Discover Sustainability

Research

Climate justice: The contribution of higher education institutions

Walter Leal Filho[1,2] · Eundeok Kim[3] · Guillermo Palau-Salvador[4] · Pablo Aránguiz-Mesías[4] · Shola Oyedeji[5] · Lourdes Molera[6] · María Semitiel-García[7] · Salvador Ruiz-de-Maya[8] · Amir Moradi[9] · Lais Viera Trevisan[10]

Received: 18 October 2024 / Accepted: 25 March 2025
Published online: 12 April 2025

Abstract
The concept of climate justice extends traditional environmentalism by emphasizing the social dimensions of environmental issues. Recently, it has gained much attention due to the growing impacts of climate change, especially on vulnerable communities that contribute minimally to global emissions. Based on the need for research in this field, this paper reports on a study that examined how higher education institutions (HEIs) are integrating climate justice into education, based on a literature review and a set of case studies. These cases highlight actions undertaken by various HEIs to incorporate climate justice into education across the globe. Based on the increasing number of publications, the findings show a growing research interest in the topic and reveal that some countries such as the US, the UK, China, Australia, and Germany have a visible presence in the literature. It also provides a wide range of perspectives on educational practices in climate justice, including real-world examples of courses implemented in HEIs. The findings reveal that HEIs have significant potential to address climate justice in their educational programs, which may help to transform students' values and actions despite challenges.

Keywords Climate change · Climate justice · Education · Higher education institution · Sustainability · Sustainable development

✉ Eundeok Kim, ekim@fsu.edu; Walter Leal Filho, w.leal@mmu.ac.uk; Guillermo Palau-Salvador, guipasal@agf.upv.es; Pablo Aránguiz-Mesías, pabarme@doctor.upv.es; Shola Oyedeji, shola.oyedeji@lut.fi; Lourdes Molera, lmolera@um.es; María Semitiel-García, mariase@um.es; Salvador Ruiz-de-Maya, salvruiz@um.es; Amir Moradi, amir.moradi@han.nl; Lais Viera Trevisan, lais.trevisan@ufrgs.br | [1]Department of Natural Science, Manchester Metropolitan University, Chester Street, Manchester M15 5GD, UK. [2]European School of Sustainability Science and Research, Hamburg University of Applied Sciences, Ulmenliet 20, 21033 Hamburg, Germany. [3]Jim Moran College of Entrepreneurship, Florida State University, 111 South Monroe Street, Tallahassee, FL 32301-1110, USA. [4]INGENIO CSIC-UPV, Universitat Politècnica de València, Camino de Vera S/N, 46022 Valencia, Spain. [5]Department of Software Engineering, LENS School of Engineering, LUT University, Lappeenranta, Finland. [6]Department of Quantitative Methods to Economics and Business, Faculty of Economics, University of Murcia, Campus de Espinardo, 30100 Murcia, Spain. [7]Department of Applied Economics, Faculty of Economics, University of Murcia, Campus de Espinardo, 30100 Murcia, Spain. [8]Marketing Department, Faculty of Economics and Business, University of Murcia, Campus de Espinardo, 30100 Murcia, Spain. [9]International School of Business at HAN University of Applied Sciences, Ruitenberglaan 31, 6826 CC Arnhem, the Netherlands. [10]School of Administration, Federal University of Rio Grande Do Sul (UFRGS), 855 Washington Luiz St, Porto Alegre, RS 90010460, Brazil.

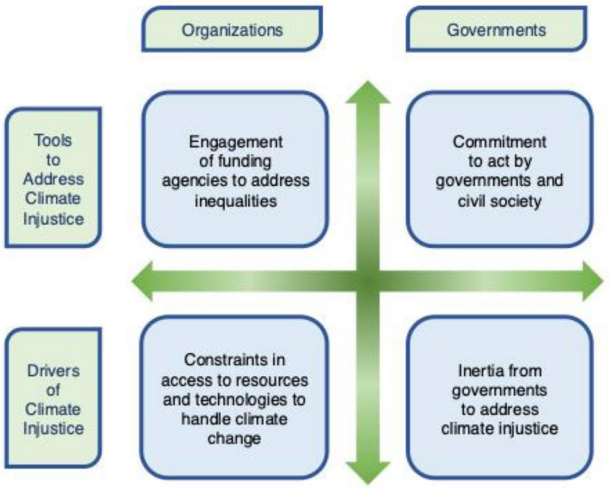


Fig. 1 Some drivers and tools to address climate injustice
Source: The authors

1 Introduction

The term 'climate justice' integrates environmental conservation with human rights and social justice. It views man-made climate change as not only an environmental problem and technical challenge but also a political and ethical issue linked to equality, human rights, and social justice [1]. As an example of the appropriateness of this concept, countries and groups most affected by the consequences of global warming such as people in developing countries, particularly indigenous communities, women, and children, are often the least responsible for causing it [2, 3].

Climate justice endeavors to distribute the burdens and opportunities of climate change fairly across the globe. It acknowledges that industrialized nations have historically contributed the most to climate change and therefore have a greater responsibility for mitigating its effects [4]. The main perpetrators of climate change, industrialized countries and some emerging economies, not only need to drastically reduce their greenhouse gas emissions but also assist developing countries in coping with climate change impacts [5] and making the transition to a climate-neutral, sustainable economy and way of life [6].

Climate justice also intersects with other forms of social justice such as racial, economic, and gender justice, recognizing that climate impacts are worsened for people facing discrimination [7]. Other features of climate justice are as follows:

1. It advocates for sustainable development (SD) that satisfies the needs of the present without sacrificing the ability of future generations to meet their own needs.
2. It calls for action at all levels, from local community initiatives to international agreements, recognizing that global cooperation is essential.
3. It emphasizes the importance of involving all stakeholders, especially those most affected, in decision-making processes concerning climate change.

Implementing climate justice is a process characterized by significant barriers. Firstly, economic and political interests, particularly from fossil fuel-based industries, often resist policies that would reduce emissions but harm profits [8, 9]. Secondly, developing countries claim that they should not bear the same burden for decreasing emissions as developed countries, which have historically contributed more to climate change [3]. This creates a challenge in reaching global agreements that are perceived as fair by all parties [10]. Additionally, varying levels of awareness and attitudes across communities towards climate change make collective action or changes in lifestyle challenging [11]. Furthermore, climate justice requires integrating environmental policies with other social and economic policies [12], which can be complex and require coordination across multiple sectors and levels of government.

Addressing these barriers requires coordinated efforts at the local, national, and international levels, involving governments, businesses, non-governmental organizations, and communities [1, 13]. As shown in Fig. 1, governments

and organizations have the capacity to address climate injustice. Governments have authoritative and regulatory powers to implement specific actions and controls, whereas the latter can independently develop their social advocacy and community service to contribute to climate justice. As their social functions differ, each has different drivers and can use different tools to address climate injustice. Governments have more power to sanction practices that promote climate justice, but their inertia is, in fact, a driver of climate injustice, giving organizations the opportunity to engage with funding agencies to address inequalities derived from climate change.

Climate justice and education form a multifaceted nexus within the sustainability discourse, emphasizing the role of equitable education implementation in addressing global climate and environmental challenges. Education provides citizens and communities with the knowledge, skills, and awareness necessary to empower them to adopt a more equitable approach to climate action [14].

There is a perceived need for research on the topic of climate justice and its implementation in education. Against this background, this study aims to examine the extent to which climate justice is implemented by higher education institutions (HEIs) and to explore their practices in climate justice education. The findings inform and inspire HEIs to enhance their contributions to climate justice education. The specific research questions are as follows:

1. How is the theme "climate justice" discussed in the literature focusing on higher education?
2. What are the practices, including real-world examples, showcasing how climate justice is implemented into education at HEIs?

To address the research questions, this paper is structured as follows: Sect. 2 identifies the connections between climate justice and education; Sect. 3 outlines the study's methods; Sect. 4 presents the results, followed by the discussion in Sect. 5; and Sect. 6 draws the main conclusions.

2 Climate justice and education

Education can play a key role in situating human rights and social equity at the center of climate action [15, 16]. It can highlight how marginalized communities—those with less political, economic, or social power—are disproportionately affected by climate change. When people understand these intersections, they are more likely to support policies that promote justice and equity in climate responses. In this context, there is an urgent need to inform individuals about the causes and consequences of climate change, since these cannot be separated from issues of poverty, race, and global inequality. Table 1 presents the main connections between climate justice and education.

One of the significant advantages of teaching climate justice through education is that it is based on critical thinking, with an emphasis on participatory learning, leading to the development of civic competencies that enable individuals to understand the complex relationship between climate change and social justice [17]. This understanding is essential to develop the agency that motivates people to contribute to climate solutions [18]. It is a call to the deepest goal of education: a transformative process to change societies.

Table 1 Main connections between climate justice and education

Climate justice component	Relevance to education
Empowerment	By equipping people with knowledge about climate change, education empowers them to make informed decisions and take action
Awareness and understanding	Education plays a critical role in enhancing awareness and understanding of climate justice and its importance
Influence on policies	Educated populations are more likely to advocate for strong climate policies
The capacity to adapt	Education systems can integrate climate justice into curricula, not only teaching about the problem but also offering practical skills for fostering it
Global and local perspectives	Education can foster a dual perspective: understanding global issues and their local implications
Fairness to future generations	By integrating climate justice into educational systems, future generations become better prepared to deal with the challenges of climate change

Source: The authors

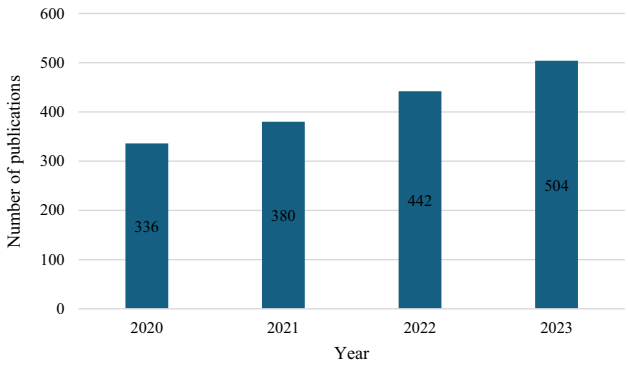


Fig. 2 Number of publications on climate change and climate justice (2020–2023). Source: The authors

However, this approach often faces resistance due to the economic implications of the required actions and ideological concerns, or even skepticism regarding the scientific consensus on climate change. As such, the incorporation of climate justice into educational curricula requires a balanced interdisciplinary approach that combines science, social research, and ethics [19]. Its implementation is more effective through experiential project-based learning as it can facilitate a deeper understanding of the socio-economic dimension of environmental sustainability [20]. It also involves the development of scientific and socio-cultural educational materials that can compensate for the previously mentioned resistance [21].

Recent empirical studies have shown how educational institutions contribute to a more equitable understanding of climate issues [22]. The new curriculum designs based on climate justice principles offer students a better, more holistic understanding of climate change and its social antecedents and consequences [23]. New challenges of climate justice education are twofold: first is the need to increase teachers' knowledge and skills to effectively deliver climate justice education [20], and second is the need to elevate public policy sensitivity to promote the incorporation of environmental culture and values into educational settings to foster climate justice [24].

3 Methods

In order to ensure the robustness of the study, two methods were deployed. The first was an assessment of the latest literature concerning climate change and climate justice in higher education using a bibliometric analysis aimed at identifying and listing some of the key literature on the topic. It entails a compilation of citations to identify the impact of various categories on the topic, including the subject matters, periodicals where the papers were published, authors' home base, and a set of keywords. Although there are various databases from which the information could be gathered, the authors selected Scopus due to its comprehensive coverage of peer-reviewed publications.

As a first step, search strings were identified, which entailed relavent terms and the Boolean operators "AND" and "OR." The terms used for the investigation were: ("climate chang*" OR "climate justice") AND ("higher education" OR "universit*"). A total of 8,833 papers were initially chosen with the options of "article title, abstract, and keywords" and all types of papers. In the next phase, the publicaiotn years were limited to the period of 2020–2023 to assess

Table 2 Five major journals based on the number of published papers (2020–2023)

Journal title	Number of publications	Citations	Impact factor (2022)
Sustainability	113	656	3.9
International Journal of Sustainability in Higher Education	25	92	3.1
International Journal of Environmental Research and Public Health	22	104	3.2
Journal of Cleaner Production	15	209	11.1
Environmental Education Research	13	61	3.2

Source: The authors

the latest publications on the topic, which returned 2826 documents. In the next step, only peer-reviewed articles were considered, resulting in 1803 papers. Using "English" as the final criterion for selection, the sample included 1662 publications. The search was conducted on December 15, 2023. As a further step, the data was analyzed based on the number of publications by year, per journal, country, and subjects. Finally, a co-occurrence analysis of the keywords was carried out to identify the frequently used keywords on the topic with the support of VOSviewer software (version 1.6.20). This analysis examines the proximity between two or more terms within a text unit, enabling the identification of key research topics. Terms that frequently appear near one another are likely to be related and form thematic clusters based on their co-occurrence patterns (see [25]).

The second method used to complement the bibliometric analysis was an in-depth look at case studies, which provided examples of specific educational practices in climate justice. Conducted on December 18, 2023, a search for papers in the English language using the search string ("climate chang*" OR "climate justice") AND ("higher education" OR "universit*") AND ("case stud*") yielded 148 results for 2020–2023. Then, 11 journal articles that seemed most suitable for this study were selected. The authors initially planned to select twenty real-world examples of courses/workshops on climate justice offered at HEIs worldwide; however, they could find only seven of them. Therefore, four additional case studies focused on learning through participatory action research were added to the seven case studies. The details of the eleven papers are illustrated in Table 3 in the following 4.2. Analysis of selected case studies section. All of these case studies that provide real-world examples of initiatives to foster the learning about climate justice at universities, increased the qualitative depth of the research. For the analysis of these case studies, the authors focused on the learning objectives, discipline(s), course content, pedagogical approaches, and outcomes of the courses and workshops under study.

4 Results

4.1 Bibliometric analysis

As seen in Fig. 2, over the period of 2020–2023 there was a noticeable increase in the number of papers published concerning climate change and climate justice. This attests the increased focus on the topic as part of university research. The most recent one year from 2022 to 2023 saw the increase from 442 publications (2022) to 504 publications (2023).

The data analysis reveals that the papers have been published in 160 different periodicals. It is noticeable that a set of five outlets are leading the conversation, particularly *Sustainability* with 113 papers and 656 citations and the *International Journal of Sustainability in Higher Education* with 25 papers and 92 citations (see Table 2 below).

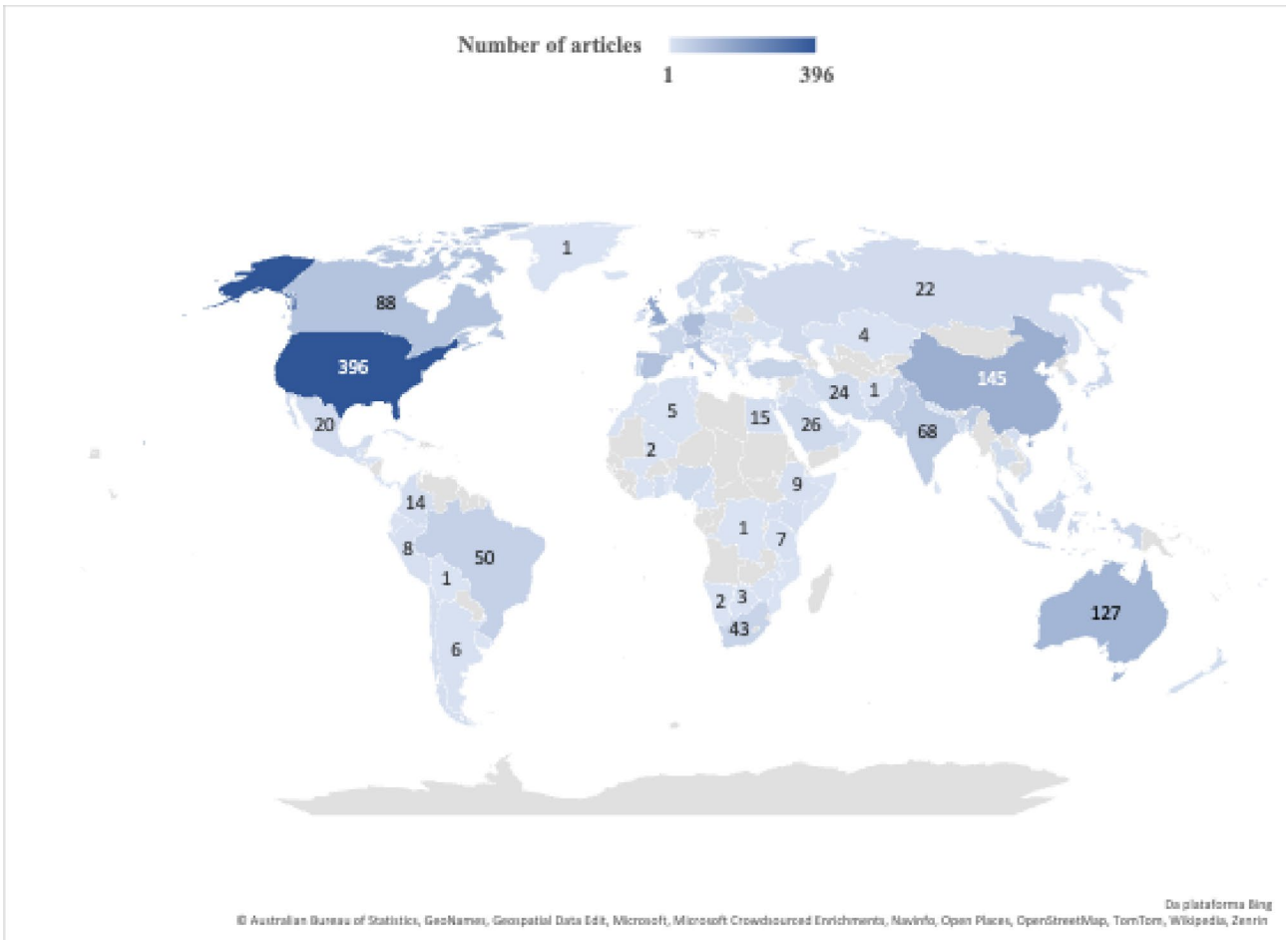
As for the countries, Fig. 3 showcases that authors from the US (with 396 papers) are most widely present in the literature, followed by the UK (164 papers), China (145 papers), Australia (127 papers), and Germany (108 papers).

Concerning the subject areas, Fig. 4 shows that most of the publications are from the *Social Sciences* (680), *Environmental Science* (607), *Agricultural and Biological Sciences* (286), *Energy* (237), and *Earth and Planetary Sciences* (209).

As shown in Fig. 5, the result of the term co-occurrence analyis reveals five thematic clusters, with the red and green clusters being more developed, while others receive less attention. The red cluster includes keywords such as "food system," "indigenous knowledge," "climate justice," "energy," and "environmental education." The importance of indigenous knowledge in new university programs is also emphasized, promoting multidisciplinary approaches [26]. Notable examples include project-based learning initiatives such as the Isalab Workshop in Valencia [27] and water management training programs in India [28].

Key aspects of a research-society interaction involve citizen science and co-creation. Examples include ocean temperature measurements related to seismological activity in Australia [29] and rainwater harvesting in Arizona [30]. Co-creation extends to university design projects, like the University of Denver's Center for a Regenerative Future [31]. These initiatives aim to promote climate justice while addressing students' expectations [32], including capitalism's influence [33] and degrowth approaches [31]. Campuses as living labs and experimental arenas is also emphasized to propose innovative solutions and raise awareness about food security and sovereignty inequities [34].

The blue cluster connects education, climate change, environmental awareness, science communication, and health. Innovative educational approaches are emerging to address pressing environmental challenges [35]. Notable initiatives include the Evolution of Land Plants Garden at University College Dublin, serving as a living outdoor classroom to enhance students' understanding of plant evolution. Simultaneously, attention is growing toward the



Country	N	Country	N	Country	N	Country	N	Country	N
United States	396	Pakistan	48	Austria	30	Czech Republic	21	Colombia	14
United Kingdom	164	South Africa	43	Finland	30	Nigeria	21	Denmark	14
China	145	Turkey	43	Poland	26	Thailand	21	Chile	13
Australia	127	France	40	Saudi Arabia	26	Mexico	20	Ireland	13
Germany	108	Netherlands	37	Iran	24	Belgium	19	Kenya	13
Spain	96	Indonesia	36	Norway	24	New Zealand	19	Ghana	12
Canada	88	Portugal	33	South Korea	24	Greece	17	Jordan	10
Italy	84	Switzerland	33	Sweden	24	Taiwan	16	Romania	10
India	68	Japan	31	Russian Federation	22	Egypt	15	Slovakia	10
Brazil	50	Malaysia	31	Bangladesh	21	Viet Nam	15	United Arab Emirates	10

Fig. 3 Publications by countries on climate change and climate justice in higher education (2020–2023). * N refers to the number of publications. The countries with less than 10 publications are not included in this table. Source: The authors

intersection of biodiversity and health within educational settings worldwide [36], particularly in fields like public health, veterinary sciences, and medicine, though more integration and interdisciplinary collaboration are needed [37]. Moreover, studies among HEI students in universities of Canada and China shed light on their perceptions and behaviors regarding environmental issues [38, 39].

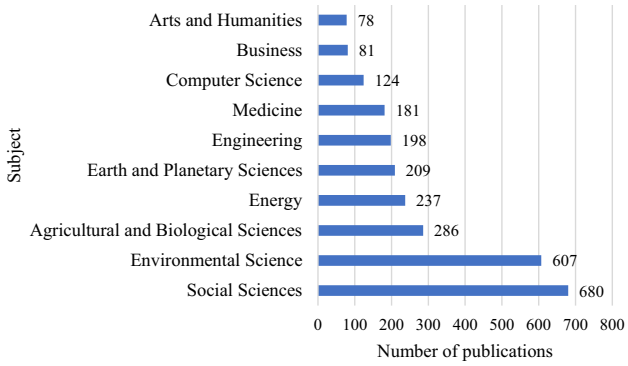


Fig. 4 Publications on climate change and climate justice in higher education by subject. Source: The authors

The yellow cluster explores the connection between health and sustainability in higher education. Initiatives like New York University's Environmental Health in a Global World [40] exemplify participatory learning, emphasizing

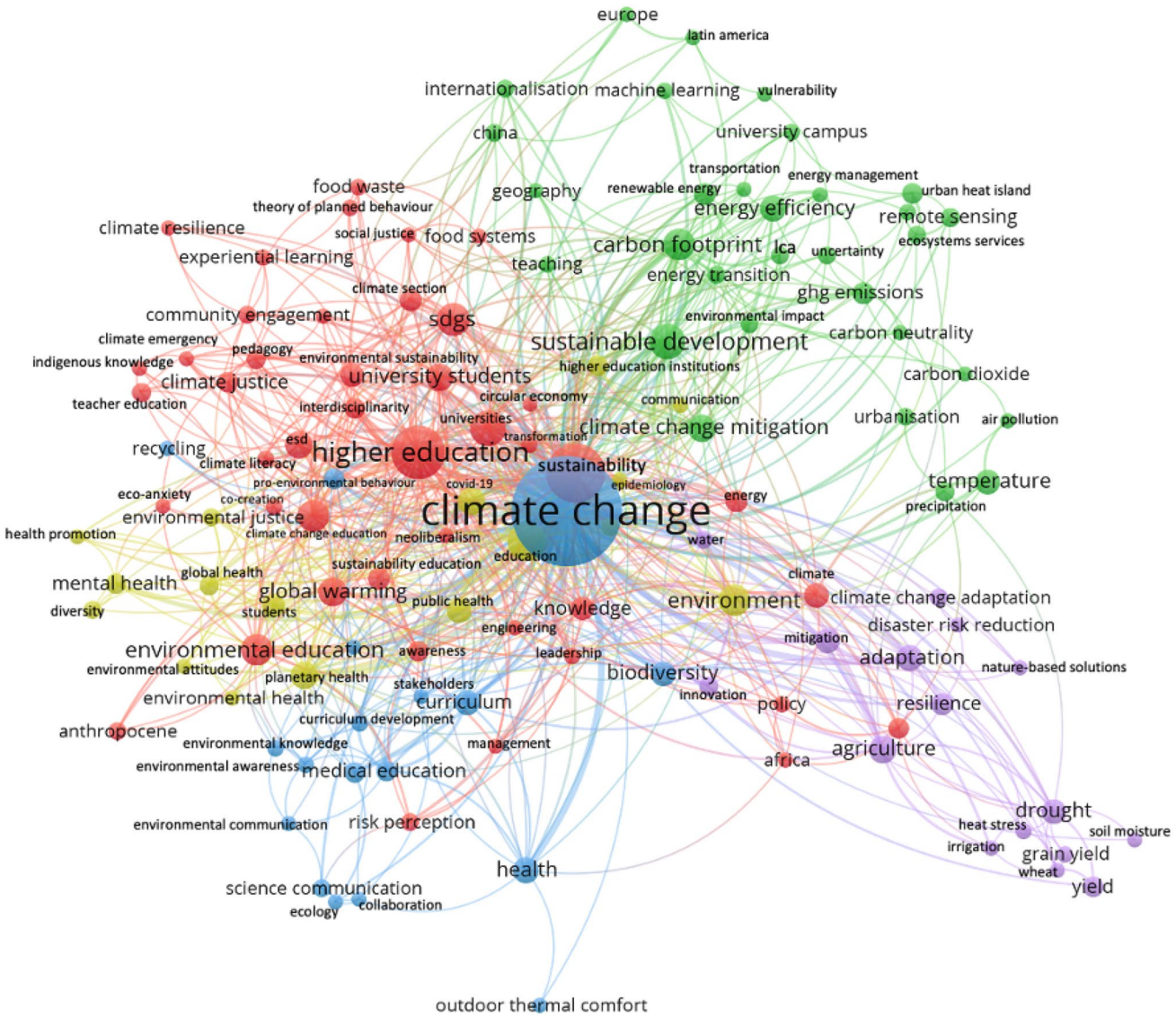


Fig. 5 The result of the term co-occurrence analysis. Source: The authors

interdisciplinary perspectives and empowering students to address diverse environmental challenges.

Nursing education programs have successfully integrated environmental health content, impacting students' education and policy engagement [41]. However, medical education still lags in addressing climate change's health impacts [42]. Furthermore, while incorporating biodiversity in health education underscores the need for collaboration across disciplines [36]. Student-driven initiatives like the Planetary Health Task Force at Brown University demonstrate successful integration strategies [43].

The purple cluster emphasizes disaster risk reduction (DRR), resilience, and climate change adaptation (CCA). The causal relationship between climate change and disaster risk has been assessed and determined by considering exposure, vulnerability, and the resilience of a population to prepare for, respond to, and recover from its consequences [44]. Chandra et al. [45] articulate that despite the existence of CCA and DRR policies, there may be inadequacies in addressing non-economic loss and damage, stemming from areas including a lack of knowledge. To illustrate the significance of education in DRR practices, a community-based DRR program in Ottawa led by young individuals has developed DRR training modules designed to assist educators [46].

The development of local climate resilience strategies is imperative within communities [47], and climate change education serves as a pivotal instrument in bolstering their resilience [48]. Nature-based solutions (NbSs) are essential for reducing and adapting to the effects of climate change [49], which makes them essential to be incorporated into higher education [50] and campus management.

The green cluster covers SD, carbon footprint, GHG emissions, university campuses, energy efficiency, environmental impacts, and teaching. The escalating impact of global challenges such as climate change and population growth underscores the significance of the United Nations' (UN) 17 SDGs in fostering future peace and prosperity, with education emerging as a central catalyst for achieving these goals, though more attention is needed [51]. For instance, certain HEIs in Spain and Italy are actively promoting sustainability awareness among students and researchers through the implementation of environmental policies on university campuses [52].

Furthermore, there is a growing recognition for HEIs to play a more proactive role in addressing the UN SDGs [53], cultivating sustainability-aware designers [54] and engaging stakeholders. As such, HEIs must collaborate with regional actors to address societal challenges such as energy efficiency and climate change [55].

On the other hand, the carbon footprint resulting from university activities significantly contributes to climate change, presenting a notable challenge for SD due to the complexity of monitoring and evaluation tools for sustainability within universities [56]. However, various studies (e.g., Sun et al. [57]) highlight universities' efforts to quantify and mitigate their carbon footprint through practices such as aligning academic calendars with holidays [58].

In general, the analysis reveals that universities have a central role as agents of change in the face of global challenges by integrating sustainability, education, and climate action in their activities. Through higher education, innovative approaches that combine theory and practice are promoted, fostering connections between local contexts and global issues. Initiatives such as project-based learning, the inclusion of indigenous knowledge and the implementation of nature-based solutions are prominent examples of how institutions are moving towards more sustainable and transformative models. A cross-cutting aspect is the active participation of communities and other stakeholders through co-creation and citizen science. These practices strengthen the link between universities and society, enriching both learning and social impact. Climate justice and local resilience emerge as key priorities, highlighting the need for strategies that address structural inequities while adapting to ecological and social dynamics. In this sense, universities are called to lead with inclusive, transdisciplinary approaches that integrate diverse perspectives and foster contextualized solutions.

In addition, university campuses are consolidating as experimental spaces for sustainability. Their transformation into living laboratories allows for testing and scaling innovative solutions, such as carbon footprint reduction and environmental policy advocacy. However, challenges related to sustainability measurement and management persist, underscoring the need for more effective tools and broader collaborations. In education, the adoption of multidisciplinary pedagogical approaches is essential to prepare future generations for complex challenges. From environmental health to biodiversity, educational programs are evolving to integrate diverse knowledge and encourage action. However, areas such as medical education require greater attention to fully incorporate climate change impacts into their curricula.

Table 3 Selected case studies on research on climate justice in education

Case	Paper title	Focus	Reference
1	Broad spectrum integration of climate change in health science curricula	Advocates for the importance of the connection between the physical scientific basis of climate change and the aspects of vulnerability, adaptation, and mitigation concerning health impacts	[59]
2	Teaching about climate change impacts on health: Capturing the experience for educators	Explains how public health is not a discipline but is informed by an integration of thinking from a range of disciplines and perspectives	[60]
3	Improving the capacity and diversity of local public health workforce to address climate impacts to health through community partnerships and problem-based learning	Emphasizes the importance of incorporating climate- and health-related content into courses that include social determinants of health, health communication, or epidemiological methods using problem-based learning	[61]
4	Planetary health pedagogy: Preparing health promoters for 21st-century environmental challenges	Offers the design and use of a resource and postgraduate micro-credential	[62]
5	The affective dimension of crisis subjects: Teaching environmental communication through intersecting crises	Investigates the affective implications of climate change, pedagogical approaches for the development of students' sense of agency, and strategies to empower students in their future roles	[63]
6	Environmental justice pedagogies and self-efficacy for climate action	Examines how employing social justice pedagogies in an environmental justice course supports college students' self-efficacy in combating climate change	[64]
7	Beyond colonial futurities in climate education	Offers an outline for climate education that enhances students' sense of social and ecological responsibility	[66]
8	Data-driven and research-based learning approaches to environmental education in university contexts: Two case studies in Italy and Germany	Reports research-based learning strategies on environmental communication for environmental education	[67]
9	Community-based climate action planning as an act of advocacy: a case study of liberal arts education in a rural community	Examines community-based research involving university students trained in climate action planning	[68]
10	Building university capabilities to respond to climate change through participatory action research: Towards a comparative analytical framework	Explores initiatives from universities in Brazil, Kenya, and Fiji to address climate challenges through participatory action research	[69]
11	Creating meeting grounds for transdisciplinary climate research: the role of humanities and social sciences in grand challenges	Introduces a participatory research program that fosters collaboration across diverse disciplines to tackle the climate crisis	[70]

Source: The authors

4.2 Case studies

In this section, we present and discuss a set of eleven papers concerning research on climate justice in education published in peer-reviewed journals (Table 3). They are divided into two groups: the first group includes case studies of either courses/workshops offered at HEIs on climate justice (#1–7) while the second group discusses learning through participatory action research (#8–11).

From an international perspective, a wide range of courses and workshops link climate change and climate justice to health and health education. Ogunseitan et al. [59] emphasizes the importance of connecting the physical science of climate change with vulnerability, mitigation, and adaptation concerning health impacts. For example, workshops were developed in the College of Health Sciences at the University of California—Irvine to foster learning about sustainability, barriers to incorporating new competencies into courses to train professionals, and theoretical models of curriculum integration. Strategies for implementing modules and case studies on climate change contents into the relevant curricula were discussed. One year later, participants presented how they had transformed their courses, discussed best practices, and shared specific difficulties.

It is important for public health to be guided by integrative thinking from various perspectives and disciplines. Lansbury et al. [60] stress the urgent need for indigenous knowledge in new university programs. The public health course "Exploring Wicked Problems in Health" illustrates how integrated thinking from various disciplines can illuminate public health issues. A course survey revealed strong correlations between interest and curiosity for learning and voluntary motivation to act, underscoring the importance of fostering students' intrinsic motivation.

The transformation of students' values and actions requires the effective integration of climate-health topics into curricula. Schmeltz et al. [61] highlight problem-based learning pedagogy employed by undergraduate students in the Department of Public Health at California State University at East Bay to address climate change impacts on local government organizations and communities. The outcome reveals mutual benefits, including increased knowledge and better responses to climate change in local communities. Similarly, Capetola et al. [62] present the postgraduate six-week course "Promoting human and planetary health" at Deakin University in Australia, designed to comprehend global and local challenges and facilitate the acquisition of knowledge and skills for planning co-benefits for both planetary and population health.

There has been a tendency for educators in climate and environmental change to focus on the urgency and scale of the crisis without considering its affective consequences. Thus, there is a need to investigate the affective implications of the content and instructional methods, the pedagogical approaches for student development of a sense of agency, and the strategies and practical tools to empower students. Leimbach et al. [63] present a case study of an undergraduate elective offered in the University of Technology Sydney's School of Communication in Australia that exposed students to climate and ecological crises. The pedagogical approach requires deconstructing power structures and encouraging new ways of viewing the world. Similarly, Bartlett et al. [64] examine how a pedagogical approach to social justice in a climate justice course increases self-efficacy in college students for tackling climate change. The online course at the University of Michigan used case studies, historical references, media, and presentations from activists in the local community to explore the connections between social justice and the environment. Students found that the course contributed to their sense of self-efficacy for climate solutions, indicating that educating from a justice perspective enhanced their comprehension of fundamental causes, empathy for others, and the need for collective action. They mentioned other studies (e.g., Cordero et al. [65]) revealing that students' voluntary engagement in climate action was low or non-existent even after taking science courses that covered climate change concepts, mitigations, and consequences. Thus, if the purpose of education on climate solutions is to prepare students to take true leadership in climate action, it is crucial to identify the reasons for the disconnect between learning and voluntary action.

Whereas various pedagogies that cover the climate and nature emergency propose solutions to a desired future, Stein et al. [66] offer an outline for climate education that enhances students' sense of environmental and social responsibility. They introduce "Facing Human Wrongs," a licensed creative commons course designed to highlight the significant debt owed to people on the front lines of climate and nature emergencies, including indigenous communities. The course emphasizes the importance of reparations in responding to emergencies, with economic justice identified as one dimension of healing from ecological and social violence.

Two papers provide evidence for the effectiveness of pedagogical strategies focused on research and experience in fostering environmental awareness and climate action among university students. Marcella and Samofalova [67] applied Data Driven Learning (DDL) and Research Based Learning (RBL), while Community-Based Research (CBR) is discussed in

[68]. A feedback questionnaire revealed that a significant percentage of students consider climate change an important discussion topic and intend to act more conscientiously toward it. CBR was also implemented in a collaborative climate action plan in Hamilton, New York, involving students from Colgate University as part of a working group alongside community members and other university actors, to mentor and train students through the environmental studies curriculum.

Nussey et al. [69] and Lieberknecht et al. [70] explore how universities can contribute to climate justice through participatory research, ultimately influencing student learning. The first study outlines some initiatives in Brazil, Kenya, and Fiji to integrate community knowledge into university policies and curriculum design. The second advocates for transdisciplinary spaces involving community stakeholders as well as students, teachers, and researchers to address the climate crisis and its effects on marginalized communities, using the initiative "Planet Texas 2050" at the University of Texas as an example.

These eleven papers illustrate educational practices and learning strategies developed by universities to address the topic of climate justice. Systematic literature reviews also examine the role of educational institutions in climate justice. Kinol et al. [71] highlight initiatives like The University of Vermont's mandatory sustainability course. Trott et al. [23] explore how educational practices in social sciences incorporate climate justice frameworks.

Several authors explore the integration of climate justice into education in general. Dunlop and Rushton [72] assess England's public strategy for climate change and sustainability education, finding that it prioritizes knowledge over action, lacks ethical considerations, and relies on extracurricular offerings rather than a mandatory curriculum. The strategy appeared to focus on superficial changes instead of fundamental ones, shifting the responsibility to teachers without adequate financial support. Meanwhile, Svarstad [73] promotes critical climate education to empower citizens with the knowledge and skills for responsible action. The Norwegian case study illustrates the consequences of climate mitigation decisions without considering climate justice across both time and space, underscoring the need for students to critically analyze such measures.

Fig. 6 Main issues related to climate justice in study programs. Source: The authors

5 Discussion

The aim of this study was to explore the extent to which universities have addressed climate justice education in recent years. A comprehensive bibliometric analysis was conducted to explore the relationships between climate justice, climate change and HEIs, revealing the key thematic areas. Subsequently, a detailed examination of case studies was undertaken to identify specific educational practices in climate justice at HEIs.

Both the bibliometric analysis and an in-depth look at case studies revealed that HEIs have a significant potential to address climate change and climate justice in their education, despite numerous challenges to facilitate a transformation of students' values and actions. Figure 6 summarizes the main issues related to the inclusion of climate justice as part of study programs. These elements collectively aim to foster an environment where HEIs can play a pivotal role in advancing climate justice by educating and empowering the next generation of leaders.

HEIs' proactive role in addressing the UN SDGs and balancing global economic development with the need to address climate change, has been increasingly recognized. To integrate environmental awareness and climate justice, HEIs have been using innovative approaches, expanding their academic boundaries. One example of this innovation is the establishment of co-curricular and interdisciplinary concentrations, such as the focus on planetary health in public health and medical programs that intertwine environmental considerations with regional health initiatives and explore the interconnectedness between biodiversity and human health. In fact, such an integration is increasingly recognized as vital for addressing global health challenges and preparing future healthcare professionals, emphasizing the role of HEIs in cultivating environmentally and socially responsible citizens.

The findings also highlight that viable curricular and pedagogical development is urgently required to integrate climate change and climate justice topics and competencies across the curriculum into core and elective courses by connecting the physical science of climate change to the aspects of vulnerability, adaptation, and mitigation. Examples include incorporating indigenous knowledge into new university programs, creating multidisciplinary and transdisciplinary programs/courses, employing a systems thinking approach, implementing micro-credentials, and providing experiential learning opportunities, such as problem-based learning. This echoes the literature review in an earlier section of this paper, emphasizing participatory learning to develop civic competencies that enable individuals to understand the complexity of the relationship between climate change and social justice. Some examples of pedagogical innovations focused on climate change and climate justice are presented in Table 4. These innovations not only educate students about the topics but also empower them to become active participants in addressing those global challenges. The findings also emphasize the importance of the affective aspects of education, including fostering students' intrinsic motivation and self-efficacy for climate solutions; thus, the emotional implications of the content and instructional methods should be carefully considered. It is also suggested that educating from a justice perspective increases students' comprehension of fundamental causes, empathy, and urgency for collective action as climate change is not only a technical or scientific problem but also a social, political, and ethical one, requiring a holistic and justice-oriented approach. Therefore, it is imperative to enhance students' sense of social and ecological responsibility to better prepare them with the motivation and affective, relational, and intellectual capacities to play a role in creating a more just world.

Moreover, participatory action research led by universities can help address environmental and climate change education challenges, considering the knowledge and needs of local vulnerable communities. This approach will significantly help to raise students' awareness about climate change, have a positive impact on the implementation of climate mitigation and resilience strategies, and thereby contribute to achieving long-term climate goals. While several studies highlight efforts made to achieve learning in climate justice through university initiatives and educational practices, some researchers point out shortcomings, such as cosmetic and superficial approaches and a lack of critical perspective in education overall.

6 Conclusions

As shown in the paper, education in climate justice can play an important role in equipping future decision-makers with the knowledge and skills to address interconnected environmental and social challenges. Through this research, the authors examined and documented the efforts of some HEIs to incorporate climate justice principles and content into their educational and operational frameworks. The findings suggest recognition among academic researchers and

Table 4 Some examples of pedagogical innovations focused on climat change and climate justice

Pedagogical innovation	Description	Example activity
Project-based learning	Engaging students in real-world projects that address climate issues in their community	Creating a community garden to promote biodiversity
Collaborative learning	Working in groups to discuss, research, and propose solutions for climate-related challenges	Debating in groups on local climate policies and their impacts
Experiential learning	Learning through direct experience, such as field trips or simulations that highlight climate issues	Visiting to a local recycling facility or a nature reserve
Interdisciplinary learning	Combining different subjects to explore climate justice from various perspectives (e.g., science, art, social studies)	Creating a multimedia presentation on climate change impacts
Service learning	Conducting projects that combine learning objectives with community service to address climate injustice	Partnering with local NGOs for local community initiatives
Technology integration	Utilizing digital tools and platforms to enhance learning about climate change and justice	Using apps to track carbon footprints and analyze data
Critical pedagogy	Encouraging students' critical thinking and discussions about the social justice aspects of climate change	Analyzing case studies of communities affected by climate change
Gamification	Utilizing game mechanics to teach about climate justice in an engaging way	Designing a role-playing game that simulates climate negotiations
Culturally relevant pedagogy	Incorporating local cultures, histories, and practices in teaching climate justice	Students research Indigenous practices in sustainability
Storytelling	Using narratives to explore personal and community experiences related to climate change	Writing and sharing stories about local climate impacts

Source: The authors

their institutions about the urgency of addressing the challenges of climate change and the complexities of coping with them. However, while climate change has been widely discussed in the literature–often with numerous examples of its implementation at universities around the world–explicit references to climate justice remain relatively scarce. This paper aims to contribute to filling the gap in the current literature.

A key aspect of integrating climate justice into academic curricula involves understanding the interrelation between environmental degradation and social inequality. For example, courses on ecological economics play a crucial role in this context by examining the trade-offs between economic growth, environmental preservation, and social equity. These courses may help students grasp the systemic nature of these issues and equip them with the tools to design policies that balance economic and ecological considerations, fostering a concerted global response. By encouraging critical analysis, participatory learning experiences, and the cultivation of civic skills, educational initiatives can empower learners to perceive climate change not just as an environmental issue but as a profound socio-ethical challenge requiring collective, informed action. The analysis of current educational methodologies within HEIs highlights emerging innovations and shows the need for a focus on balancing environmental and social responsibility. The results from this study illustrate some of the ways HEIs are incorporating awareness of environmental issues, their relationship with agriculture and food systems, indigenous perspectives, population health, and the SDGs as a general framework that underscore the need for climate justice.

This paper has several limitations. First, not all topics related to the theme could be covered because the bibliometric analysis focuses on the latest literature. This temporal limitation may have resulted in the exclusion of earlier foundational works that could provide additional historical context and insights. Additionally, a limited set of case studies was analyzed due to the lack of published real-world examples of courses on climate justice. As a result, the findings may not fully represent the diversity of teaching modalities used in climate justice education, potentially limiting the applicability of conclusions to different educational contexts. Restricted access to reliable data on climate initiatives in higher education also posed a challenge. The analysis was constrained by the availability of data, which may have led to an underrepresentation of initiatives from institutions that do not widely communicate their climate-related activities. Finally, given the wide range of perspectives on climate justice, this paper does not capture all possible viewpoints on the subject, with a potential exclusion, for example, of community-based educational initiatives that have a valuable impact on climate justice education.

The implications of this paper to theory and practice are as follows: first, the incorporation of climate justice into university programs appears to be an emerging trend that recognizes the importance of educating students about the intersection of environmental sustainability, social equity, and policy. Second, the paper provides a valuable addition to the literature by highlighting the current level of emphasis on climate justice in higher education. It identifies gaps in existing provisions and offers insights into areas requiring further attention. While visible efforts are being made by some universities to expand their curricula and research focus to address these interconnected issues, more comprehensive integration of sustainability learning across all disciplines could enhance this progress. Such an approach would help ensure that all students, regardless of their field of study, develop an understanding of the intersection between environmental sustainability and social justice.

There are several research needs on the topic that future studies could address. For instance, research is needed to explore how universities might offer interdisciplinary and cross-disciplinary courses that integrate aspects of environmental science, sociology, political science, and economics to study climate justice. Within this scope, courses on ecological economics are particularly relevant, as they provide critical insights into balancing economic development with environmental and social justice. Future research could evaluate how these courses could be optimized to address the unequal impacts of climate change and foster more equitable solutions. Further investigation is also required to determine how existing courses can examine topics such as the unequal impacts of climate change, ethical considerations in environmental policies, and strategies for community engagement and empowerment. Moreover, studies are needed on methods to encourage students to engage in activities that may cater to a better understanding of the impacts of climate change on vulnerable populations and to evaluate the effectiveness of policy interventions.

In summary, this research highlights the potential of participatory action and community involvement education, with HEIs playing a role in developing new curricula and training practices that foster values such as inclusivity, collaboration, and sustainable accountability. However, this educational transformation cannot solely be based on knowledge but also on embedding a deep acquisition of social and ecological responsibility. In the required social effort to lessen the effects of climate change, integrating climate justice into educational practices is both ethically significant and strategically valuable. Furthermore, it is crucial that discussions and actions relating to climate policy consider equity, granting a voice to those most affected by climate change and environmental degradation, particularly in vulnerable communities.

Acknowledgements This paper is part of the "100 papers to accelerate the implementation of the UN Sustainable Development Goals" initiative undertaken by the Inter-University Sustainable Development Research Programme (IUSDRP).

Author contributions W.L.F.: Conceptualization, Methodology, Writing—original draft, Writing—review & editing, Supervision. E.K.: Methodology, Investigation, Formal analysis, Visualization, Writing—original draft, Writing—review & editing, Project administration. G.P.-S.: Investigation, Formal analysis, Writing—original draft, Writing—review & editing. P.A.-M.: Investigation, Formal analysis, Writing—original draft, Writing—review & editing. S.O.: Investigation, Formal analysis, Writing—original draft, Writing—review & editing. L.M.: Investigation, Formal analysis, Writing—original draft, Writing—review & editing. M.S.-G.: Investigation, Formal analysis, Writing—original draft, Writing—review & editing. S.R.-d.-M.: Investigation, Formal analysis, Writing—original draft, Writing—review & editing. A. M.: Investigation, Formal analysis, Writing—original draft, Writing—review & editing. L. V.T.: Methodology, Investigation, Software, Formal analysis, Visualization, Writing—original draft, Writing—review & editing.

Funding No funding was received for conducting this study.

Data availability The data that support the findings of this study are available from the authors upon reasonable request.

Declarations

Ethics approval and consent for participate Not applicable.

Consent for publication The authors provide the full consent to participate and publish the article.

Competing interests The authors declare no competing interests.

References

1. Sultana F. Critical climate justice. Geogr J. 2022;188(1):118–24. https://doi.org/10.1111/geoj.12417.
2. Bathiany S, Dakos V, Scheffer M, Lenton TM. Climate models predict increasing temperature variability in poor countries. Sci Adv. 2018;4(5):eaar5809. https://doi.org/10.1126/sciadv.aar5809.
3. Paul HK. Climate change affects rich and poor unequally. Climate justice redresses the balance. 2020. https://www.greenpeace.org.uk/news/climate-change-inequality-climate-justice/. Accessed 14 Mar 2024.
4. Robinson M. Climate justice: challenge and opportunity. ISIA. 2011;22:67–74. https://www.jstor.org/stable/41413194.
5. Jaworska S. Change but no climate change: discourses of climate change in corporate social responsibility reporting in the oil industry. Int J Bus Commun. 2018;55(2):194–219. https://doi.org/10.1177/2329488417753951.
6. United Nations. Developed countries must deliver on climate change, finance commitments, delegates stress, as second committee continues its general debate. General Assembly. 4 Oct 2022.
7. Amorim-Maia AT, Anguelovski I, Chu E, Connolly J. Intersectional climate justice: a conceptual pathway for bridging adaptation planning, transformative action, and social equity. Urban Clim. 2022;41: 101053. https://doi.org/10.1016/j.uclim.2021.101053.
8. Donaghy T. 8 reasons why we need to phase out the fossil fuel industry. 2021. https://www.greenpeace.org/usa/research/8-reasons-why-we-need-to-phase-out-the-fossil-fuel-industry/. Accessed 22 Feb 2024.
9. Foran J, Widick R. Breaking barriers to climate justice. Contexts. 2013;12(2):34–9. https://doi.org/10.1177/1536504213487696.
10. Huang X, Khan YA, Arshed N, Salem S, Shabeer MG, Hanif U. Increasing social resilience against climate change risks: a case of extreme climate affected countries. IJCCSM. 2023;15(3):412–31. https://doi.org/10.1108/IJCCSM-04-2022-0051.
11. Adger WN, Dessai S, Goulden M, Hulme M, Lorenzoni I, Nelson DR, Naess LO, Wolf J, Wreford A. Are there social limits to adaptation to climate change? Clim Change. 2009;93:335–54. https://doi.org/10.1007/s10584-008-9520-z.
12. Menton M, Larrea C, Latorre S, Martinez-Alier J, Peck M, Temper L, Walter M. Environmental justice and the SDGs: from synergies to gaps and contradictions. Sustain Sci. 2020;15:1621–36. https://doi.org/10.1007/s11625-020-00789-8.
13. McCauley D, Heffron R. Just transition: integrating climate, energy and environmental justice. Energy Policy. 2018;119:1–7. https://doi.org/10.1016/j.enpol.2018.04.014.
14. Stevenson KT, Peterson MN, Bondell HD, Moore SE, Carier SJ. Overcoming skepticism with education: interacting influences of worldview and climate change knowledge on perceived climate change risk among adolescents. Clim Change. 2014;126:293–304. https://doi.org/10.1007/s10584-014-1228-7.
15. Caney S. Climate change, human rights, and moral thresholds. In: Caney S, editor. Climate ethics: essential readings. Oxford: Oxford University Press; 2010. https://doi.org/10.1093/oso/9780195399622.003.0018.

16. Kim E, Coonan T. Advancing sustainability education through a cross-disciplinary online course: Sustainability and Human Rights in the Business World. Sustainability. 2023;15(6):4759. https://doi.org/10.3390/su15064759.
17. Jickling B, Wals AEJ. Globalization and environmental education: looking beyond sustainable development. J Curric Stud. 2008;40(1):1–21. https://doi.org/10.1080/00220270701684667.
18. Liefländer A, Fröhlich G, Bogner F, Schultz P. Promoting connectedness with nature through environmental education. Environ Educ Res. 2013;19:370–84.
19. Bajaj M, Chiu B. Education for sustainable development as peace education. Peace Chang. 2009;34:441–55. https://doi.org/10.1111/j.1468-0130.2009.00593.x.
20. Monroe MC, Plate RR, Oxarart A, Bowers A, Chaves WA. Identifying effective climate change education strategies: a systematic review of the research. Environ Educ Res. 2019;25:791–812. https://doi.org/10.1080/13504622.2017.1360842.
21. Cook J, Oreskes N, Doran PT, Anderegg WRL, Verheggen B, Maibach EW, et al. Consensus on consensus: a synthesis of consensus estimates on human-caused global warming. Environ Res Lett. 2016;11:48002. https://doi.org/10.1088/1748-9326/11/4/048002.
22. Nussey C, Sanchez Tyson L, Dandare K, Perry J, Mccowan T. How are universities responding to the challenges of the climate crisis? A systematic review of literature. 2023. Working Paper No.: 14.
23. Trott CD, Lam S, Roncker J, Gray ES, Courtney RH, Even TL. Justice in climate change education: a systematic review. Environ Educ Res. 2023;29:1535–72. https://doi.org/10.1080/13504622.2023.2181265.
24. Ulibarri N, Pérez Figueroa O, Grant A. Barriers and opportunities to incorporating environmental justice in the National Environmental Policy act. Environ Impact Assess Rev. 2022;97: 106880.
25. Van Eck NJ, Waltman L. Manual for VOSviewer version 1.6.16. CWTS Meaningful Metrics, Universiteit Leiden; 2021.
26. Yates A, Pedersen Zari M, Bloomfield S, Burgess A, Walker C, Waghorn K, et al. A transformative architectural pedagogy and tool for a time of converging crises. Urban Sci. 2022;7:1. https://doi.org/10.3390/urbansci7010001.
27. Orozco-Messana J, de la Poza-Plaza E, Calabuig-Moreno R. Experiences in transdisciplinary education for the sustainable development of the built environment, the ISAlab Workshop. Sustainability. 2020. https://doi.org/10.3390/su12031143.
28. Maheshwari B, Hagare D, Spencer R, Dollin J, Reynolds J, Atkins D, et al. Training young water professionals in leadership and transdisciplinary competencies for sustainable water management in India. WWP. 2023;9:300–14. https://doi.org/10.1002/wwp2.12114.
29. Lynam CJ, Karunaratne A. Citizen Science and The University of Queensland Seismograph Stations (UQSS)—a study of seismic T waves in S-W Pacific Ocean. Sustainability. 2023. https://doi.org/10.3390/su151410885.
30. Moses A, Ramírez-Andreotta MD, McLain JET, Obergh V, Rutin E, Sandhaus S, et al. The efficacy of hydrogen sulfide (H2S) tests for detecting microbial contamination in rooftop-harvested rainwater. Environ Monit Assess. 2023;195:1398. https://doi.org/10.1007/s10661-023-11942-y.
31. Bexell SM, Saitta D, Sher A, Sutton P. Co-creation of a center for a regenerative future. Sustainability. 2023. https://doi.org/10.3390/su151712861.
32. Rolleston C, Nyerere J, Brandli L, Lagi R, McCowan T. Aiming higher? Implications for higher education of students' views on education for climate justice. Sustainability. 2023;15(19):14473. https://doi.org/10.3390/su151914473.
33. Al-Saleh D, Vora N. US Higher education and fossil fuels: the limits of liberalism in university climate action. Clim Dev. 2023. https://doi.org/10.1080/17565529.2023.2247378.
34. Cleveland DA, Jay JA. Integrating climate and food policies in higher education: a case study of the University of California. Clim Policy. 2021;21(1):16–32. https://doi.org/10.1080/14693062.2020.1787939.
35. Elliott-Kingston C, Haines N, Stewart G, McCabe P. Creating a university evolution garden: an integrated learning approach for teaching land plant evolution. Plants People Planet. 2021;3(6):761–74. https://doi.org/10.1002/ppp3.10227.
36. Cianfagna M, Bolon I, Babo Martins S, Mumford E, Romanelli C, Deem SL, Pettan-Brewer C, Figueroa D, Velásquez JCC, Stroud C, Ruiz de Castañeda R. Biodiversity and human health interlinkages in higher education offerings: A First Global Overview. Front Public Health. 2021;9: 637901. https://doi.org/10.3389/fpubh.2021.637901.
37. Leal Filho W, Krishnapillai M, Minhas A, Ali S, Nagle Alverio G, Hendy Ahmed MS, Naidu R, Prasad RR, Bhullar N, Sharifi A, Nagy GJ, Kovaleva M. Climate change, extreme events and mental health in the Pacific region. Int J Clim Chang Strateg Manag. 2023;15(1):20–40. https://doi.org/10.1108/IJCCSM-03-2022-0032.
38. Ma L, Shahbaz P, Haq SU, Boz I. Exploring the moderating role of environmental education in promoting a clean environment. Sustainability. 2023;15(10):8127. https://doi.org/10.3390/su15108127.
39. Ram SA, MacLean HL, Tihanyi D, Hannah L, Posen ID. The complex relationship between carbon literacy and pro-environmental actions among engineering students. Heliyon. 2023;9(11): e20634. https://doi.org/10.1016/j.heliyon.2023.e20634.
40. Rom WN, Rao A, Hoepner L, Dickey C. A new model of learning: environmental health in a global world. Int J Environ Res Public Health. 2023;20(12):6146. https://doi.org/10.3390/ijerph20126146.
41. McElroy KG, Gilden R, Sattler B. Environmental health nursing education: one school's journey. Public Health Nurs. 2021;38(2):258–65. https://doi.org/10.1111/phn.12815.
42. Fülbert H, Schäfer LN, Gerspacher LM, Bösner S, Schut C, Krolewski R, Knipper M. Elective course "Climate-sensitive health counselling"—prevention as an opportunity for people and planet? An interactive, student-led project focusing on prevention and agency in physician's climate communication. GMS J Med Educ. 2023. https://doi.org/10.3205/ZMA001616.
43. Navarrete-Welton A, Chen JJ, Byg B, Malani K, Li ML, Martin KD, Warrier S. A grassroots approach for greener education: An example of a medical student-driven planetary health curriculum. Front Public Health. 2022;10:1013880. https://doi.org/10.3389/fpubh.2022.1013880.
44. Busayo ET, Kalumba AM, Afuye GA, Ekundayo OY, Orimoloye IR. Assessment of the Sendai framework for disaster risk reduction studies since 2015. Int J Disaster Risk Reduct. 2020;50: 101906. https://doi.org/10.1016/j.ijdrr.2020.101906.
45. Chandra A, McNamara KE, Clissold R, Tabe T, Westoby R. Climate-induced non-economic loss and damage: understanding policy responses, challenges, and future directions in Pacific small island developing states. Climate. 2023;11(3):74. https://doi.org/10.3390/cli11030074.

46. Pickering CJ, Guy E, Al-Baldawi Z, McVean L, Sargent S, O'Sullivan T. "I believe this team will change how society views youth in disasters": the EnRiCH Youth Research Team: a youth-led community-based disaster risk reduction program in Ottawa Canada. Can J Public Health. 2021;112(5):957–64. https://doi.org/10.17269/s41997-021-00486-8.
47. Sugg MM, Ryan S, Spurlock T, Duncan S, Hege A, Ogwu MC, Tyson J, Shay E, Renwick KA, Hendren C, Roy M, Runkle JD. Climate change and health in rural mountain environments: summary of a workshop on knowledge gaps, barriers, and opportunities for action. GeoJournal. 2023;88:5397–409. https://doi.org/10.1007/s10708-023-10916-4.
48. Takinana A, Baars RC. Climate change education in the South Pacific: resilience for whom? Asia Pac Viewp. 2023;64(1):72–84. https://doi.org/10.1111/apv.12358.
49. Couch VT, Salata S, Saygin N, Frary A, Arslan B. De-Sealing reverses habitat decay more than increasing groundcover vegetation. Clim. 2023;11(6):116. https://doi.org/10.3390/cli11060116.
50. Versini PA, Al Sayah M, Bordignon F, Schertzer D. How the concept of nature-based solutions for climate adaptation could be introduced in Master's curricula. Insights from France. J Clean Prod. 2023;395: 136364. https://doi.org/10.1016/j.jclepro.2023.136364.
51. Buerkle A, O'Dell A, Matharu H, Buerkle L, Ferreira P. Recommendations to align higher education teaching with the UN sustainability goals—a scoping survey. IJEDRO. 2023;5: 100280. https://doi.org/10.1016/j.ijedro.2023.100280.
52. Puertas R, Guaita-Martinez JM, Marti L. Analysis of the impact of university policies on society's environmental perception. Socio-Econ Plan Sci. 2023;88: 101672. https://doi.org/10.1016/j.seps.2023.101672.
53. Healey NM. Reinventing international higher education for a socially just, sustainable world. PPPHE. 2023;27(4):69–178. https://doi.org/10.1080/13603108.2023.2217780.
54. Staniewska A, Sykta I, Ozimek A, Barnaś K, Dudek M, Marasik M, Racoń-Leja K. Framework for the design of a small transport hub as an interdisciplinary challenge to implement sustainable solutions. Sustainability. 2023;15(14):10975. https://doi.org/10.3390/su151410975.
55. Bogedain A, Hamm R. Strengthening local economy—an example of a higher education institutions' engagement in "co-creation for sustainability." Region. 2020;7(2):2. https://doi.org/10.18335/region.v7i2.271.
56. Jiang Q, Kurnitski J. Performance based core sustainability metrics for university campuses developing towards climate neutrality: a robust PICSOU framework. SCS. 2023;97: 104723. https://doi.org/10.1016/j.scs.2023.104723.
57. Sun L, Kaufman MF, Sirk EA, Durga S, Mahowald NM, You F. COVID-19 impact on an academic Institution's greenhouse gas inventory: the case of Cornell University. J Clean Prod. 2022;363: 132440. https://doi.org/10.1016/j.jclepro.2022.132440.
58. Matsunobu LM, Coimbra CFM. Reimagining the academic calendar for a changing climate: modeled impact of shifting the fall term at the University of California. CESYS. 2023;9: 100113. https://doi.org/10.1016/j.cesys.2023.100113.
59. Ogunseitan OA. Broad spectrum integration of climate change in health science curricula. Front Public Health. 2022;10:1–7. https://doi.org/10.3389/fpubh.2022.954025.
60. Lansbury N, Mishro K, Son KY, Milsom O, Baston S, Buckley L. Teaching about climate change impacts on health: capturing the experience for educators. CSE. 2023;7(1):1925640. https://doi.org/10.1525/cse.2023.1925640.
61. Schmeltz MT, Ganesh C. Improving the capacity and diversity of local public health workforce to address climate impacts to health through community partnerships and problem-based learning. Front Public Health. 2023;10:1–6. https://doi.org/10.3389/fpubh.2022.1090129.
62. Capetola T, Noy S, Patrick R. Planetary health pedagogy: preparing health promoters for 21st-centuryenvironmental challenges. Health Promot J Austr. 2022;33(1):17–21. https://doi.org/10.1002/hpja.641.
63. Leimbach T, Kent J, Walter J. The affective dimension of crisis subjects: teaching environmental communication through intersecting crises Aust. J Adult Learn. 2022;62(3):325–51.
64. Bartlett M, Larson J, Lee S. Environmental justice pedagogies and self-efficacy for climate action. Sustainability. 2022;14:15086. https://doi.org/10.3390/su142215086.
65. Cordero EC, Todd AM, Abellera D. Climate change education and theecological footprint. J Am Chem Soc. 2008;89:865–72. https://doi.org/10.1175/2007bams2432.1.
66. Stein S, Andreotti V, Ahenakew C, Susa R, Valley W, Kui NH, Tremembé M, Taylor L, Siwek D, Cardoso C, Duque CA, da Silva Huni Kui SO, Calhoun B, van Sluys S, Amsler S, D'Emilia D, Pigeau D, Andreotti B, Bowness E, McIntyre A. Beyond colonial futurities in climate education. J Teach Educ. 2022;28(5):987–1004. https://doi.org/10.1080/13562517.2023.2193667.
67. Marcella V, Samofalova Y. Data-driven and research-based learning approaches to environmental education in university contexts: two case studies in Italy and Germany. Lang Teach High Educ. 2022;12(2):567–86. https://doi.org/10.1515/cercles-2022-2064.
68. Pattison A, Henke CR, Pumilio J. Community-based climate action planning as an act of advocacy: a case study of liberal arts education in a rural community. J Environ Sci Stud. 2021;2021(11):183–93. https://doi.org/10.1007/s13412-020-00655-0.
69. Nussey C, Frediani AA, Lagi R, Mazutti J, Nyerere J. Building university capabilities to respond to climate change through participatory action research: towards a comparative analytical framework. J Hum Dev Capab. 2022;23(1):95–115.
70. Lieberknecht K, Houser H, Rabinowitz A, Pierce SA, Rodríguez L, Leite F, Lowell J, Gray JN. Creating meeting grounds for transdisciplinary climateresearch: the role of humanities and social sciences in grand challenges. Interdiscipl Sci Rev. 2022;48(4):585–607. https://doi.org/10.1080/03080188.2022.214888.
71. Kinol A, Miller E, Axtell H, Hirschfeld I, Leggett YS, Stephens JC. Climate justice in higher education: a proposed paradigm shift towards a transformative role for colleges and universities. Clim Change. 2023;176(15):1–29. https://doi.org/10.1007/s10584-023-03515-2.
72. Dunlop L, Rushton EAC. Putting climate change at the heart of education: Is England's strategy a placebo for policy? Br Educ Res J. 2022;48:1083–101. https://doi.org/10.1002/berj.3816.
73. Svarstad H. Critical climate education: studying climate justice in time and space. Int Stud Sociol Educ. 2021;30:214–32. https://doi.org/10.3390/app131911034.