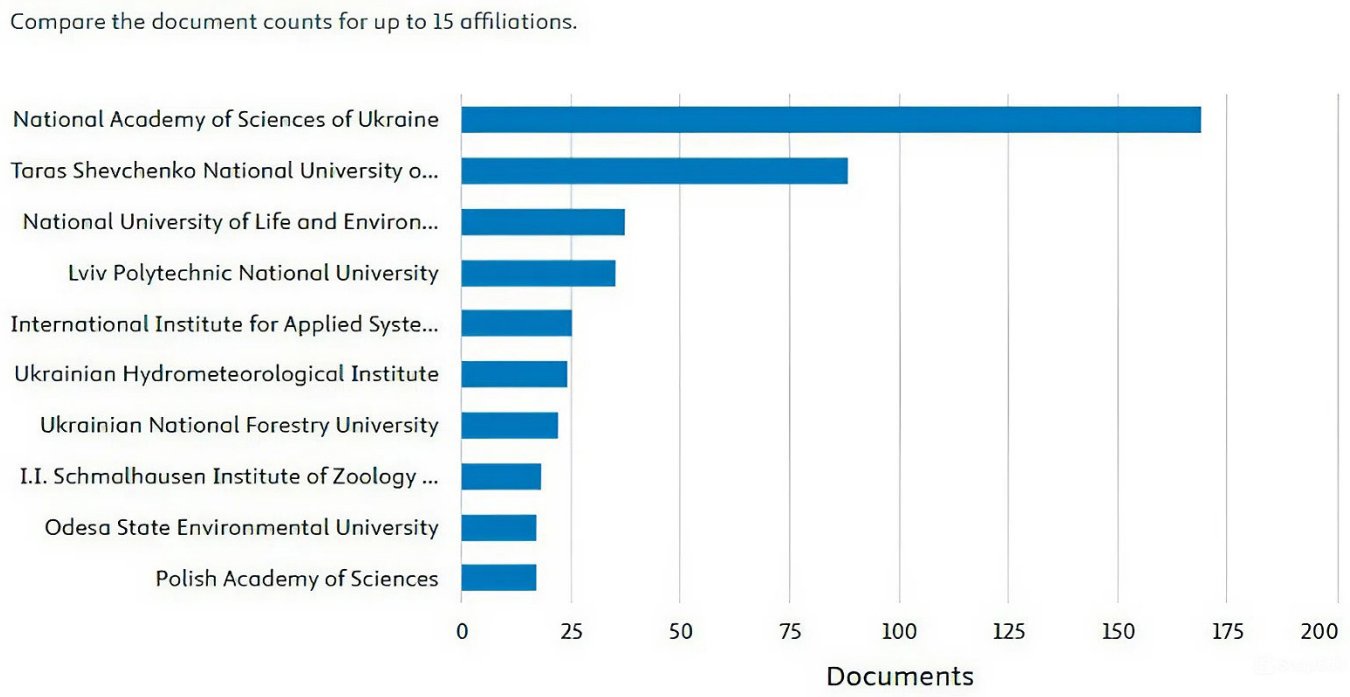

Fig. 4. Documents by affilations

search institutions to climate change studies in Ukraine.

Another important aspect is the evaluation of the geographical distribution of leading researchers and institutions. Scientometrics allows for the identification of which countries or regions are leaders in climate change research. This is crucial for identifying gaps in global scientific collaboration. For example, the analysis may reveal that some countries with high levels of climate change risk are underrepresented in international research consortia. In such cases, strategies can be developed to involve their scientists and institutions in global initiatives.

Ultimately, identifying leaders in climate change research not only facilitates the formation of partnerships but also creates the conditions for effectively implementing research findings in practical applications. This enables the development of policies and innovations that address the challenges of climate change and have a significant socio-economic impact.

An analysis of the funding for climate change research can offer valuable insights into the global landscape of efforts to tackle this critical issue. By examining the sources and amounts of financial support directed towards climate-related research, we can identify the leading institutions, countries, and regions involved in this field. Such an analysis also helps uncover disparities in the distribution of funding, shedding light on areas that may require additional resources or support (Fig. 5).

For instance, the European Commission emerges as the largest contributor, with 42 instances of funding, reflecting Europe's strong commitment to addressing climate change. Similarly, the Ministry of Education and Science of Ukraine, with 28 instances, signals the importance of governmental involvement in climate research in Ukraine. This indicates a significant effort on the part of Ukrainian authorities to engage in global climate change initiatives.

The National Science Foundation of the United States (16 instances) and the Horizon 2020 Framework Programme (15 instances) are other notable sources of funding, demonstrating substantial investments from both the U.S. and the European Union in advancing climate research. These contributions highlight the active role played by large international funding bodies in fostering scientific advancements related to climate change.

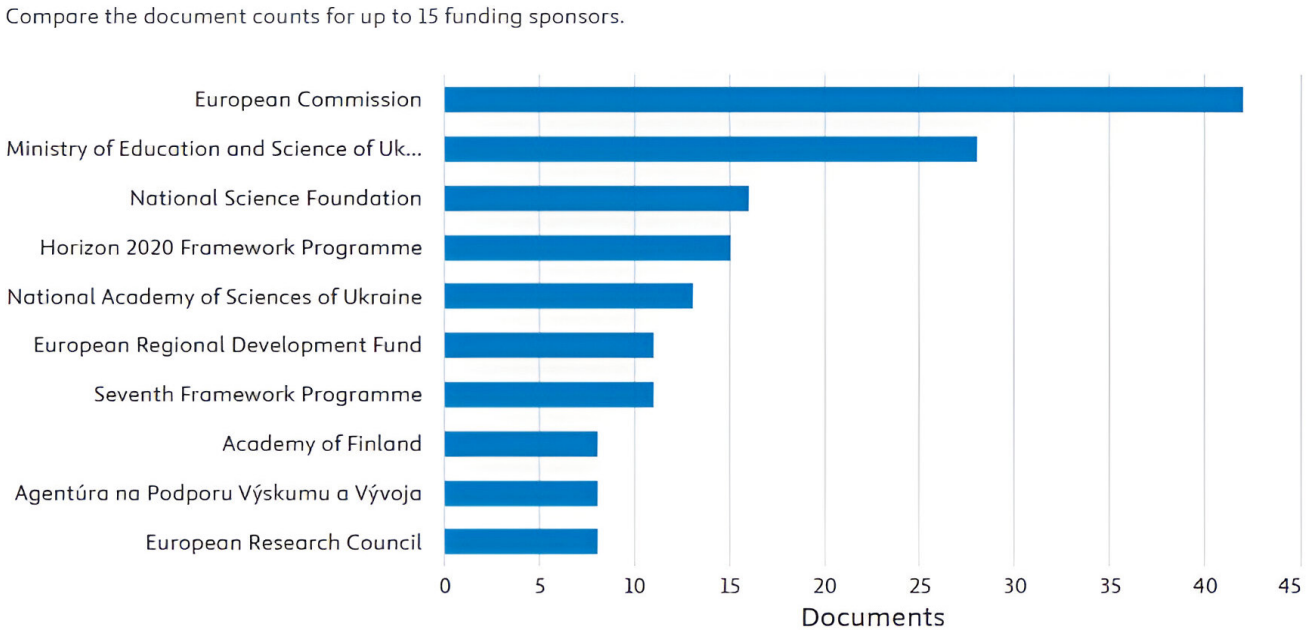

Fig. 5. Documents by funding

Moreover, international funding organizations such as the European Research Council (8 instances) and the National Natural Science Foundation of China (8 instances) emphasize the global nature of the climate research effort. These organizations are crucial in ensuring that both developed and developing nations contribute to and benefit from climate change research, which is essential for achieving a unified global response to climate challenges.

The funding landscape also includes a diverse range of contributors, such as the Bill and Melinda Gates Foundation, NASA, and the National Geographic Society, further illustrating the broad interest in addressing climate change from various sectors, including philanthropy, space agencies, and scientific organizations. This diverse funding ecosystem is critical for driving innovation and collaborative efforts in climate change research.

By analyzing the distribution of funding sources, we gain a clearer understanding of which regions and institutions are currently leading the charge in climate change research. It also helps identify potential gaps in funding or areas where additional resources may be needed. For example, countries at high risk from climate change that are underrepresented in the funding data could be targeted for increased research collaboration and financial support. Overall, such an analysis provides valuable insights into the current state of global climate change research and helps shape future strategies for international cooperation and funding allocation.

Policy impact research is a vital component of scientometric analysis, enabling the evaluation of how scientific results are integrated into the policymaking process addressing climate change. Such analysis is based on the study of citations of scientific works in policy documents, official reports, strategies, government resolutions, and other regulatory acts related to climate change.

Citations of scientific publications in policy documents serve as a direct indicator of how research influences policymaking, particularly in the context of climate adaptation and greenhouse gas emissions reduction. Scientometric analysis, in particular, allows for identifying which scientific works have laid the foundation for developing government strategies, how they were utilized to justify specific policy decisions, and the extent to which they contributed to formulating concrete actions at international, national, or regional levels.

One critical aspect of this analysis is assessing how relevant scientific findings were incor-

porated into decision-making within a specific timeframe. This helps reveal the responsiveness of policymakers to new scientific data, reflecting the level of collaboration between scientific and political institutions. The faster scientific results are reflected in policy decisions, the more effective climate adaptation efforts become.

For instance, the analysis can identify which scientific articles, reports, studies, or projects underpinned international climate agreements, such as the Paris Agreement, or national climate strategies. For example, if a scientific publication on climate adaptation strategies served as the basis for developing a national program to strengthen infrastructure or manage water resources, it represents a significant indicator of science's influence on policy.

It is also crucial to consider the type of policy documents citing scientific research. For example, if scientific works are extensively cited in international reports on global climate change, this indicates that the research is internationally recognized and used to shape global policies. Conversely, citations in national reports or strategies may point to more localized integration of scientific findings into policy practices.

This type of analysis also helps identify which academic schools, research institutions, or individual scientists contribute most significantly to shaping climate policy. By examining citations of their works, one can determine who the key drivers of new ideas and concepts influencing state strategies are. These strategies may include cutting-edge technologies for emissions reduction, adaptation strategies for agriculture, or ecosystem management under changing climate conditions.

Policy impact assessment through scientometric methods also highlights potential gaps in scientific research that have yet to be reflected in policy decisions. For example, if certain aspects of climate change, such as impacts on health or biodiversity conservation, receive insufficient attention in policy documents, this may indicate the need for further research and publications to address these gaps.

Scientific influence on climate policy can be measured not only by the number of citations but also by the quality of these citations–that is, whether scientific research is used to substantiate critical policy steps. This includes evaluating whether scientific works support decisions with long-term effects, such as in the fields of energy, construction, or transport infrastructure.

Thus, scientometric analysis of citations in policy documents is a powerful tool for examining how science shapes climate-related policies and how research findings contribute to effective decision-making, ensuring sustainable development and mitigating the impacts of climate change.

For instance, the Kyoto Protocol served as a catalyst for Ukraine's environmental research and policy development. While the implementation of its mechanisms faced criticism, the Protocol's influence on the scientific community was undeniably positive. The increased volume of research outputs reflects the growing acknowledgment of science as a cornerstone for effective climate action in Ukraine. The alignment of Ukraine's climate commitments with the global scientific agenda created opportunities for international collaboration. Ukrainian scientists contributed to joint research projects, particularly within the frameworks of EU programs, and gained access to funding and expertise through partnerships with foreign institutions. This collaborative approach not only enhanced the quantity of scientific publications but also improved their quality and relevance in addressing global challenges.

The analysis of innovative impact is a key aspect of scientometric research, enabling the evaluation of how scientific studies in the field of climate change are translated into specific technological solutions and innovations for sustainable development. This analysis involves studying patents derived from scientific works and examining their connections to publications to understand how scientific knowledge and research are applied practically in engineering, technology, and industry.

Patents related to climate change often emerge as the result of innovative scientific ideas developed during research. For instance, these could include new water treatment technologies, the development of alternative energy sources,

methods for reducing greenhouse gas emissions, or advancements in eco-friendly materials and products. The innovative impact of scientometric analysis lies in its ability to not only examine patents but also trace their links to scientific publications, thereby identifying the research that leads to the creation of new technologies.

The connection between scientific publications and patents is of great importance since publications often represent the initial stage in the development of innovative ideas. Researchers publish their findings, which can serve as a foundation for subsequent technological advancements. Engineers, technologists, and entrepreneurs can use these publications to create new products and processes that align with the goals of sustainable development and reduced environmental impact.

Patent analysis in the context of climate change helps identify specific technologies that have the greatest impact on addressing climate challenges. For example, patents related to wind and solar power technologies demonstrate how energy research contributes to the development of renewable energy sources. Studying such patents not only provides insights into the volume of innovations but also assesses their practical application in industry and markets.

Through scientometric analysis, it is possible to evaluate the level of innovative activity arising from scientific research. This allows an understanding of whether there is progress in the commercialization of scientific developments and which technologies are most widely adopted in combating climate change. Scientometric approaches also help identify the countries or institutions leading the development of innovations for sustainable development and study the global dissemination of these technologies.

Innovative impact can be assessed not only by the number of patents but also by their social and economic effects. For example, technologies that reduce energy consumption or environmental pollution can foster the creation of new markets, generate jobs, and improve quality of life. Scientometric analysis explores how such innovations are integrated into industry or daily life.

Moreover, analyzing patents in the context of climate change helps identify key institutions actively working on technologies for sustainable development, as well as determining which scientific fields hold the greatest potential for innovation. This analysis also reveals the influence of scientific research on economic and political decisions, as patents can form the basis for new legislative initiatives or innovation support programs aimed at environmental preservation.

Thus, scientometric analysis of the innovative impact of climate change research serves as an important tool for understanding how scientific studies lay the groundwork for technological solutions capable of addressing climate challenges. It enables the evaluation of how scientific ideas are transformed into real innovations with the potential to improve quality of life and ensure sustainable development in the face of climate change.

Contributing to Sustainable Development Goal (SDG) 13, which focuses on combating climate change, is a vital aspect of analyzing scientific research, and scientometric tools provide valuable opportunities to assess this contribution. Through scientometric data, it is possible to identify which studies contribute to solving climate-related challenges and how these studies integrate into the broader context of sustainable development. This approach reveals how scientific efforts in specific areas, such as energy, ecology, technology, and social sciences, help achieve not only SDG 13 but also other interconnected sustainability goals.

Scientometric tools enable the analysis of scientific publications addressing climate change issues and assess their contributions to global initiatives aimed at resolving these challenges. For example, citation analysis can uncover which studies have formed the basis for political strategies or technological developments directly impacting climate change mitigation. Integrating such research into global initiatives or national programs is a key aspect of evaluating their contributions to SDG 13.

Furthermore, scientometric analysis provides insights into how studies from various scientific domains—such as environmental sciences,

energy, urban planning, agriculture, engineering, and social sciences—integrate into broader sustainable development strategies. For instance, scientometric analysis can demonstrate how ecological studies supporting climate adaptation strategies interact with research aimed at improving carbon emission reduction technologies or biodiversity conservation.

Additionally, scientometric methods allow for the assessment of collaboration levels among countries, research institutions, and other stakeholders, which is crucial for achieving global climate goals. These insights can identify key regions or institutions actively working on solutions contributing to SDG 13 and evaluate their influence on policy development, international agreements, or scientific initiatives.

Lastly, analyzing how climate change research aligns with other SDGs — such as SDG 7 (Affordable and Clean Energy), SDG 11 (Sustainable Cities and Communities), or SDG 12 (Responsible Consumption and Production) — is another important aspect. Scientometric data can reveal how climate change studies impact addressing these challenges, highlighting the interconnection between various aspects of sustainable development.

In conclusion, scientometric analysis of contributions to SDG 13 enables the identification of scientific studies with the greatest impact on developing solutions and policies addressing climate change. It also reveals how these studies influence the broader picture of global sustainable development. This tool is indispensable for evaluating the effectiveness of scientific efforts in achieving global goals, ensuring greater transparency, and adopting a strategic approach to solving climate change challenges.

Geographic analysis in scientometrics is a powerful tool for studying territorial features and global patterns of scientific research, particularly those related to climate change. Scientometric analysis allows researchers to trace how scientific work is distributed across different regions of the world, identify zones of high activity, and pinpoint areas where climate change research needs significant intensification. This approach provides a clearer understanding of global trends and enables targeted intervention by the scientific community, governments, and international organizations to address climate-related challenges.

The analysis of scientometric data makes it possible to determine which regions or countries concentrate the majority of climate change research. It is crucial to identify scientific centers and institutions actively working in this field and to examine the research published in these regions. This analysis reveals regions with high levels of scientific activity and achievements in climate change studies, as well as areas where there is a lack of research in this field. Such insights are especially important to understand where global efforts to combat climate change are underrepresented or need reinforcement.

One of the key advantages of geographic analysis is its ability to highlight regions that are at high risk of climate change impacts but lack sufficient research or development in this area. These may include countries or regions experiencing instability, such as those affected by economic or political crises, or those with limited access to funding for scientific research. In such cases, scientometric analysis can identify the need for intensified scientific initiatives to assess and mitigate climate threats in these areas.

On the other hand, geographic analysis also helps identify countries or regions that are leaders in climate change research. These are places where scientific articles are actively published, new methodologies are developed, or international projects are initiated. Such countries often have advanced scientific infrastructures, numerous universities and research institutions, and strong participation in international scientific collaborations. Identifying these leaders facilitates the exchange of experiences, intellectual resources, and best practices among countries and research institutions.

Regional analysis also uncovers geographic patterns and trends in publications related to specific aspects of climate change, such as temperature fluctuations, sea-level rise, land degradation, or the increasing frequency of extreme weather events. For example, studying publications on climate change in low-lying coastal

areas may reveal a growing body of research on sea-level rise and its impact on ecosystems and populations. Meanwhile, in mountainous regions, researchers may focus on adaptation strategies to changes in precipitation or temperature regimes.

The analysis also identifies key regions that require greater attention from the scientific community, particularly in industrializing countries or rural areas where climate change could have severe socio-economic consequences. These are often territories where the effects of climate change are insufficiently studied or where there is no solid foundation for developing effective adaptation policies.

In conclusion, geographic analysis of scientometric data on climate change opens up critical pathways for further scientific research and practical initiatives. It enables more precise alignment of scientific efforts aimed at addressing specific problems in various parts of the world, facilitates more targeted international collaboration, and optimizes resources for effectively combating climate change on a global scale.

CONCLUSIONS

The bibliometric analysis of scientific research trends related to climate change provides valuable insights into the evolution of research interests and the identification of emerging topics. By tracking the number of publications, citations, authors, and institutions, bibliometrics allows for a comprehensive understanding of the dynamics of scientific activity in the field of climate change. The data reveal key patterns in research, showing how interest in climate change has grown significantly, particularly since 2010, as global awareness and technological advances have driven new methodologies and areas of focus.

The analysis highlights several core areas of research, such as Environmental Science, Earth and Planetary Sciences, and Agricultural and Biological Sciences, which are central to understanding climate change impacts on ecosystems, agriculture, and biodiversity. Other important areas, including Engineering, Social Sciences, and Economics, emphasize the interdisciplinary nature of climate change research, highlighting the need for integrated solutions that address both scientific and socio-economic challenges. Furthermore, the presence of research in less-explored fields such as health and veterinary sciences indicates a growing recognition of the broader implications of climate change on human and animal health.

One of the significant advantages of scientometrics is its ability to identify emerging research «hotspots» and knowledge gaps. Areas such as climate scenario modeling, renewable energy, and the socio-economic impacts of climate change are growing rapidly in terms of publication output and citation frequency. At the same time, the identification of under-researched regions or topics enables the strategic allocation of resources and funding to address urgent and underexplored issues in climate change science.

The interdisciplinary approach is essential for solving the complex challenges posed by climate change. Scientometric tools facilitate the identification of collaborative efforts between different scientific fields, such as the intersection of ecology and economics or engineering and social sciences, and measure the impact of such interdisciplinary research on both academic and policy-making circles. This integrated approach is vital for developing innovative solutions that consider both the technical and socio-economic dimensions of climate change.

Furthermore, the identification of leading researchers and institutions plays a critical role in fostering collaboration and global cooperation. By analyzing performance indicators such as publication counts, citation indices, and institutional collaborations, scientometrics helps to identify key players in climate change research, promoting the creation of scientific consortia and partnerships. These collaborations are essential for addressing the global challenges of climate change and for ensuring the effective application of research findings.

The analysis of scientific research trends related to climate change, through the use of bibliometrics, reveals important insights into the development of this critical field. The identification of key areas of focus, such as the growing

attention to environmental science, Earth and planetary sciences, and agriculture, highlights the multifaceted approach required to tackle climate change. It is clear that addressing climate change requires an interdisciplinary effort that spans across different scientific domains, integrating knowledge from environmental sciences, engineering, economics, and social sciences. The growing number of publications in these fields shows an increasing recognition of the complexity of climate challenges.

However, the study also reveals several challenges related to the lack of granularity in institutional data, especially in the context of Ukraine. Many researchers affiliated with the National Academy of Sciences of Ukraine tend to identify with the Academy as a whole rather than with specific institutions. This makes it difficult to accurately track contributions from individual research centers, hindering the ability to evaluate their roles in advancing climate change research. Therefore, improving the collection and reporting of data on institutional affiliations will be critical to refining scientometric analysis and understanding institutional contributions to climate change science in Ukraine.

The analysis of funding sources highlights the central role of international organizations, such as the European Commission and the National Science Foundation of the United States, in supporting climate change research. However, it also reveals potential disparities in the global funding landscape, with certain regions, particularly those most affected by climate change, being underrepresented. Targeted efforts to increase funding for these regions and facilitate international collaborations are necessary to ensure a more equitable global research effort.

Furthermore, the policy impact of scientific research is a crucial element in bridging the gap between scientific discovery and practical application. By evaluating the incorporation of scientific findings into climate policies, it is possible to assess the extent to which research influences decision-making at both national and international levels. Identifying key researchers and institutions whose work shapes climate policy can guide future collaborations and ensure that scientific knowledge is effectively translated into actionable climate strategies.

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ПОТЕНЦІАЛ НАУКОМЕТРИЧНОГО АНАЛІЗУ ДЛЯ ВИВЧЕННЯ ПИТАНЬ ЗМІНИ КЛІМАТУ: ПРИКЛАД УКРАЇНИ

Анотація. *Дослідження зміни клімату має критично важливе значення через її широкомасштабний вплив на екосистеми, економіку та соціальні структури. Зміна клімату, включно з підвищенням температури, підняттям рівня моря, екстремальними погодними явищами та посухами, уже завдає значної шкоди людям, біорізноманіттю та довкіллю, що підкреслює необхідність проведення досліджень для розроблення стратегій адаптації та пом'якшення наслідків. Крім того, розуміння базових механізмів кліматичних процесів є необхідним для прогнозування майбутніх наслідків та створення ефективних політик і технологій. Такі зусилля є ключовими для скорочення викидів парникових газів, переходу до відновлюваних джерел енергії та запобігання природним катастрофам.*

Окрім цього, дослідження зміни клімату відіграє важливу роль у глобальних наукових і політичних дискусіях, впливаючи на формування міжнародних угод і законодавства, що підтримують сталий розвиток та охорону довкілля. Наукові знання сприяють ухваленню обґрунтованих рішень на міжнародному, національному та місцевому рівнях, зокрема у створенні стратегій соціальної підтримки вразливих груп населення, зокрема тих, що проживають у бідних регіонах та малих острівних державах.

У цьому дослідженні застосовано бібліометричний аналіз для вивчення наукового ландшафту досліджень зі зміни клімату, зокрема для виокремлення ключових напрямів, визначення прогалин у знаннях і визначення пріоритетних сфер для подальших досліджень. Бібліометрія також допомагає оцінити міждисциплінарний характер досліджень у цій галузі, що охоплює широкий спектр дисциплін — від екології до соціальних наук, — та надає уявлення про внесок наукових досліджень у досягнення Цілей сталого розвитку. Такий підхід сприяє кращому розумінню географічних аспектів досліджень зі зміни клімату, формуванню наукових пріоритетів і підвищенню впливу досліджень на розв'язання практичних проблем.

Для аналізу використано дані платформи Scopus щодо публікацій, присвячених адаптації до зміни клімату, зменшенню ризику стихійних лих, сталим сільськогосподарським практикам і циркулярній економіці. Усього ідентифіковано 1 689 документів за період з 1991 по 2024 рік, за якими проведено описову статистику. У дослідженні застосовано методи структурної наукометрії, включно з аналізом бібліометричних зв'язків, співавторства та спільного цитування, а також картуванням когнітивних структур, що забезпечує комплексне бачення еволюції досліджень зі зміни клімату. Результати показали, що науковий інтерес до цієї тематики суттєво зріс після 2010 року, що стало переломним моментом у глобальному усвідомленні та дослідницькій активності.

Ключові слова: *наукометричний аналіз, зміна клімату, Україна.*

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