Climate Change: Why Higher Education Matters?

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Abstract

Higher education (HE) matters to the global struggle to combat climate change. Research builds knowledge and informs climate solutions. Educational programmes and courses upskill current and future leaders and professionals to tackle the systems change and the transformation needed to improve society. Through their outreach and civic engagement

work, HE helps people understand and address the climate change impacts, notably on under-resourced or marginalised people. By raising awareness of the problem and supporting capacity and capability building, HE encourages changes in attitudes and behaviours, focusing on adaptive change in preparing people to face the challenges of a changing climate. However, HE has yet to fully articulate its contribution towards climate change challenges, which means that organisational structures, curricula and research programmes do not reflect the interdisciplinary nature of the climate crisis. This paper describes the role of HE in supporting education and research efforts on climate change and outlines areas where further action is urgently needed. The study adds to the empirical research on HE's role in combating climate change and the role of cooperation in maximising the global effort to cope with a changing climate.

Keywords: Sustainability; Climate change agenda; Interdisciplinarity; Higher Education Agenda; Social change.

1. Introduction

As well as being part of the solution, universities and colleges contribute to the global emission of greenhouse gases through their estates and operations, travel by staff and students, student residences and food waste. Many are now focused on reducing their carbon footprint (Valls-Val & Bovea, 2021; Leal Filho et al., 2023a), albeit consistency is limited (Helmers et al., 2021), with some making public pledges to reach net zero (UNEP, 2021). Switching to greening their operations and paying attention to waste management,

green buildings, and low-carbon transportation (Fissi et al., 2021; Papantoniou et al., 2020) are ways HEIs seek to reduce their carbon footprint.

Globally, Higher Education institutions (HEIs) are well positioned to use their resources more widely to drive sustainability initiatives beyond their campus and the local community to help shape more sustainable societies and reduce pressures on the environment and the world's climate. However, the degree to which universities implement sustainability practices and initiatives varies across developed (Swearingen White, 2014) and developing nations (Hoque et al., 2017), institutional archetypes, and mission (Purcell & Haddock-Fraser, 2023). Nevertheless, what is clear is that sustainability initiatives championed by HEIs can address both the causes and impacts of climate change, both locally and globally.

Unlocking the potential contribution of HEIs to addressing climate change demands institutional support (Ssekamatte, 2022). Leadership and governance for transformational change are necessary prerequisites and enablers of change over time (Purcell, 2019; Leal Filho et al., 2023b). Climate change should not be limited to science and engineering departments but must be addressed at a whole institutional level as central to academic strategy. HEIs can then directly engage in climate change through discipline-led activities, interdisciplinary efforts, and collaborative work with local, national and international stakeholders and partners (Leal Filho et al., 2021, 2022a, 2023c). Furthermore, they can think and act over the long term while providing a space for discussion and debates that foster the development of relevant solutions, such as by declaring a climate emergency (Latter & Capstick, 2021).

HEIs are central to education for sustainable education (Molthan-Hill et al., 2019), which has contributed to developing new skills, tools and concepts to tackle unsustainable practices and promote pro-sustainability efforts. This substantial amplification effect, with trained and educated people in the workforce and broader society, aids in building resilience to climate change and other related environmental effects with HEIs adopting different discourses and practices (Ruiz-Mallén & Heras, 2020). In addition, many institutions recognise the importance of supporting lifelong learning (English & Carlsen, 2019; Ouane, 2011), offering training and executive education for those in work and facing the frontline challenges presented by climate change and the sustainable development goals (SDGs) (Leal Filho et al., 2022b; Vieira, 2020).

This perspective attempts to explain how HEIs can engage with the climate agenda. In order to shed further light on the topic, an expert-driven review was performed to explore such connections. Based on the findings, some key issues are highlighted in Table 1.

Table 1. Some Ways for Higher Education to Engage with the Climate Change Agenda

Type of higher education institution	Climate change aspects relevant to the institutions	References
Conventional universities	environmental education, green initiatives, climate declarations and pledges, and climate change research	Blanco et al. (2022); Fissi et al. (2021); Latter, B., & Capstick, S. (2021)
Medical universities	health impact research, public health literacy, eco-medical literacy, sustainable healthcare, clinical competency, and indigenous knowledge	Maxwell & Blashki (2016); Liao et al. (2019); Goshua et al. (2021); Teherani et al. (2023); Brand et al. (2023)
Business schools	economics, organisational transformation, performance measurement, operations, marketing, leadership, and governance	Howard-Grenville et al. (2014); Purcell (2019)
Law schools	governance, policies, climate law, agreements and treaties, and advocacy	Bouwer et al. (2022); Mehling et al. (2020); Giraudou (2021)
Arts schools	climate change awareness, and creative climate change communication	Qi (2023); Sommer et al. (2019); Cook et al. (2022)
Veterinary schools	animal health impact research, animal health literacy, and interdisciplinary learning and partnership (One Health)	Lacetera (2019); Wilkes et al. (2019).

Source: authors

As seen in Table 1, HEIs may incorporate climate change into their curricula in various ways. For example, this could be done by creating courses dedicated to climate change or by weaving climate change concepts into existing courses.

2. Operationalising climate action

In choosing to focus on climate change more explicitly, HEIs may need to adjust the scope of their work; the approaches used and their priorities (see Figure 1). Opportunities across the institutions emerge to connect disciplines with consequent impact on the design of educational programmes and research projects. Using the lens of climate change enables HEIs to be alert to new ways of working, gaps in the current course and

programme provision, and emergent research questions with prospects for additional and new funding streams.

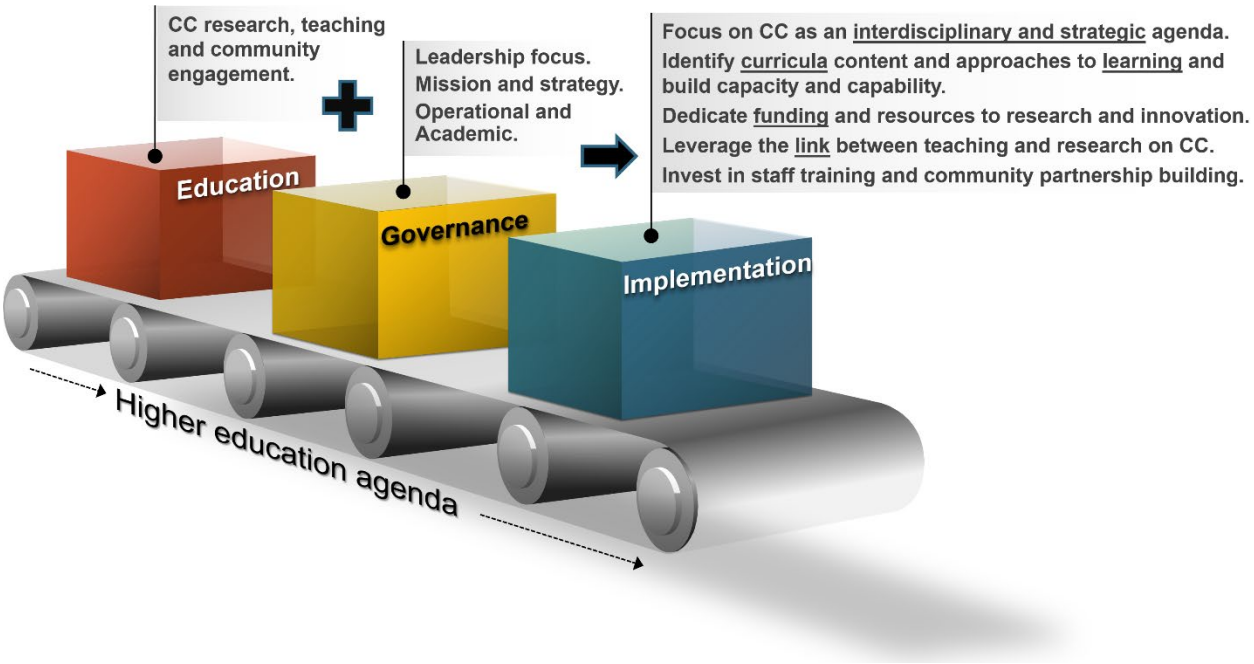

Fig. 1. Ways a focus on climate change can impact the higher education agenda. Source: Authors. Based on data from Torkzadeh and Mohtaram (2022) and Leal Filho et al. (2021).

Although there is an increasing body of work on campus sustainability and climate issues in the curriculum, there is a need to understand more holistically the forms of influence that universities have on society and the environment (McGowan, 2020).

By providing training and capacity building, conducting climate change sensitisation campaigns, and advising communities and policymakers on the subject, HEIs can use their convening power to bring stakeholders together to tackle the causes of climate change and roll out solutions to reduce its impact and support adaptation where possible. In addition, research-intensive and technical universities and colleges can help community actors address climate change-related issues, offering, for example, analysing air quality and temperature measurements, monitoring traffic flows, and piloting interventions in waste management (Strachan et al., 2022). Similarly, they can be involved in co-production efforts with neighbouring communities in local adaptation and mitigation initiatives (Hsieh & Lee, 2021; Khayyam et al., 2021). The potential for HEIs to promote societal change in this respect reflects their anchor status (Fissi et al., 2021; Hernández-Diaz et al., 2021). Moreover, it promotes synergies across disciplines (Leal Filho et al., 2021) and campus actions in the guise of the living laboratory model (Purcell et al., 2019). In addition to the climate management measures taken by governments and civil society organisations around the world, the response to climate change and sustainability across the nations by HEIs is core to a contemporary mission for the 21st century and beyond (Leal Filho et al., 2021; Su Jeong et al., 2021; Villavicencio Calzadilla et al., 2018).

The recent COVID-19 pandemic revealed how fast HEIs could act when faced with a crisis and accelerated the adoption of online learning and the roll-out of new working

practices (Purcell & Lumbreras, 2021). As such, we should expect HEIs to act with a similar level of urgency and attention, given the gravity of the climate crisis. Takshe et al. (2022) showed the importance of post-pandemic regulations to stop a return to pre-pandemic behaviours by students in the United Arab Emirates. Similarly, the perspective of Finnish university students on climate change education highlighted the need to increase and organise knowledge, cultivate critical-thinking abilities, and promote action both now and in the future (Yli-Panula et al., 2022). A study of the impact of climate change information on university students in Turkey (Yilmaz et al., 2022) revealed that their awareness translated into improved risk perception and a heightened sense of greater responsibility with students engaged in environmental behaviour to reduce climate change.

To successfully implement a culture of social change within universities to focus on climate action, leadership is essential (Leal Filho et al., 2021; Torkzadeh & Mohtaram, 2022) since change needs to involve all organisational levels and cross-cutting agenda, new measures of impact and accountability, as well as attention to incentives and strategies (Torkzadeh & Mohtaram, 2022). As with other organisations, universities compete for resources, and their survival and success depend on understanding emergent trends, scenario planning, and adaptability. Partnerships with other universities can help (Leal Filho et al., 2021). For example, the university questionnaire (CEDU-Q) developed by Ferrari et al. (2022) served Salamanca University (Spain) to declare a climate emergency. It showed that PhD students had the keenest awareness about the university's actions to tackle climate change, likely due to their direct focus on related research projects (Leal Filho et al., 2021). However, the same instrument revealed a need for more communication across the university community and highlighted the need to develop a more participatory culture. Environmental education by HEIs is central to increased awareness. It supports action (Blanco et al., 2022), contributing to a global problem but with local impacts (Leal Filho et al., 2021).

Nevertheless, climate change is not the exclusive domain of social sciences. Instead, it also entails various elements from the natural sciences. Figure 2 outlines some of these connections.

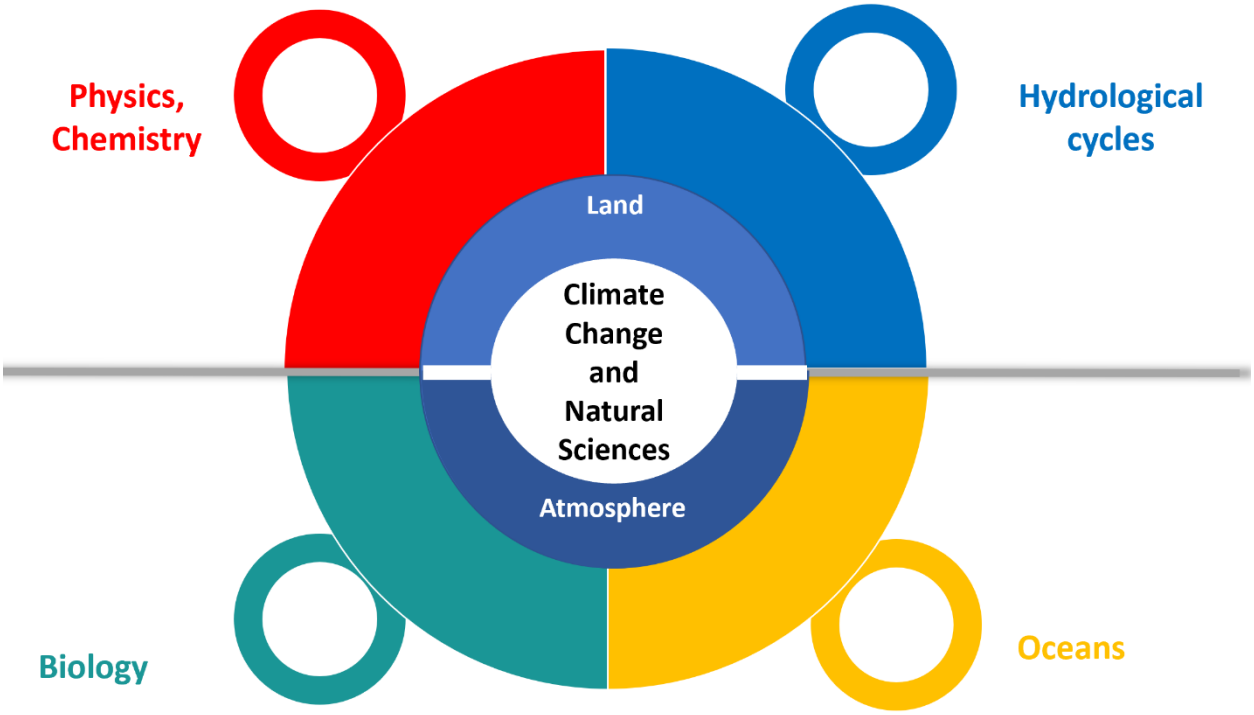

Fig. 2. Some Connections Between Climate Change and Natural Sciences

In particular, the natural sciences are essential in developing and evaluating potential solutions to climate change. For example, studying atmospheric cycles is critical in preparing climate models and influencing policymaking. In addition, knowledge of how climate change influences fauna and flora is helping in guiding measures to protect biodiversity.

3. Future trends

HEIs play a critical role in efforts to tackle climate change. They are key players in education, research, and policymaking and have the potential to lead the way in developing innovative solutions to the climate crisis. HEIs can educate students on the science of climate change and its policy, economics, and social aspects. They can also lead the way in researching and developing renewable energy technologies and promoting sustainability through campus initiatives. Finally, universities can shape public policy by advocating and providing a platform for dialogue between industry, government, and civil society.

Some emerging research streams on climate change at universities are:

i. Climate Modelling and Prediction: many Universities are using sophisticated climate models to predict future climate scenarios and assess the potential impacts of climate change on the environment or agriculture. Such research streams explore new data

sources and statistical methods to capture better the climate system's complexity, including its interactions with the biosphere, oceans, and atmosphere.

ii) Climate Adaptation and Resilience: This research stream focuses on understanding how communities, ecosystems, and infrastructure are influenced by or can adapt to a changing climate. Many universities are studying climate change's social, economic, and environmental impacts and exploring strategies for building resilience and reducing vulnerability.

iii) Climate Policy and Governance: This research stream examines the design and implementation of policies to mitigate greenhouse gas emissions and adapt to the impacts of climate change. Many universities are studying the political and institutional barriers to climate action, exploring the role of international agreements and national policies, and evaluating the effectiveness of different policy instruments.

iv) Climate Change Communication and Education: This research stream explores how to communicate climate science to the public and policymakers effectively. Many universities are studying the psychology of climate change denial and scepticism, developing new communication strategies and tools, and exploring the role of education and outreach in promoting climate literacy and engagement. One particular initiative is the "International Climate Change Information and Research Programme" https://www.haw-hamburg.de/en/ftz-nk/programmes/iccirp/, created in 2008, congregates over 7,000 climate researchers, and coordinates the World PhD Students Climate Change Network, which regularly organises climate change summits for doctoral students working on the topic (https://esssr.eu/9-3-2022-world-phd-students-climate-change-summit/).

v) Climate Change and Health: This research stream investigates the health impacts of climate change, including the spread of vector-borne diseases, the effects of air pollution and urban heat on health, and the mental health consequences of extreme weather events. Universities are exploring new data sources and analytical methods to understand the complex relationships between a changing climate and human health.

Against this background, HEIS must engage further by, for instance, partnering with local organisations to foster dialogue and raise awareness about climate change and its impacts. Also, HEIs can provide opportunities for students to get involved in climate activism and create a campus culture that values sustainability and environmental stewardship.

Scholars can further their efforts to tackle climate change in several ways, such as researching climate change, its causes, impacts, and potential solutions and publishing their findings in peer-reviewed journals and other media such as newspapers and other non-academic publications. This can help advance scientific understanding of the issue, inform policy decisions, and foster public awareness. Also, scholars may collaborate more with colleagues from other disciplines, which makes perfect sense since climate change is a complex issue that requires expertise from multiple disciplines. Scholars can collaborate with experts from other fields, such as environmental science, engineering,

economics, and policy, to develop interdisciplinary solutions. A further area of action for scholars is to engage more in educating the public about climate change through various means, such as public lectures, workshops, and outreach programmes. This can raise awareness and encourage individuals to take action to reduce their carbon footprint. A further area is advocacy: scholars can use their expertise to advocate for policies that address climate change at local, national, and international levels. They can provide evidence-based recommendations to policymakers -as many do as part of the work of the Intergovernmental Panel on Climate Change (IPCC) and engage in public discourse to promote climate action.

Drawing from its main assets: human resources and knowledge, and acting locally but connected through global networks, HEIs can bring them together to the advantage of national and international efforts to address climate change. Here collaboration between disciplines may play a key role in producing sound technological and socio-cultural solutions, which may assist in efforts to cope with a changing climate.

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References

Blanco, M.A., Blanco, M.E., & Vila Hinojo, B. T. (2022). Environmental education and attitude towards climate change in university students. *Revista San Gregorio*(49), 1-15. https://doi.org/10.36097/rsan.v0i49.1924

Bouwer, K., John, E., Luke, O., & Rozhan, A. (2022). 'Climate Change isn't Optional': Climate Change in the Core Law Curriculum. Legal Studies, 1-19. http://dx.doi.org/10.1017/lst.2022.35.

Brand, G., Wise, S., Bedi, G., & Kickett, R. (2023). Embedding Indigenous knowledges and voices in planetary health education. The Lancet Planetary Health, 7(1), e97-e102. http://dx.doi.org/10.1016/s2542-5196(22)00308-4

Cook, J., Ecker, U. K., Trecek-King, M., Schade, G., Jeffers-Tracy, K., Fessmann, J., ... & McDowell, J. (2022). The cranky uncle game—Combining humor and gamification to build student resilience against climate misinformation. Environmental Education Research, 1–17. http://dx.doi.org/10.1080/13504622.2022.2085671

English, L. M., & Carlsen, A. (2019). Lifelong learning and the Sustainable Development Goals (SDGs): Probing the implications and the effects. In (Vol. 65, pp. 205-211): Springer. http://dx.doi.org/10.1007/s11159-019-09773-6

Ferrari, E., Mariel Reyes-Carrasco, P., Barron Ruiz, A., & Ruiz, C. (2022). Testing an instrument to assess the perception of climate change policies in universities: the case of Salamanca University. *International Journal of Sustainability in Higher Education*. https://doi.org/10.1108/ijshe-09-2021-0379

Fissi, S., Romolini, A., Gori, E., & Contri, M. (2021). The path toward a sustainable green university: The case of the University of Florence. Journal of Cleaner Production, 279, 123655. https://doi.org/10.1016/j.jclepro.2020.123655. Giraudou, I. (2021).

Environmental Legal Education as if Earth Really Mattered: A Brief Account from Japan. Asian Journal of Legal Education, 8(1), 7–18. http://dx.doi.org/10.1177/2322005820959951.

Goshua, A., Gomez, J., Erny, B., Burke, M., Luby, S., Sokolow, S., ... & Nadeau, K. (2021). Addressing climate change and its effects on human Health: A call to action for medical schools. Academic Medicine, 96(3), 324–328. http://dx.doi.org/10.1097/acm.0000000000003861

Helmers, E., Chang, C. C., & Dauwels, J. (2021). Carbon footprinting of universities worldwide: Part I—objective comparison by standardised metrics. Environmental Sciences Europe, 33(1), 1-25. https://doi.org/10.1186/s12302-021-00454-6

Hernández-Diaz, P.M., Polanco, J.A., Escobar-Sierra, M. & Leal Filho, W. (2021). Holistic integration of sustainability at universities: Evidences from Colombia. Journal of Cleaner Production, 305, p.127145. http://dx.doi.org/10.1016/j.jclepro.2021.127145

Hoque, A., Clarke, A., & Sultana, T. (2017). Environmental sustainability practices in South Asian university campuses: an exploratory study on Bangladeshi universities. Environment, Development and Sustainability, 19(6), 2163-2180. https://doi.org/10.1007/s10668-016-9845-0

Howard-Grenville, J., Buckle, S. J., Hoskins, B. J. & George, G. (2014). Climate change and management. Academy of Management Journal, pp. 57, 615– 23. http://dx.doi.org/10.5465/amj.2014.4003.

Hsieh, T.-F., & Lee, Y.-M. (2021). Community-Based Adaptation to Climate Change: The Case of a Community University Workshop in Taiwan. *Sustainability*, *13*(4), Article 1729. https://doi.org/10.3390/su13041729

Khayyam, U., Bano, R., & Alvi, S. (2021). Towards Climate Change Mitigation and Adaptation. *Comparative Sociology*, *20*(1), 138-158. https://doi.org/10.1163/15691330-bja10028

Lacetera, N. (2019). Impact of climate change on animal health and welfare. Animal Frontiers, 9(1), 26–31. https://doi.org/10.1093/af/vfy030

Latter, B., & Capstick, S. (2021). Climate emergency: UK universities' declarations and their role in responding to climate change. Frontiers in sustainability, p. 2, 660596. https://doi.org/10.3389/frsus.2021.660596.Liao, W., Yang, L., Zhong, S., Hess, J. J., Wang, Q., Bao, J., & Huang, C. (2019). Preparing the next generation of health professionals to tackle climate change: are China's medical students ready? Environmental Research, pp. 168, 270–277. http://dx.doi.org/10.1016/j.envres.2018.10.006.

Leal Filho, W., Vidal, D. G., Dinis, M. A. P., Lambrechts, W., Vasconcelos, C. R. P., Molthan-Hill, P., Abubakar, I. R., Dunk, R. M., Salvia, A. L., & Sharifi, A. (2023a). Low carbon futures: assessing the status of decarbonisation efforts at universities within a 2050 perspective [Research]. Energy, Sustainability and Society, 13, Article 5. https://doi.org/10.1186/s13705-023-00384-6.

Leal Filho, W., Abubakar, I. R., Mifsud, M. C., Eustachio, J. H. P. P., Albrecht, C. F., Dinis, M. A. P., Borsari, B., Sharifi, A., Levesque, V. R., Ribeiro, P. C. C., LeVasseur, T. J., Pace, P., Trevisan, L. V., & Dibbern, T. A. (2023b). Governance in the implementation of the UN sustainable development goals in higher education:

Global trends. Environment, Development and Sustainability. https://doi.org/10.1007/s10668-023-03278-x.

Leal Filho, W., Trevisan, L. V., Dinis, M. A. P., Sivapalan, S., Wahaj, Z., & Liakh, O. (2023c). Ensuring sustainability in internationalisation efforts at higher education institutions [Literature Review]. International Journal of Sustainability in Higher Education 1-14. https://doi.org/10.1108/IJSHE-10-2022-0333.

Leal Filho, W., Wall, T., Barbir, J., Alverio, G. N., Dinis, M. A. P., & Ramirez, J. (2022a). Relevance of International Partnerships in the Implementation of the UN Sustainable Development Goals [Comment]. Nature Communications, 13(1), Article 613. https://doi.org/10.1038/s41467-022-28230-x.

Leal Filho, W., Vidal, D. G., Chen, C., Petrova, M., Dinis, M. A. P., Yang, P., Rogers, S., Álvarez-Castañón, L. d. C., Djekic, I., Sharifi, A., & Neiva, S. (2022b). An assessment of requirements in investments, new technologies and infrastructures to achieve the SDGs [Research]. Environmental Sciences Europe, 34, 1-17, Article 58. https://doi.org/10.1186/s12302-022-00629-9.

Leal Filho, W., Sima, M., Sharifi, A., Luetz, J. M., Salvia, A. L., Mifsud, M., Olooto, F. M., Djekic, I., Anholon, R., Rampasso, I., Donkor, F., Dinis, M. A. P., Klavins, M., Finnveden, G., Chari, M. M., Molthan-Hill, P., Mifsud, A., Sen, S. K., & Lokupitiya, E. (2021). Handling climate change education at universities: an overview. Environmental Sciences Europe, 33, 1-19, Article 109. https://doi.org/10.1186/s12302-021-00552-5 .

McCowan, T. (2020). The impact of universities on climate change: a theoretical framework. Transforming Universities for a Changing Climate, Working Paper Series No. 1. http://dx.doi.org/10.1007/978-3-642-10751-1_4.

Maxwell, J., & Blashki, G. (2016). Teaching about climate change in medical education: an opportunity. Journal of Public Health Research, 5(1), 14–20. https://doi.org/10.4081/jphr.2016.673.

Mehling, M., van Asselt, H., Kulovesi, K., & Morgera, E. (2020). Teaching climate law: Trends, methods and outlook. Journal of Environmental Law, 32(3), 417-440. http://dx.doi.org/10.1093/jel/eqz036

Molthan-Hill, P., Worsfold, N., Nagy, G. J., Leal Filho, W., & Mifsud, M. (2019). Climate change education for universities: A conceptual framework from an international study. Journal of Cleaner Production, 226, 1092-1101. https://doi.org/10.1016/j.jclepro.2019.04.053

Ouane, A. (2011). Evolution of and perspectives on lifelong learning. In J. Yang & A. R. Valdés-Coter (Eds.), Conceptual evolution and policy developments in lifelong learning (pp. 24–39). UNESCO Institute for Lifelong Learning. http://dx.doi.org/10.1007/978-1-4020-6193-6_6.

Papantoniou, P., Yannis, G., Vlahogianni, E., Attard, M., Regattieri, A., Piana, F., & Pilati, F. (2020). Developing a Sustainable Mobility Action Plan for University Campuses. Transportation Research Procedia, 48, 1908-1917. https://doi.org/10.1016/j.trpro.2020.08.223.

Purcell, W.M. (2019). A conceptual framework of leadership and governance in sustaining entrepreneurial universities illustrated with case material from a retrospective review of a university's strategic transformation: the enterprise university. Chapter

in Springer 978-981-13-8129-4, Kliewe *et al.* (Eds): *Developing Engaged and Entrepreneurial Universities. http://dx.doi.org/10.1007/978-981-13-8130-0_13.*

Purcell, W.M., Hendriksen, H.A. & Spengler, J. (2019). Universities as the engine of transformational sustainability toward delivering the sustainable development goals: 'living labs' for sustainability. *International Journal of Sustainability in Higher Education.* https://www.emerald.com/insight/content/doi/10.1108/IJSHE-02-2019-0103/full/html.

Purcell, W.M. & Lumbreras, J. (2021). Higher education and the covid-19 pandemic: navigating disruption using the sustainable development goals. *Discover Sustainability* 2:6. https://doi.org/10.1007/s43621-021-00013-2.

Purcell, W.M., & Haddock-Fraser, J. (2023). Bloomsbury Handbook of Sustainability in Higher Education. Bloomsbury Press. http://dx.doi.org/10.5040/9781350244375

Qi, R., (2023). Keep Silent or Speak Louder: An International Asian Student Using Art to Speak to the World. In Counternarratives from Asian American Art Educators (pp. 102–111). Routledge. http://dx.doi.org/10.4324/9781003222293-16

Ruiz-Mallén, I., & Heras, M. (2020). What sustainability? Higher education institutions' pathways to reach the Agenda 2030 goals. Sustainability, 12(4), 1290. https://doi.org/10.3390/su12041290.

Sommer, L. K., Swim, J. K., Keller, E., & Klöckner, C. A. (2019). "Pollution Pods": The merging of art and psychology to engage the public in climate change. Global Environmental Change, 59, 101992. http://dx.doi.org/10.1016/j.gloenvcha.2019.101992.

Ssekamatte, D. (2022). The role of the university and institutional support for climate change education interventions at two African universities. *Higher Education*. https://doi.org/10.1007/s10734-022-00828-6. Strachan, S., Logan, L., & Marshall, S. (2022). Vertically integrated projects for sustainable development: achieving transformational action by embedding research-based ESD in curricula. Environmental Sciences Proceedings, 15(1), 63. http://dx.doi.org/10.3390/environsciproc2022015063.

Su Jeong, J., Gonzalez-Gomez, D., Carmen Conde-Nunez, M., Samuel Sanchez-Cepeda, J., & Yllana-Prieto, F. (2021). Improving Climate Change Awareness of Preservice Teachers (PSTs) through a University Science Learning Environment. *Education Sciences*, *11*(2), Article 78. https://doi.org/10.3390/educsci11020078.

Swearingen White, S. (2014), "Campus sustainability plans in the United States: where, what, and how to evaluate?" International Journal of Sustainability in Higher Education, Vol. 15 No. 2, pp. 228-241. https://doi.org/10.1108/IJSHE-08-2012-0075.

Takshe, A. A., Lovett, J. C., Stenner, P., Contu, D., & Weber, N. (2022). Prioritising climate change actions post COVID-19 amongst university students; a Q methodology perspective in the United Arab Emirates. *International Journal of Global Warming*, *26*(1), 120-139. https://doi.org/10.1504/ijgw.2022.120071

Teherani, A., Nicastro, T., Clair, M. S., Nordby, J. C., Nikjoo, A., Collins, S., ... & Weiser, S. D. (2023). Faculty Development for Education for Sustainable Health Care: A University System-Wide Initiative to Transform Health Professional Education. Academic Medicine, 10-1097. http://dx.doi.org/10.1097/acm.0000000000005137.

Torkzadeh, J., & Mohtaram, M. (2022). Developing a Framework for Managing Change Climate in Social Systems: Some Practical Implications for Medical Education Universities. *Education Research International*, *2022*, Article 9352882. https://doi.org/10.1155/2022/9352882

UNEP (2021). over 1,000 universities and colleges make net-zero pledges as new nature initiative is unveiled. https://www.unep.org/news-and-stories/press-release/over-1000-universities-and-colleges-make-net-zero-pledges-new-nature

Valls-Val & Bovea (2021). Carbon footprint in Higher Education Institutions: a literature review and prospects for future research. Clean Techn Environ Policy 23, 2523–2542 (2021). https://doi.org/10.1007/s10098-021-02180-2.

Vieira, D. (2020). Lifelong Learning and Its Importance in Achieving the Sustainable Development Goals. In W. Leal Filho, A. Azull, I. Brandl, P. Özuyar, & W. T (Eds.), Quality Education (pp. 535–544). http://dx.doi.org/10.1007/978-3-319-95870-5_7.

Villavicencio Calzadilla, P., Mauger, R., & Du Plessis, A. (2018). Climate Change Communication in Higher Education Institutions: The Case of the North-West University in South Africa. In *Handbook of Climate Change Communication: Vol. 3* (pp. 241-255). https://doi.org/10.1007/978-3-319-70479-1_15

Wilkes, M. S., Conrad, P. A., & Winer, J. N. (2019). One health–one education: medical and veterinary inter-professional training. Journal of veterinary medical education, 46(1), 14–20. http://dx.doi.org/10.3138/jvme.1116-171r.

Yilmaz, V., Gulec, P., & Ari, E. (2022). Impact of climate change information of university students in Turkey on responsibility and environmental behavior through awareness and perceived risk. *Environment Development and Sustainability*. https://doi.org/10.1007/s10668-022-02319-1.

Yli-Panula, E., Jeronen, E., Koskinen, S., & Maki, S. (2022). Finnish University Students' Views on Climate Change Education and Their Own Ability to Act as Climate Educators. *Education Sciences*, *12*(3), Article 169. https://doi.org/10.3390/educsci12030169