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Examining Climate Change Issues for Improving Cross-Generation Awareness in 21st Century Agenda: A Bibliometric Approach

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ABSTRACT

Climate change and cross-generation awareness have been widely investigated by the academic community, and numerous research findings have emerged. A bibliometric analysis of 401 academic works related to climate change and cross-generation awareness published between 1993 and 2023 is presented in this paper to characterize the intellectual landscape by identifying and revealing the basic characteristics, research power, intellectual base, research topic evolution, and research hotspots in this field using VOSviewer. According to the findings, the number of publications in this sector has expanded fast, and the discipline has become more interdisciplinary. The findings show that: 1) the number of publications in this field has increased rapidly and the field has interdisciplinary; 2) the most productive authors and institutions in this subject area are in the United Kingdom, United States, Australia, China, South Africa, Germany, Sweden, Canada, Netherland, Spain, and their cooperation is closer than that of other researchers in the field; 3) 210 of the 401 papers analyzed in this study have played a key role in the evolution of the field; and Scholars are becoming increasingly concerned about drought issues. 4) In this article, we divide research hotspots into three decades-long eras (1993-2002, 2003-2012, and 2013-2023). This study provides an in-depth review of climate change and cross-generational awareness research to better comprehend the worldwide trends and tendencies that have formed in this subject over the last 30 years, as well as a reference for future research in this field.

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1. INTRODUCTION

Scientific study on climate change and cross-generational awareness during the previous three decades utilizing bibliometric analysis is an alternative study for interpreting trends mapping in social science. Human activities, particularly the combustion of fossil fuels, have increased the concentration of greenhouse gases in the atmosphere since the Industrial Revolution, resulting in global climate change leading to global warming (Yoro & Daramola, 2020). Climate change has become one of the top ten ecological problems confronting humans relating to cross-generational awareness (Diprose *et al*., 2019). In the climate change study, the term cross-generational awareness was into five components: knowledge, climate-friendly behavior, multiplicative actions, attitude, and personal concern (Barnes *et al*., 2019).

How to slow down, adapt to, and safeguard the environment including human awareness of multi-generation in the face of climate change has become a hot topic in the international community (Malhi, 2020). In the early 1990s, the United States, the United Kingdom, and the Netherlands assumed the lead in performing climate change and awareness research, followed by other countries (Degroot, 2021). To deal with climate change, scholars have been researching cross-generational awareness in the earth's ecosystems (Almassi, 2017). This climate change has had a significant impact on the concept of sustainable development (Cramer, 2018). Although many studies have been undertaken, little emphasis has been made on describing the research trends in this topic. Some expert-authored empirical and qualitative review articles have provided an overview of the topic of climate change and cross-generational awareness research; however, they tend to be sparse in some specific features, such as regions, issues, and ecological systems. Furthermore, standard review articles make it difficult to effectively arrange, synthesize, and quantitatively examine the progress of a certain area across a vast number of studies over a long time. Climate change and cross-generational awareness are also interdisciplinary research subjects that include environmental science, geographical area, forest products, atmospheric sciences, environmental engineering, and social science (Brownlee *et al*., 2013).

Climate change, according to various research, could pose global and unprecedented threats to humanity (Yoro & Daramola, 2020; Al-Ghussain, 2019). Climate change, for example, is expected to create intense heat waves, acute droughts, and air pollution, as well as the danger of catastrophic flooding (Banholzer *et al*., 2014), which might lead to water scarcity, food insecurity, hunger, and malnutrition (Yoro & Daramola, 2020; Banholzer *et al*., 2014). Similarly, analysts believe that climate change will exacerbate the effects of pollution and environmental issues, posing serious dangers to human health, well-being, and safety (Maibach *et al*., 2015). Climate change, according to the World Health Organization (WHO), will have a significant impact on human health in a variety of ways, including disruptions in drinking water supplies, nutritional food composition, and safe housing (Balbus *et al*., 2013). These climate change issues necessitate more expansive imaginations that are responsive to the situated and interconnected worlds that we inherited and transmit throughout time, generations, and species (Almassi, 2017).

Given the current and possible impacts of climate change on humans, ecosystems, and the environment, worldwide analysts believe that severe action is required to study, reduce, and mitigate climate change to avoid future devastating and costly consequences related to awareness (Capstick *et al*., 2015). Many strategic strategies and transformative initiatives have been proposed over the years to reduce CO2 and other greenhouse gas (GHG) emissions and surface temperatures around the world to better recognize and respond to the effects of climate change (Yoro & Daramola, 2020; Banholzer *et al*., 2014). Similarly, sustainable

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approaches and innovative technologies are being used to predict and comprehend the effects of climate change on numerous sectors (Cramer, 2018). The use of computational approaches such as artificial intelligence (AI), the Internet of Things (IoT), and deep machine learning is one such strategy (Messaoud *et al*., 2020). To create a comprehensive overview of the study of climate change and cross-generational awareness, bibliometric analysis is needed.

2. LITERATURE REVIEW

Besides the strictly scientific components of climate research, much of the contemporary interest in it has been driven by the accumulation of observational and modeling information on the ways humans influence the climate system, involving cross-generational knowledge (Donelson *et al*., 2018). To review and coordinate the scientific community's research activities in this area, the United Nations Environment Program (UNEP) and the World Meteorological Organization (WMO) established the Intergovernmental Panel on Climate Change (IPCC) in 1988; its assessment reports (ARs) are issued every 4-6 years (Van Beek *et al*., 2020). The ARs describe scientific advances, unresolved problems, and bottlenecks in our ability to detect, model, analyze, and predict the evolution of the climate system by assembling systematic reviews of pertinent scientific literature (Torres *et al*., 2022). Evolution of climate models across the first four IPCC assessment reports, ranging from the early 1990s to the mid-2000s (**Figure 1**) (Ghil & Lucarini, 2020).

Many climatic variables are now being remotely sensed from the most remote areas of the globe; for example, they measure the overall intensity and spectral parameters of emitted infrared and displayed noticeable and ultraviolet radiation, as well as complex algorithms relate these basic measurements to actual atmospheric properties such as temperature and the amount of cloudiness (Adjovu *et al*., 2023). The growth of the observational network for climate data is depicted schematically in **Figure 2**.

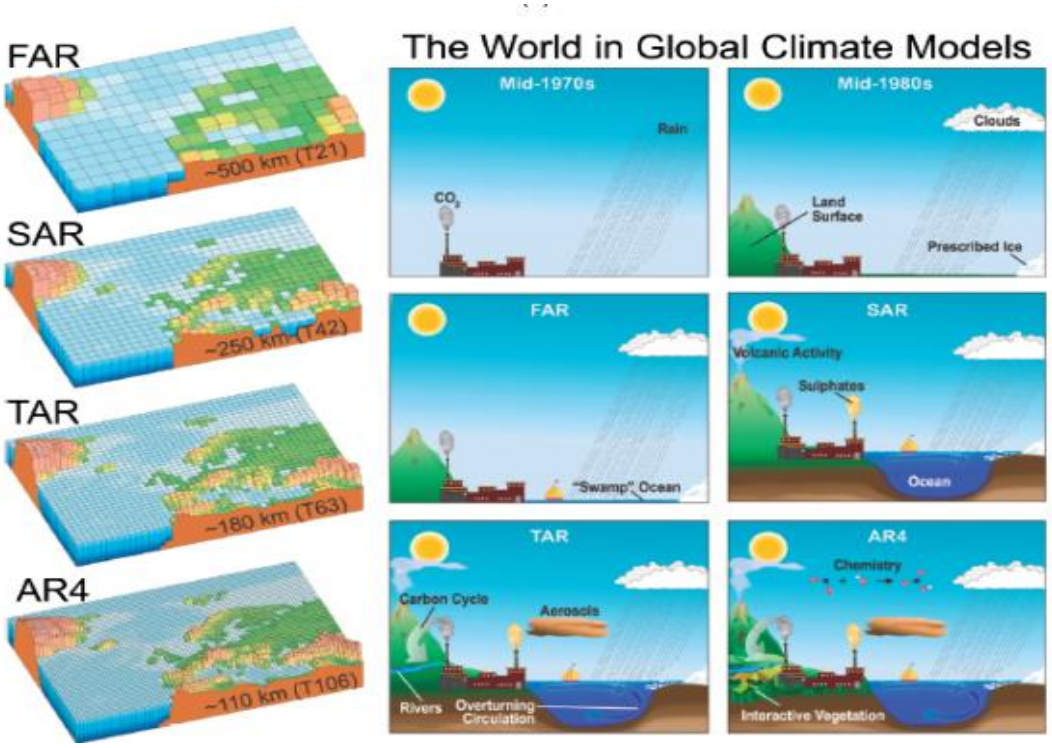

Figure 1. The evolution of climate models over the first four IPCC assessment reports, from the early 1990s to the mid-2000s (Ghil & Lucarini, 2020).

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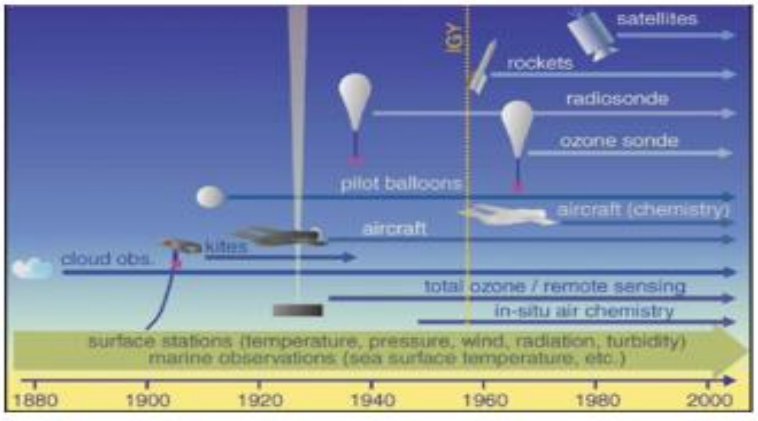

Figure 2. The evolution of the weather and climate data observation network (Ghil & Lucarini, 2020).

Because perceptions of climate change risk among generations are poorly understood, the theoretical model is based on environmental behavior theory and incorporates current knowledge of how generations perceive the environment (Skeirytė *et al*., 2022). The Value Belief Norm (VBN) theory of environmentally responsible behavior draws on several awareness-related behavior theories to form a causal chain of variables: personal values, a set of beliefs about the environment, awareness of consequences, attribution of responsibility, and personal norms for environmental action (Fenitra *et al*., 2022). Risk perception can be viewed as awareness of consequences using the VBN framework; values help generate beliefs, which is illustrated in **Figure 3**. turn influence risk perception (awareness of consequences) (Mamun *et al*., 2022).

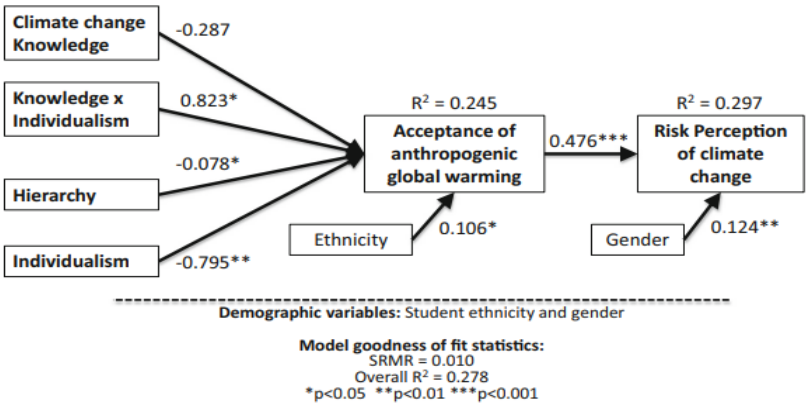

Figure 3. Path diagram model for climate change risk perceptions and awareness among adolescents (Mamun *et al*., 2022).

3. METHOD

The purpose of this paper is to explore the present research landscape on the use of machine learning algorithms in addressing climate change and cross-generational awareness. To that purpose, we established that a procedure that would provide more accuracy in determining the sample database was required. As a result, we adhered to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines given by Ref. to discover, screen, and evaluate published documents (or publications) for a bibliometric review, the PRISMA approach was used (**Figure 4**) (Wong *et al*., 2022).

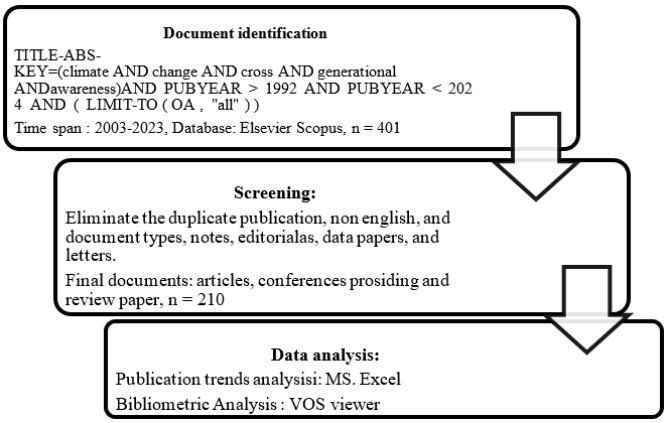

Figure 4. PRISMA methodology for published documents data identification, screening, and analysis.

This study determines bibliometric characteristics and visualizes the interactions between articles in this field published in Scopus journals between 1993 and 2023 using a bibliometric analysis based on Vos Viewer to present a comprehensive and target overview of the scientific literature on climate change and carbon sinks. The objectives of this study are as follows: (1) determining the key features of the literature, such as the number of articles and citations, research subject categories, and representative journals; (2) determining the research power of this research area, such as the corresponding countries, institutions, and authors; (3) recognizing the intellectual base based on frequently cited references; and (4) uncovering the changing trends in research topics and hotspots over time. (5) identifying future research prospects. Our findings could help scholars all over the world better grasp the present state and most recent studies in this sector, thereby encouraging more research.

This study uses the Scopus core collection as the object database, which includes the keyword (climate AND change AND cross AND generational AND awareness) as the retrieval condition, with a period of 1993-2023. The downloaded literature records were saved in the format .csv, which was utilized as the sample data in the study. This study used three types of bibliometric approaches given by VOS viewers to provide a systematic overview of climate change and cross-generational awareness research and achieve the desired objectives: cooperation analysis, co-citation analysis, and keyword co-occurrence analysis. Collaboration analysis uses author names, countries of affiliation, and institutional affiliation as the units of analysis and visualizes scientific collaboration networks to evaluate their publication contributions and academic influences. Document co-citation analysis examines the amount and authority of references mentioned by publications and provides views into the intellectual structures of a knowledge area.

4. RESULTS AND DISCUSSION

Figure 5 depicts the trends in the number of articles recognized by Scopus that were relevant to climate change and cross-generational awareness during the previous 30 years. In terms of quantity, research on climate change and cross-generational awareness has usually progressed from moderate growth (after 2003) to a steady increase (2001-2010) to rapid expansion (2012-present). In the early 1993s, relevant academics did not begin to pay particular attention to this research subject, and studies on climate change and cross-generational awareness were none. However, because this discipline was in its early stages of development, the amount of material available before 2000 was limited. Between 2003 and 2013, 15 papers on climate change and cross-generational awareness were published.

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However, between 2013 and 2023, 194 papers focusing on climate change and cross-generational awareness were published worldwide. which increased by 75.75% in the following decade (**Figure 5**).

Figure 5. Increasing number of articles.

Table 1 illustrates the total publication output of a country as well as the average publication year of articles published by scholars from that country. With extraordinarily high publishing outputs (37.8%) of total publication output combined), the United States and the United Kingdom stand out among countries active in climate change and cross-generational awareness research. However, there is a big discrepancy between the United States and the United Kingdom: in the United States, the average publishing year is 40, whereas in the United Kingdom, it is 36. This pattern shows that climate change and cross-generational awareness research has just recently acquired traction in the United States, and given the discrepancy in publishing dynamism between the two nations, Australia and China may soon be the world's leading innovators in Climate change and cross-generational awareness.

Table 1. The most popular country of publication between 2003-2013 (first decade) and 2003-2013 (second decade).

Country	Number of Publication	Country	Number of Publication
South Africa	4	United Kingdom	40
Australia	3	United States	36
India	3	Australia	23
Sweden	3	China	18
United Kingdom	3	Germany	16
United States	8	Canada	14
Canada	1	South Africa	14
Chile	1	Sweden	13
France	1	Netherlands	11
Germany	1	Nigeria	9

We applied keyword analysis to uncover a long-term evolution of sustainable cities and communities research subjects and hotspots. **Table 2** shows the keywords having the most citations between 2003 and 2023. We classified terms into three primary evolution clusters based on their keyword pattern. As a confirmation of the previous section's findings, the initial keywords in Cluster #1 are connected to "awareness" and "cross-generational awareness," which were the strongest keywords in the first cluster. The majority of the keywords in Phase

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1 represent the social side of climate change issues. Cluster #2's keywords are divided into two groups. One line has the keywords "environmental change" and "evolutionary awareness", its effects ("urbanization"), and the possibility of reducing it through education means ("cross-generational effect planning and evolutionary awareness"). The keywords in Cluster #3 fall into two categories. One of the keywords is related to climate change ("climate change adaptation"). The other keywords highlight the research's sustainability aspect; nonetheless, "sustainable development" is one of the most recently utilized terms.

Table 2. The most popular keyword on climate change issues and cross-generational awareness research.

No.	Cluster #1	Cluster #2	Cluster #3
1.	Awareness	Environmental change	Climate change
2.	Cross-generational awareness	Ecology	Climate change adaptation
3.	Understanding	Evolutionary biology	Global change
4.	Knowledge	Environmental exposure	Biodiversity
5.	Social change	Temperature	Social justice
6.	Global warming	Rapid environmental change	Knowledge system
7.	Cross-generational comparison	Cross-generational transfer	Sustainable development
8.	Cross-generational dialogue	Cross-generational effect Planning	Ecology
9.	Future climate change	Evolutionary awareness	Cross-generational challenge
10.	Collaboration	urbanization	Cross-generational impact

The overlay visualization, as shown in Fig. 6, includes the most recent terms from research on climate change and cross-generational awareness. Keywords in Clusters 1 and 3 are more likely to be related to research on the latest trend of climate change issues and cross-generational awareness than keywords in Cluster 2. Based on this data, we can conclude that the study of the relationship between climate change and cross-generational awareness has gained widespread attention among researchers, pushing awareness research to the margins.

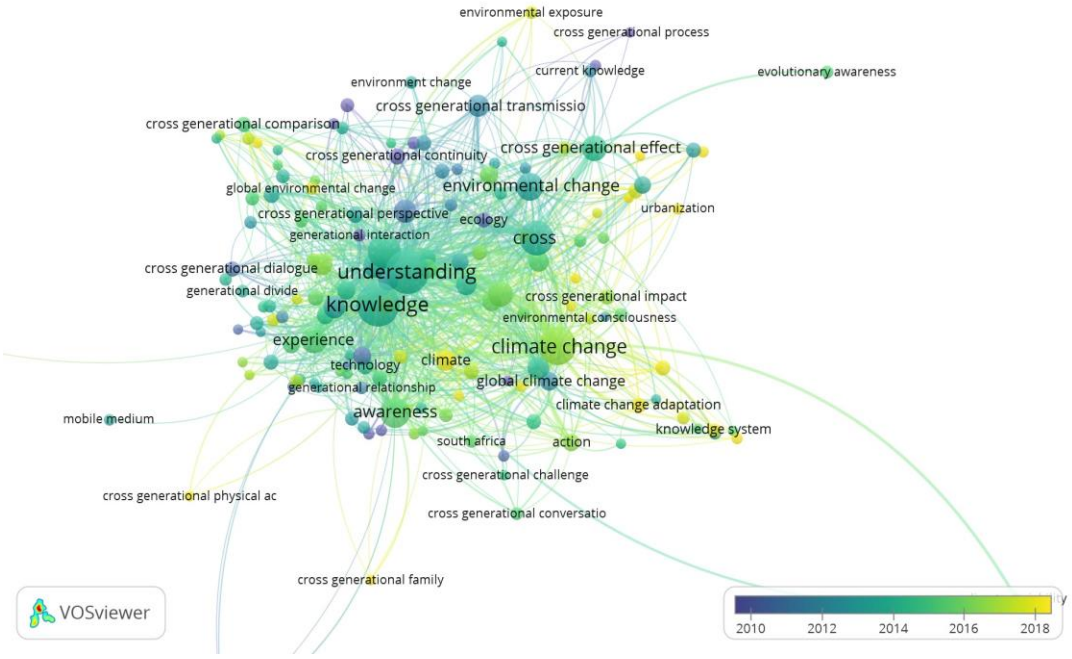

Figure 6. Overlay visualization of climate change and cross-generational awareness on VOS viewer.

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For future study, four newest trends have been identified: (1) climate change; (2) multiple generations; (3) cross-generational acclimatization; (4) climate change adaptation; and (5) ocean warning. The five identified trends carry research potentials, such as perspectives on science and civic education for sustainable development. Overall, academics who investigate the study point of the piece should focus on types of cross-generational awareness such as better understanding, social action, and evolutionary awareness inserted in the context of climate change issues, as these are the trends that appear most frequently in some studies (Matos *et al*., 2022; Weiskopf *et al*., 2020). Although several studies on the subject have been conducted, certain ideas can still be addressed in such a way that the practical application of climate change, and cross-generational awareness is possible.

5. CONCLUSION

Cross-generational awareness or awareness from multiple generations has recognized that cross-generational effect planning, and evolutionary awareness may be useful strategies for reducing urbanization and climate change impact. Researchers' major focus has steadily switched from climate change aims to a social viewpoint of cross-generational awareness study over the previous there decades. As a result, we should go a little further to evaluate the influence of other aspects, rather than only evaluating article titles, abstracts, and keywords. Furthermore, because the Scopus databases are skewed toward the English language, we should explore alternative databases (such as the Scopus Index and WOS) that include more journals published in other languages. Overall, we have offered a comprehensive grasp of the future trends and patterns that have defined three decades of research in 1) climate change; (2) multiple generations; (3) cross-generational acclimatization; (4) climate change adaptation; and (5) ocean warning.

6. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the paper was free of plagiarism.

7. REFERENCES

Adjovu, G. E., Stephen, H., James, D., and Ahmad, S. (2023). Overview of the application of remote sensing in effective monitoring of water quality parameters. *Remote Sensing*, *15*(7), 1938.

Al Mamun, A., Hayat, N., Mohiuddin, M., Salameh, A. A., Ali, M. H., and Zainol, N. R. (2022). Modelling the significance of value-belief-norm theory in predicting workplace energy conservation behaviour. *Frontiers in Energy Research*, *10*, 940595.

Al-Ghussain, L. (2019). Global warming: Review on driving forces and mitigation. *Environmental Progress & Sustainable Energy*, *38*(1), 13-21.

Almassi, B. (2017). Climate change and the need for intergenerational reparative justice. *Journal of Agricultural and Environmental Ethics*, *30*(2), 199–212.

Balbus, J. M., Boxall, A. B., Fenske, R. A., McKone, T. E., and Zeise, L. (2013). Implications of global climate change for the assessment and management of human health risks of chemicals in the natural environment. *Environmental Toxicology and Chemistry*, *32*(1), 62-78.

DOI:
p- ISSN 2828-3287 e- ISSN 2828-3295

Banholzer, S., Kossin, J., and S. Donner, S. (2014). The impact of climate change on natural disasters. *Reducing Disaster: Early Warning Systems for Climate Change*, *3*(2), 21–49.

Barnes, C. M., Esterle, L., and Brown, J. N. A. (2019). When you believe in things that you don't understand': the effect of cross-generational habits on self-improving system integration. *IEEE 4th International Workshops on Foundations and Applications of Self Systems (FASW)*, *2019*, 28–31.

Brownlee, M. T. J., Powell, R. B., and Hallo, J. C. (2013). A review of the foundational processes that influence beliefs in climate change: Opportunities for environmental education research. *Environmental Education Research*, *19*(1), 1–20.

Capstick, S., Whitmarsh, L., Poortinga, W., Pidgeon, N., and Upham, P. (2015). International trends in public perceptions of climate change over the past quarter century. *Wiley Interdisciplinary Reviews: Climate Change*, *6*(1), 35-61.

Cottrell, C. (2022). Avoiding a new era in biopiracy: Including indigenous and local knowledge in nature-based solutions to climate change. *Environmental Science & Policy*, *135*, 162-168.

Cramer, W. (2018). Climate change and interconnected risks to sustainable development in the Mediterranean. *Nature Climate Change*, *8*(11), 972–980.

Degroot, D. (2021). Towards a rigorous understanding of societal responses to climate change. *Nature*, *591*(7851), 539-550.

Diprose, K., Liu,C., Valentine, G., Vanderbeck, R. M., and McQuaid. (2019). Caring for the future: climate change and intergenerational responsibility in China and the UK. *Geoforum*, *105*(2), 158–167.

Donelson, J. M., Salinas, S., Munday, P. L., and Shama, L. N. (2018). Transgenerational plasticity and climate change experiments: where do we go from here?. *Global Change Biology*, *24*(1), 13-34.

Fenitra, R. M., Premananto, G. C., Sedera, R. M. H., Abbas, A., and Laila, N. (2022). Environmentally responsible behavior and knowledge-belief-norm in the tourism context: The moderating role of types of destinations. *International Journal of Geoheritage and Parks*, *10*(2), 273-288.

Ghil, M., and Lucarini, V. (2020). The physics of climate variability and climate change. *Reviews of Modern Physics*, *92*(3), 035002.

Maibach, E. W., Kreslake, J. M., Roser-Renouf, C., Rosenthal, S., Feinberg, G., and Leiserowitz, A. A. (2015). Do Americans understand that global warming is harmful to human health? Evidence from a national survey. *Annals of Global Health*, *81*(3), 396-409.

Malhi, Y., Franklin, J., Seddon, N., Solan, M., Turner, M. G., Field, C. B., and Knowlton, N. (2020). Climate change and ecosystems: threats, opportunities and solutions. *Philosophical Transactions of the Royal Society B*, *375*(1794), 20190104.

Matos, S., Viardot, E., Sovacool, B. K., Geels, F. W., and Xiong, Y. (2022). Innovation and climate change: A review and introduction to the special issue. *Technovation*, *117*, 102612.

DOI:
p- ISSN 2828-3287 e- ISSN 2828-3295

Messaoud, S., Bradai, A., Bukhari, S. H. R., Quang, P. T. A., Ahmed, O. B., and Atri, M. (2020). A survey on machine learning in Internet of Things: Algorithms, strategies, and applications. *Internet of Things*, *12*, 100314.

Skeirytė, A., Krikštolaitis, R., and Liobikienė, G. (2022). The differences of climate change perception, responsibility and climate-friendly behavior among generations and the main determinants of youth's climate-friendly actions in the EU. *Journal of environmental management*, *323*, 116277.

Torres, C., Moranta, J., and. Murray, I. (2022). The construction of a growth-oriented global climate agenda: a critical historical analysis. *Investig. Geográficas*, *77*(1), 161.

Van Beek, L., Hajer, M., Pelzer, P., van Vuuren, D., and Cassen, C. (2020). Anticipating futures through models: the rise of integrated assessment modelling in the climate science-policy interface since 1970. *Global Environmental Change*, *65*, 102191.

Weiskopf, S. R., Rubenstein, M. A., Crozier, L. G., Gaichas, S., Griffis, R., Halofsky, J. E., and Whyte, K. P. (2020). Climate change effects on biodiversity, ecosystems, ecosystem services, and natural resource management in the United States. *Science of the Total Environment*, *733*, 137782.

Wong, S. L., Mong, G. R., Nyakuma, B. B., Ngadi, N., Wong, K. Y., Hernández, M. M., and Chong, C. T. (2022). Upcycling of plastic waste to carbon nanomaterials: a bibliometric analysis (2000–2019). *Clean Technologies and Environmental Policy*, *24*(3), 739-759.

Yoro, K.O., and Daramola, M.O. (2020). CO2 emission sources, greenhouse gases, and the global warming effect. *Advances in Carbon Capture*, *20*(1), 3–28.

DOI:
p- ISSN 2828-3287 e- ISSN 2828-3295