



Review

Access to Sustainability in Conservation-Restoration Practices

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Abstract: Cultural heritage faces significant threats from environmental challenges and unchecked development. Sustainability has made its way into the field, and there is a growing interest in seeing it thrive. The particular field of the conservation and restoration of tangible movable cultural heritage is also being improved by new concepts and treatment options more aligned with environmental standards. This article investigates the integration of sustainability into the conservation and restoration of this specific cultural heritage by leveraging the SCOPUS and BCIN databases to examine the evolution of scientific content on the topic over the past 24 years. Key trends in research include assessing greener practices in conservation and education and guidance for the promotion of sustainable practices. These themes are also championed by organizations and initiatives that disseminate this message to conservation professionals through effective and less formal communication strategies. The findings emphasize the critical value of bridging the gap between scientific research and practical application, advocating for accessible resources and collaborative efforts to advance sustainable conservation practices.

Keywords: sustainability; conservation; restoration; cultural heritage; access



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1. Introduction

Our cultural heritage stands as a testament to our shared identity, creativity, and resilience, as well as to our human history [1]. Tangible treasures connect us to our ancestors and enrich our understanding of the world. Yet the passage of time, coupled with environmental challenges [2] and unchecked development, threatens to unravel this intricate fabric of our past. Inevitably, the concept of sustainability has emerged as a guiding principle across various fields. A systematic review on climate change and cultural heritage [3] conducted a thorough examination of the literature on the intersection of climate change and cultural heritage, acknowledging the ongoing growth and transformation in this field. Focusing on how cultural heritage is integrated into climate change mitigation and adaptation strategies, it found a continued increase in the volume of research but the still prevailing lack of integration of cultural heritage into the climate discourse reflects a practical, correlative reality: despite the significance of culture and heritage sectors as vital institutions in many communities, they frequently remain distant from direct involvement in climate action efforts, often being side-lined in climate action efforts [4]. The sector is

also affected by the fact that, too often, discourses on climate delay are used to downplay or ignore the need for action, focusing attention on the negative aspects of climate policies and raising doubts about whether mitigation is crucial or even useful [5,6].

In parallel to the trend presented earlier [3], several organizations have been created to push forward the message of sustainability within the cultural heritage sector as a whole. Julie's Bicycle [7] is possibly one of the most active, focusing on integrating environmental sustainability within the arts and culture and striving towards a net-zero carbon sector, environmental justice, and fairness. It organizes a variety of programmes, including the Arts Council England Programme, Creative Green, Creative Climate Leadership, and Creative Climate Justice, designed to minimize environmental impacts, offer sustainability consultancy, and emphasize the importance of environmental justice in the cultural sphere. Others, such as The Happy Museums [8], Museums for Climate Action [9], the Climate Heritage Network [10], Tipping Point [11], and Cape Farewell [12], have, each in their own way, helped reinforce the need for more sustainable approaches. All are inspirational in their conduct and trust art and creativity to be leaders in the transformational processes needed for humanity to survive, as both emerge as incredibly effective means of communication for sustainability [13]. The trust placed in museums and cultural institutions as venerable sources of knowledge and learning positions them as crucial messengers in advancing the cause of sustainability, and the success of the mentioned organizations speaks to this truth.

Conservation and restoration is a professional field inserted within cultural heritage's broader scope, and it is dedicated to its preservation. According to the ECCO guidelines, "conservation consists mainly of direct action carried out on cultural heritage with the aim of stabilizing its condition and retarding further deterioration", while "restoration consists of direct action carried out on damaged or deteriorated cultural heritage with the aim of facilitating its perception, appreciation and understanding, while respecting as far as possible its aesthetic, historic and physical properties" [14]. The conservation and restoration of tangible movable cultural heritage is not excused from considering sustainability concerns and practices, and these should be integrated into the everyday activities of the professionals executing it [15]. From the correct disposal of chemical agents to the best sustainable options for storing, protecting, and keeping a cultural artefact, sustainability has plenty of room to develop within conservation and restoration. However, despite the complex set of skills necessary to practice this profession [16], the constant influx of science-based solutions to address these issues (and others) can prove to be too much to fully comprehend, assimilate and, finally, put into practice. Accessing scientific articles, books, and book chapters is definitely a possibility (and these resources will be mentioned throughout this article), but one cannot disregard other methods of breaking down sustainability and giving it the stage it must assume. This article will discuss some of the literature produced on this topic and shed light on the organizations or initiatives created to help ease the way into a new and more sustainable way of working within this particular type of cultural heritage safekeeping.

2. Materials and Methods

Cultural heritage has been increasingly recognized as part of the sustainable growth of society [17], and it is becoming increasingly connected to sustainability, as mentioned [3]. The conservation and restoration of tangible movable cultural heritage, is, however, a specific field within cultural heritage, and it is important to ascertain how the literature on the topic has evolved in the last 24 years (from 2000 to 2024). The SCOPUS [18] database was chosen for its comprehensive multidisciplinary abstract and citation coverage, and the terms "cultural heritage" AND "sustainability" were used to perform the first selection. The search was refined with the terms "conservation" OR "restoration" (for the title, abstract, and keywords). The literary scientific content was also tested in a more specialized database, the BCIN (Bibliographic Database of the Conservation Information Network) [19]. The BCIN is a free search engine that gathers information from renowned institutions/databases in the field of cultural heritage, such as the Canadian Conservation Institute, the Getty

Conservation Institute, the AATA Online Database, the ICCROM (International Centre for the Study of the Preservation and Restoration of Cultural Property), the ICOMOS (International Council of Monuments and Sites), the Smithsonian Museum Conservation Institute, and the Courtauld Institute [19]. All are bastions of good practice in the field of cultural heritage in general and in conservation/restoration in particular. For the BCIN, the keywords were refined with the search term “sustainability”, and the results were then selected to include only “conservation” OR “restoration”-related sources. Only the English language was considered for both databases. The terms “urban”, “architecture”, “tourism”, “city”, “economy”, and “building” were excluded from the results for both databases to focus on the core theme of sustainable practices in tangible movable cultural heritage conservation. The results were filtered based on relevance (highly specific case-studies were not considered) and accessibility.

After defining the most discussed topics retrieved by the bibliographic analysis, it is important to understand if these are also being communicated to the professionals using non-formal mediums. There are a number of initiatives, programmes, and organizations that have been created to facilitate the integration of sustainable practices into the everyday work of a conservator. Some of the initiatives and engagement actions may be more visible than others, as they are being offered by known international institutions, such as the ICCROM, the International Institute of Conservation of Historic and Artistic Work (IIC), and the International Council of Museums (ICOM-CC). Based on the authors’ experience in the field, some of these initiatives will be presented, and their message will be related to the scientific advances made by conservation science. While not exhaustive, this selection aims to highlight key players and resources in the field and to increase the number of available sources of information.

3. Results and Discussion

The analytical methodology applied to both databases produced a list of scientific publications that translate not only the interest in the topic but also the specific areas upon which research is more focused.

3.1. Sustainability in Conservation–Restoration Science: Bibliographical Research

A first search with the terms defined in the Materials and Methods section resulted in 2781 entries in the BCIN and 2648 in SCOPUS. As mentioned, to limit the analysis to the field, the terms “conservation” OR “restoration” were applied, and the results, by year, are presented below (Figure 1).

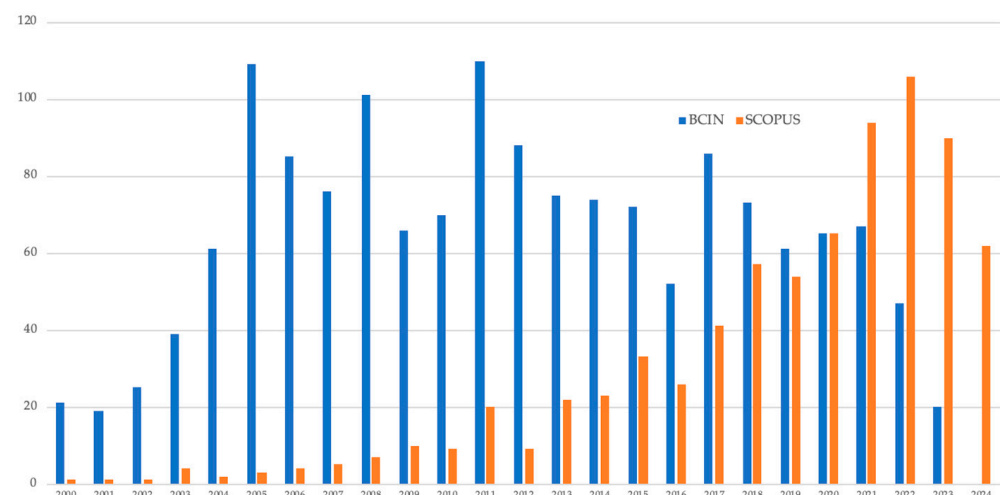


Figure 1. Distribution of the available literature (all formats) on “sustainability” AND “conservation” OR “restoration” by year of publication. Sources: the BCIN and SCOPUS.

There is a discrepancy in the trends shown by both databases. Sustainability in the field of conservation and restoration was first considered relevant by experts in the field (BCIN sources), who have raised awareness of the absolute need to incorporate sustainable practices into professional everyday activities. However, some of these practices are also highly dependent on advances in biology, chemistry, and technology, pushing the boundaries of other areas of expertise and thus creating opportunities for other sources of information to become predominant. As these sources contribute with more research, more time is needed for the relevant, effective, and safe alternatives being explored and created by science to be selected and promoted by the institutions setting the gold standard. This could account for the lower number of publications presented by the BCIN database in the last few years.

It is also important to break down these numbers by format because format influences availability. Figure 2 illustrates this distribution.

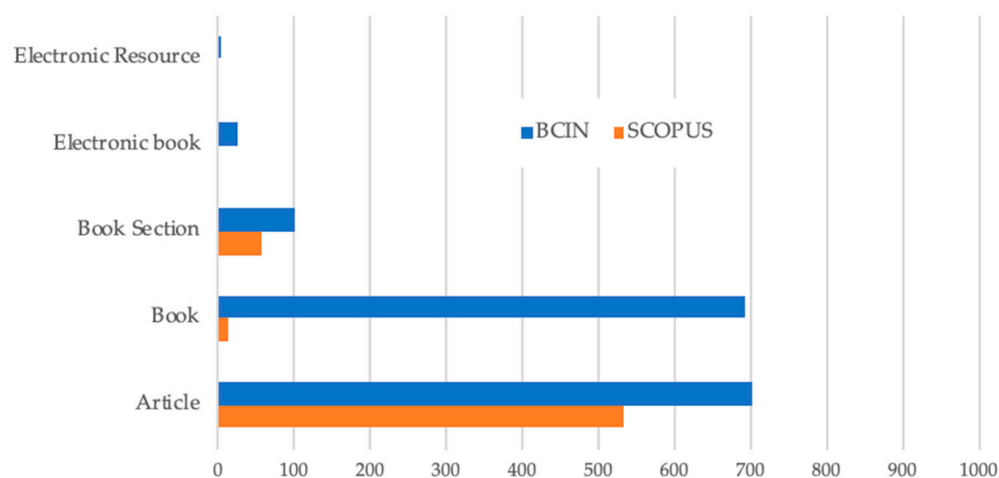


Figure 2. Distribution of the available literature (all formats) on sustainability in conservation/restoration. Sources: the BCIN and SCOPUS.

The BCIN, although prolific in content, has almost half of its publications in book format, and these publications are not accessible online (or at least most of them are not), which limits access. Some of the book sections also present the same issue. The articles and electronic books and resources are much more convenient to assess (some need to be paid for though) and encompass 731 entries. Using SCOPUS (articles and book sections), one can access 592 entries.

When analysing the 1323 combined results provided by both databases, it was found that it is hard for a conservator–restorer to find entries related specifically to the practice of the conservation and restoration of tangible movable cultural heritage, as many of these, although related to the topic, explore the economic and development dynamics of sustainability within a broader sense of cultural heritage. This happens with both databases and forces the user to dig deeper. As mentioned in the Materials and Methods section and for this particular purpose, the terms “urban”, “architecture”, “tourism”, “city”, “economy”, and “building” were excluded from the results for both databases. The final selection retrieved 179 entries from the BCIN and 175 entries in SCOPUS, but many of these, although significant, still fell out of scope, as they included nature, landscape, or built heritage, and the goal was to screen for practices suitable to a conservator in a museum, where tangible movable collections can normally be found.

The final selection of freely available resources from the literature includes critical terms and concepts [20–22] and addresses the need to see them integrated into conservation and restoration education/guidance [23,24], as this is seen as vital for the full incorporation of these practices. Some of the selected sources describe efforts to minimize the impact conservation and restoration may have on the planet, considering both preventive

conservation (actions taken that impact on the surrounding environment) and conservation–restoration. On the preventive conservation side, practical measures include reusing crates for transportation or exhibition [25] and the consideration of the life cycle assessment of treatments and equipment [26,27]. They also tackle the surrounding temperature/relative humidity and lighting in order to respect the need to save energy without endangering collections [28–30] and are in line with the latest recommendations by the Bizot protocol [31]. For pest management, toxic options have to be better targeted so they do not cause damage to the planet after being used [32]. In fact, options for cleaner and less toxic approaches [33] can be found in most of the encountered articles, and these can be grouped as greener approaches to conservation. Plant extracts and oils are entering our practices, and they are used to avoid corrosion or biodeterioration [34–37], and nature, especially through bacterial microorganisms, has also inspired some of the approaches now being considered for cleaning and consolidation [37–43]. Engineered nanoparticles are being imported from other areas as very promising contenders for consolidation and treatment [44–46]. Cultural heritage comprises many different matrixes, and the bibliographic database returned entries related to new and better more sustainable options for the conservation of several of these materials [47–52]. Finally, the scarcity of some resources (some of which are considered sustainable) [53,54] and the way present conservation materials may impact the planet once discarded [55,56] are also on the list of concerns.

The majority of the entries within the free BCIN database are available to the public, but a direct link to the article is not present in all cases. In the SCOPUS database, open-access articles comprise most of the entries. For both, additional payment is needed to access some of the entries related to this topic.

Although these two databases provide a good starting point and are proof of the growing interest in this area, the road to information is not straightforward, and it is difficult for a professional to easily encounter the necessary guidelines to adopt a more sustainable approach to the job. Many of the identified articles admit there is a need for further studies in order for some sustainability practices to be considered safe in the long term. Also, some of the entries are quite technical, and even if a conservator has all the skills to fully grasp the possibilities and limitations of the research, there may still be a lack of information on large-scale studies or the specificities of heritage items to be treated, leading to many questions and to a fear of adopting new treatments settling in.

Redundancy is vital to minimize this problem, and entities capable of bridging the gap between science and everyday practice and between scientists and conservation professionals are more than welcome. The organizations that feed the BCIN database (all 179 entries are the ICCROM, ICOM, the Getty Conservation Institute, and the Smithsonian Museum), and these, as mentioned before, are valuable key players in this role, but they are not the only ones. The presentation of these and other agents' (including My Green Lab [57], Sustainability in Conservation (SiC) [58], Ki Culture [59], and others) initiatives—and how these initiatives relate to the “hot” topics found in the literature (assessing greener approaches in conservation and restoration and education/guidance in sustainability)—is carried out in the next section.

3.2. Conservation Science Communication: Key Players and Resources

A series of institutions and initiatives were presented in the Introduction section. They are all promoting sustainability within the general cultural heritage sector. A somewhat similar engagement for the conservation and restoration professionals preserving cultural heritage items is expressed by organizations born out of the necessity to create this focused conversation. Their action can, as was the case with the scientific literature, be discussed within the contexts of the larger topics of assessing greener approaches in conservation–restoration (see Section 3.2.1.) and education and guidance on sustainability (see Section 3.2.2).

3.2.1. Assessing Greener Practices in Conservation–Restoration

As mentioned, many of the entries listed in Section 3.1 promote the use of safer and greener alternatives. This demands a comprehension of laboratory techniques, and even though conservator–restorers have always known how to operate inside a laboratory in order to formulate the solvents, preparations, and solutions needed for cleaning, consolidating, or preserving cultural heritage, the need to operate in agreement with sustainable practices can create an opportunity to improve overall laboratory activities.

One of the organizations that has helped engage everyone working in laboratories with greener approaches is My Green Lab [57], a non-profit organization founded with the mission to integrate sustainable practices and enhance environmental health and resource optimization across laboratories. My Green Lab also runs the ACT label programme, akin to programmes based on nutrition labels, which labels how products rank in sustainability-related categories and helps laboratories make more informed choices about the products they use. It is not clear, however, how many conservators have taken advice or knowledge from this organization, since some expertise is needed to navigate through the information provided. To make this task easier, an Institute for Conservation (ICON)-supported 18-month initiative tested the UCL Laboratory Efficiency Assessment Framework (LEAF), aimed at evaluating the sustainability of laboratories and studios. The ICON Heritage Science Group and Sustainability Network is evaluating the potential benefits of such a sustainability certification framework for the sector.

The importance of creating a greener path in conservation has led science to be particularly interested in the “design of chemical products and processes that reduce or eliminate the use and generation of hazardous substances”. This definition and the twelve principles of Green Chemistry were first formulated by Paul Anastas and John Warner and published in 1998 in their seminal book, “Green Chemistry: Theory and Practice” [60]. They are a guiding framework for the design of new chemical products and processes and include, among others, waste prevention, low toxicity of chemical products, and the use of few and safer solvents and auxiliaries [61].

The emphasis on safer solvents underscores the critical role that solvent selection plays in achieving the goals of Green Chemistry [33]. In the last 25 years, Green Chemistry innovations have been slowly replacing the traditional production methods used in the chemical and pharmaceutical industries, which have had a huge impact in terms of environmental pollution and human and non-human safety. Applicable to chemical processes and synthesis, Green Chemistry has since been further augmented with sustainable considerations, giving rise to green and sustainable chemistry. As defined in the Safe and Sustainable by Design [45,62] framework, one needs to differentiate between industrial use, professional use, consumer use, and other uses. In other words, when considering applying these frameworks and principles, context is critical. In conservation practice, for instance, where conservators must appropriately compare and select materials for varying and very specific uses—such as solvents—it is apparent that holistic assessment approaches are required, and it is this critical need which underpins the Greener Solvents Project by SiC [58] (presently a part of the larger non-governmental organization Ki Culture [59]). Conceived and launched in 2020, this project aims to create accessible resources for promoting and disseminating greener solvent research and support conservators in their safe and appropriate implementation of greener-solvent approaches. To this end, the first project resource was the creation of an expert-reviewed handbook, “Greener Solvents in Conservation: An Introductory Guide” [63]. It combines an overview of hazard and life cycle assessment methods for the comparative identification of greener solvents and outlines simplified procedures for immediately safer and application-specific solvent selection by conservators. A solvent database to help conservators see potential greener-solvent alternatives has been developed in collaboration with the University of Delaware [64], a task that is therefore shared and characterized by a partnership between industrial and academic research partners in the US and EU. SiC is involved in another project dealing with holistic assessments, the GoGreen project (HORIZON-RIA, grant agreement no.

101060768, 2022–2026), which aims to spearhead the transition to a greener future in conservation by tackling the inherently related aspects needed to achieve this. Considering the various and varying demands of conserving cultural heritage, the ability to assess and enact greener conservation decisions and practices is arguably a particularly complex challenge. Hence, alongside developing materials, methods, and preventive conservation practices, the GoGreen project includes improving the definition of what green means in conservation, elaborating green parameters and sector-wide standards, creating a ‘green thinking’ decision-making model, and creating tools to empower the conservator in their evaluations and applications for greener conservation.

3.2.2. Education and Guidance on Sustainability in Conservation–Restoration

The seminal concepts addressed in the literary references [20,22,33] will have a much larger impact on professionals if they are applied during their formative years, and this, in turn, will ease the comprehension of the scientific literature and the adoption of new practices and approaches. By empowering students with critical thinking skills and knowledge, fostering a sense of responsibility, encouraging innovation, and promoting sustainable behaviour, they can become active agents of positive change. The bibliographic research in Section 3.1 confirms this [23,24], and universities have started to adopt these principles. The Network of Universities for Sustainable Development is the first example of coordination and sharing among all universities engaged in environmental sustainability and social responsibility, and the network’s role is to spread the culture and best practices of sustainability, both within and outside universities, in order to increase the positive impacts in terms of the environmental, ethical, social, and economic aspects of the actions taken by the network’s members. This contributes to achieving the Sustainable Development Goals (SDGs) [65] and strengthening the recognition and value of experience. By the end of 2023, 86 universities had joined this initiative in Italy, and 38 had joined in Portugal, including institutions responsible for training cultural heritage conservators in both countries.

One of the first concerted efforts to effectively integrate sustainability in the curricula of conservation–restoration was advanced by the UCLA/Getty Program in the Conservation of Cultural Heritage [23]. The initial phase of the process involved literature reviews, surveys, and interviews, all aimed at studying the field and designing the best approaches to create a well-structured and successful programme, one that could integrate new concepts without clashing with existing ones. Key sustainability frameworks guiding this effort included the Three Pillars of Sustainability, the United Nations’ SDGs [65], the Paris Agreement [66], and the I3E system. According to a survey conducted in 2021, within this project, 54% of the respondents confirmed that sustainability topics were already being introduced during classes. The survey results also indicated a high international interest in incorporating sustainability principles in cultural heritage education. While this is good news, this study also suggests that conservation educators need more resources in order to successfully incorporate the topic within the existing thematic curricula without having to expand, substitute, or even oppose some of the current principles being taught [23]. Rethinking some of these will, however, be unavoidable.

In practical terms, some European examples of such integration can also be given. Though currently not part of the school’s curriculum, in France, the Institut National du Patrimoine (INP)’s conservation department has integrated, in the last couple of years, a seminar on sustainability in conservation for students about to set off on their journey into professional practice. This seminar includes an introduction to the notion of sustainability in general and a small focus on the heritage sector itself and provides the students with a list of relevant resources in the literature. As part of this, students are encouraged to look into different issues in sustainability by conducting a small literature review or experiment within the school (collecting gloves, etc.) to enable a discussion with their peers and start seeking solutions. In addition to this seminar, the INP hosts a number of training courses for conservators and curators, including one on new conditioning materials. This course took place in 2023 and will return in October 2024 [67].

Portugal has also felt the need to incorporate seminars into their conservation studies and has been doing so for the last few years at the conservation and restoration departments in Lisbon (Departamento de Conservação e Restauro/FCT-UNL) and in Tomar (Escola Superior de Tecnologia de Tomar—IPT). While the latter already incorporates sustainability within the preventive conservation syllabus, the former will, starting next year, be introducing into the curriculum a dedicated class on the concept of sustainability applied to cultural heritage and its conservation, emphasizing the importance of the connections between humans, the environment, and the past. The lectures will present basic concepts and discuss case studies to illustrate how cultural heritage can drive economic and sustainable development and enhance community well-being.

In the Italian context, some programmes dedicated to the conservation of historical and artistic heritage in universities and academies have included instruction on chemical risk in the laboratory and on site. This teaching, present in the training programme of the Istituto Centrale per il Restauro (ICR) for many years, focuses on deepening the understanding and use of solvents, as well as their potential replacement with less hazardous alternatives for both operators and the environment. Topics also include national and international regulations regarding the classification and labelling of materials, waste segregation, and management to ensure proper disposal, as well as practices that need to be developed to create a safer and legally compliant work environment. Over the years, interest in broader sustainability has grown exponentially, leading to a significant number of seminars, workshops, and initiatives open to students and professionals aimed at exploring the integration of new practices into the restoration field. These initiatives have been complemented by a master's and a doctoral programme that are also open to restorers and dedicated to various aspects of sustainability, from the study of biocompatible and green materials to sustainable development and climate change.

Sustainability notions are also being provided to future conservator–restorers by non-academic organizations. One of the first programmes created by SiC was one that aimed to promote sustainability among students. The Student Ambassador Program (SAP) was run from 2017 to 2022, supporting conservation students in making sustainable improvements to their immediate environments. This allowed them to develop a sense of agency and responsibility in their progression into professional careers in cultural heritage and become sustainable leaders in their institutions after the completion of the programme. Each programme lasted one academic year and focused on one of three topics: Materials and Waste, Energy, and Water. Each topic was accompanied by a handbook that gave students resources and challenges that they could choose to complete, aimed at making positive, sustainable changes in their institution's studios and labs. Figure 3 shows the impact of the programme on the Materials and Waste theme. Their tutors and professors were often involved in the processes and oversaw the implementation of changes.

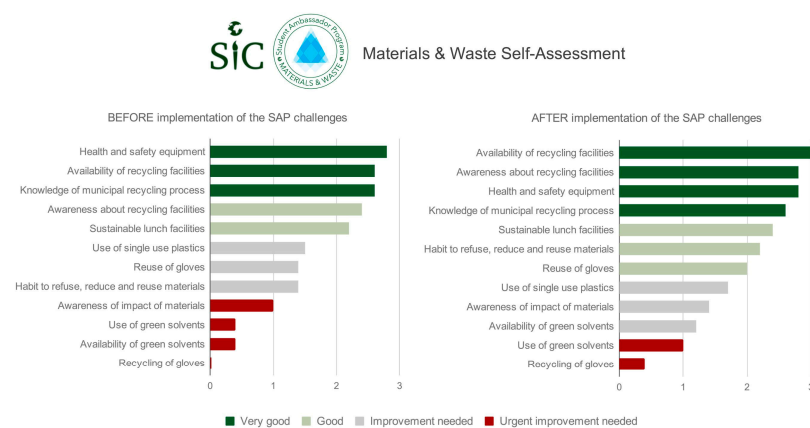


Figure 3. Average score of universities before (left) and after (right) the implementation of the challenges from the SAP Materials and Waste handbook in 2019–2020. Source: SAP success story 2019–2020. Sustainability in Conservation. (23 September 2021) [68].

From 2018 to 2022, over 130 ambassadors from 57 universities in 24 countries [69] participated in the programme, showing that there was a strong demand for sustainability to become a fixed part of the curriculum, as is now being demonstrated by the example cases in French, Portuguese, and Italian Universities. Taking this into consideration, the programme itself ceased in 2022 as part of a decision to encourage the dissemination from the institutional side and incorporate sustainability into education rather than having students take it upon themselves to partake in the Student Ambassador Program in addition to their studies.

The SAP led to the creation of handbooks wherein scientific content was presented for maximum engagement; they were the prototypes for the Ki Books, created by Ki Culture, on waste and materials, energy, and social sustainability [70] (as well as their translated versions) [71,72], which are already available online, and these books address some of the concerns expressed in the entries presented in Section 3.1. Along with the aforementioned “Greener Solvents in Conservation: An Introductory Guide” [63], they provide practical guidance for those directly involved in conservation efforts and serve as educational resources for professionals, students, and anyone in the general public interested in cultural heritage conservation.

Finally—and now speaking for both students and professionals—three of the leading international bodies within the conservation sector for cultural heritage—the IIC, the ICOM-CC, and the ICCROM—have united via the Joint Commitment for Climate Action, a global initiative created to help conservators tackle the challenges ahead and direct their efforts in an effective way. The programmes and initiatives available are precious tools that enrich the field [73,74] and provide needed guidance. The ICON is also contributing greatly to our understanding of the role a conservator can play in these urgent times by establishing a Sustainability Network [75], where, in addition to their own initiatives, they successfully present and redirect to other enterprises and services being offered throughout the world, such as Curating Tomorrow [76] and LFCP [77], just to cite a few examples. Additionally, the American Institute for Conservation (AIC) is also heavily involved in sustainability promotion, and it has established guides and content on sustainable practices [78], including a series of resources spanning from books to webinars, presentations, and conferences, with these being maintained by their own Sustainability Committee.

Table 1 shows the organizations and initiatives discussed in this article to assess greener approaches in conservation and education/guidance on sustainability.

Table 1. Organizations and activities promoting sustainability in conservation–restoration and programmes oriented towards greener approaches in conservation and education/guidance on sustainability.

Organizing Entity	Activity/Initiative	Goal/Content
My Green Lab	Training courses ACT label programme	Integrating sustainable practices and enhancing environmental health and resource optimization across laboratories.
ICON	LEAF (with UCL)	Evaluating the sustainability of laboratories and studios.
	Sustainability Network	Cross-disciplinary group created to encourage the take up of positive environmental practices in cultural heritage.

Table 1. Cont.

Organizing Entity	Activity/Initiative	Goal/Content
SiC	Greener Solvents Project	Accessible resources for promoting and disseminating greener solvent research, support, and implementation.
	Greener Solvents in Conservation: An Introductory Guide	Practical guidance on greener options.
	GoGreen Project	Facilitate the transition to a greener future in conservation.
	SiC Ambassador Program (SAP)	Introduce sustainability in the conservation and restoration training period. Handbooks on waste and materials, energy, and water.
UCLA/Getty Conservation Institute (Los, Angeles, CA, USA) INP (Paris, France) FCT-UNL; IPT (Almada and Tomar, respectively, Portugal) ICR (Rome, Italy)	Incorporation of sustainability principles and practices in the conservation and restoration curricula	Transform sustainability from option to habit.
Ki Culture	Ki Futures	Programme developed to assist in the adoption of sustainable practices by private and public institutions related to cultural heritage.
	Ki Books	Partly based on the SAP Handbooks, these expand on certain topics and serve as guidelines for sustainable practices in conservation and restoration and in cultural heritage.
IIC ICOM-CC ICCROM	Joint Committee for Climate Action	Guide conservators through the challenges of developing and adopting sustainable options.
AIC	Sustainable practices proposed by a Sustainability Committee	Provide guides and content on sustainable practices.

4. Conclusions

The integration of sustainability into cultural heritage conservation and restoration is both necessary and complex. This endeavour requires a multifaceted approach incorporating scientific advancements, practical guidelines, and educational initiatives. As such, this review started by presenting relevant scientific content tailored to conservation and restoration professionals and disseminated in the format most common to scientists. The main topic covered by the bibliographic research refers to greener approaches in conservation, followed by the need to incorporate sustainability concepts and practices into the education and guidance received by conservators, both for students and professionals.

The authors recognize the inherent limitations in keyword-based searches and the limited selection of databases, which may have excluded relevant resources in the literature not indexed in SCOPUS or the BCIN. Future studies could expand their scope to include non-English publications to provide a more comprehensive understanding of global sustainability practices in cultural heritage conservation or restoration. The gathered collection, however, shows the areas presently receiving greater attention.

Feeding on these new approaches and advances are a series of organizations that reunite, deconstruct, and make scientific content more accessible and easier to adopt using different strategies of communication. As was the case with the bibliographic research, the organizations and initiatives cited herein do not cover every source, as there are already too many sources to cite here—and fortunately so. The divulgation of the Sustainability Networks created by players such as ICON or AIC is fundamental in making these smaller

agents visible, which is needed because they provide strong encouragement to those that may deem themselves too small to make a change.

Overall, transitioning into a more sustainable field of conservation–restoration of cultural heritage requires continuous education, accessible resources, and a collaborative effort across the sector.

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References

1. UN Security Council. Implementation of Security Council Resolution 2347 (2017), S/2017/969. 17 November 2017. Available online: <https://www.refworld.org/reference/themreport/unscl/2017/en/119326> (accessed on 21 May 2024).
2. Climate Change and Cultural Heritage Working Group of ICOMOS. *The Future of Our Pasts: Engaging Cultural Heritage in Climate Action*; ICOMOS: Paris, France, 1 July 2019.
3. Orr, S.A.; Richards, J.; Fatorić, S. Climate Change and Cultural Heritage: A Systematic Literature Review (2016–2020). *Hist. Environ. Policy Pract.* **2021**, *12*, 434–477. [CrossRef]
4. Dastgerdi, A.S.; Sargolini, M.; Pierantoni, I. Climate Change Challenges to Existing Cultural Heritage Policy. *Sustainability* **2019**, *11*, 5227. [CrossRef]
5. Lamb, W.F.; Mattioli, G.; Levi, S.; Roberts, J.T.; Capstick, S.; Creutzig, F.; Minx, J.C.; Müller-Hansen, F.; Culhane, T.; Steinberger, J.K. Discourses of Climate Delay. *Glob. Sustain.* **2020**, *3*, e17. [CrossRef]
6. Brulle, R.J.; Norgaard, K.M. Avoiding cultural trauma: Climate change and social inertia. *Environ. Politics* **2019**, *28*, 886–908. [CrossRef]
7. Julie’s Bicycle. Available online: <https://juliesbicycle.com/> (accessed on 21 May 2024).
8. The Happy Museum. Available online: <https://happymuseumproject.org/> (accessed on 21 May 2024).
9. Museums for Climate. Available online: <https://www.museumsforclimateaction.org/> (accessed on 21 May 2024).
10. Climate Heritage. Available online: <https://www.climateheritage.org/> (accessed on 21 May 2024).
11. Tipping Point. Available online: <https://tippingpointuk.org/> (accessed on 21 May 2024).
12. Cape Farewell. Available online: <https://www.capefarewell.com/> (accessed on 21 May 2024).
13. Liverman, D.M. Seeking inspiration: A scientist turns to the cultural sector. In *Long Horizons: An Exploration of Art and Climate Change*; Julie’s Bicycle: London, UK, 2010; pp. 21–25.
14. European Confederation of Conservator-Restorers’ Organisations. *E.C.C.O. Professional Guidelines (I): The Profession*; Adopted by its General Assembly; ECCO: Brussels, Belgium, 1 March 2002.
15. de Silva, M.; Henderson, J. Sustainability in conservation practice. *J. Inst. Conserv.* **2011**, *34*, 5–15. [CrossRef]
16. Hutchings, J.; Corr, S. A framework for access to the conservation–restoration profession via the mapping of its specialist competencies. *High Educ.* **2012**, *63*, 439–454. [CrossRef]
17. Di Turo, F.; Medeghini, L. How Green Possibilities Can Help in a Future Sustainable Conservation of Cultural Heritage in Europe. *Sustainability* **2021**, *13*, 3609. [CrossRef]
18. SCOPUS. Available online: www.scopus.com (accessed on 21 May 2024).

19. Bibliographic Database of the Conservation Information Network (BCIN). Available online: www.bcin.ca (accessed on 21 May 2024).
20. Elnaggar, A. Nine principles of green heritage science: Life cycle assessment as a tool enabling green transformation. *Herit. Sci.* **2024**, *12*, 7. [[CrossRef](#)]
21. Del Curto, D.; Turrina, A. Towards a Reasoned Glossary of Green Conservation: A Semantic Review of Green-Oriented Terms in the Field of Cultural Heritage. *Sustainability* **2023**, *15*, 12104. [[CrossRef](#)]
22. Blundo, D.S.; Ferrari, A.M.; del Hoyo, A.F.; Riccardi, M.P.; Muiña, F.E. Improving sustainable cultural heritage restoration work through life cycle assessment based model. *J. Cult. Herit.* **2018**, *32*, 221–231. [[CrossRef](#)]
23. Wuebold, J.; Pearlstein, E.; Shelley, W.; Wharton, G. Preliminary Research into Education for Sustainability in Cultural Heritage Conservation. *Stud. Conserv.* **2022**, *67* (Suppl. S1), 326–333. [[CrossRef](#)]
24. Chusid, J.M. Teaching Sustainability to Preservation Students. *APT Bull. J. Preserv. Technol.* **2010**, *41*, 43–49. Available online: <http://www.jstor.org/stable/25652703> (accessed on 25 June 2024).
25. Tsang, J.; Scott Schmidt, R.; Hollshwander, C. Conservation meets sustainability: Recycling wooden exhibition case. *WAAC Newsl.* **2013**, *35*, 18–20.
26. Menegaldo, M.; Livieri, A.; Isigonis, P.; Pizzol, L.; Tyrolt, A.; Zabeo, A.; Semenzin, E.; Marcomini, A. Environmental and economic sustainability in cultural heritage preventive conservation: LCA and LCC of innovative nanotechnology-based products. *Clean. Environ. Syst.* **2023**, *9*, 100124. [[CrossRef](#)]
27. Sanchez, S.A.; Nunberg, S.; Cnossen, K.; Eckelman, M.J. Life cycle assessment of anoxic treatments for cultural heritage preservation. *Resour. Conserv. Recycl.* **2023**, *190*, 106825. [[CrossRef](#)]
28. Blades, N.; Poupard, S.; Barber, L. Analysing the energy consumption of conservation heating systems at the National Trust. *J. Inst. Conserv.* **2011**, *34*, 16–27. [[CrossRef](#)]
29. Cosaert, A.; De Bruyn, E. Climate2Preserv and Resilient Storage: Towards a Happy Marriage between Energy Reduction and Adequate Collection Environments. *Bull. BRK* **2021**, *4*, 10–19.
30. Thickett, D. Practical Use of Damage Functions for Environmental Preventive Conservation and Sustainability—Examples from Naturally Ventilated Buildings. *Heritage* **2023**, *6*, 2633–2649. [[CrossRef](#)]
31. Bickersteth, J. IIC and ICOM-CC 2014 Declaration on Environmental Guidelines. *Stud. Conserv.* **2016**, *61* (Suppl. S1), 12–17. [[CrossRef](#)]
32. Strang, T. *Pest Control: Sustainability, Greening, and Reducing the Use of Toxic Chemicals*; Canadian Conservation Institute: Ottawa, Canada, 2011.
33. Escamilla Martinez, M. An Introduction to Sustainability in Conservation, Green Chemistry and Green Solvents in the Field of Conservation. *Pict. Restor.* **2022**, *60*, 29–33.
34. González-Parra, J.R.; Di Turo, F. The Use of Plant Extracts as Sustainable Corrosion Inhibitors for Cultural Heritage Alloys: A Mini-Review. *Sustainability* **2024**, *16*, 1868. [[CrossRef](#)]
35. Russo, R.; Palla, F. Plant Essential Oils as Biocides in Sustainable Strategies for the Conservation of Cultural Heritage. *Sustainability* **2023**, *15*, 8522. [[CrossRef](#)]
36. Cirone, M.; Figoli, A.; Galiano, F.; La Russa, M.F.; Macchia, A.; Mancuso, R.; Ricca, M.; Rovella, N.; Taverniti, M.; Ruffolo, S.A. Innovative Methodologies for the Conservation of Cultural Heritage against Biodeterioration: A Review. *Coatings* **2023**, *13*, 1986. [[CrossRef](#)]
37. Argyropoulos, V.; Boyatzis, S.C.; Giannoulaki, M.; Guilminot, E.; Zacharopoulou, A. Organic Green Corrosion Inhibitors Derived from Natural and/or Biological Sources for Conservation of Metals Cultural Heritage. In *Microorganisms in the Deterioration and Preservation of Cultural Heritage*; Joseph, E., Ed.; Springer: Cham, Switzerland, 2021. [[CrossRef](#)]
38. Caldeira, A.T. Green Mitigation Strategy for Cultural Heritage Using Bacterial Biocides. In *Microorganisms in the Deterioration and Preservation of Cultural Heritage*; Joseph, E., Ed.; Springer: Cham, Switzerland, 2021; pp. 137–154. [[CrossRef](#)]
39. Mazzoli, R.; Pessione, E. Ancient Textile Deterioration and Restoration: Bio-Cleaning of an Egyptian Shroud Held in the Torino Museum. In *Microorganisms in the Deterioration and Preservation of Cultural Heritage*; Joseph, E., Ed.; Springer: Cham, Switzerland, 2021. [[CrossRef](#)]
40. Sprocati, A.R.; Alisi, C.; Migliore, G.; Marconi, P.; Tasso, F. Sustainable Restoration Through Biotechnological Processes: A Proof of Concept. In *Microorganisms in the Deterioration and Preservation of Cultural Heritage*; Joseph, E., Ed.; Springer: Cham, Switzerland, 2021. [[CrossRef](#)]
41. Jroundi, F.; Gonzalez-Muñoz, M.T.; Rodriguez-Navarro, C. Protection and Consolidation of Stone Heritage by Bacterial Carbonatogenesis. In *Microorganisms in the Deterioration and Preservation of Cultural Heritage*; Joseph, E., Ed.; Springer: Cham, Switzerland, 2021. [[CrossRef](#)]
42. Wang, J.; Liu, Y.; Ma, Y.; Wang, X.; Zhang, B.; Zhang, G.; Bahadur, A.; Chen, T.; Liu, G.; Zhang, W.; et al. Research progress regarding the role of halophilic and halotolerant microorganisms in the eco-environmental sustainability and conservation. *J. Clean. Prod.* **2023**, *418*, 138054. [[CrossRef](#)]
43. Barresi, G.; Di Carlo, E.; Trapani, M.R.; Parisi, M.G.; Chille, C.; Mule, M.F.; Cammarata, M.; Palla, F. Marine organisms as source of bioactive molecules applied in restoration projects. *Herit. Sci.* **2015**, *3*, 17. [[CrossRef](#)]
44. Bertolino, V.; Cavallaro, G.; Milioto, S.; Lazzara, G. Polysaccharides/Halloysite nanotubes for smart bionanocomposite materials. *Carbohydr. Polym.* **2020**, *245*, 116502. [[CrossRef](#)] [[PubMed](#)]

45. Semenzin, E.; Giubilato, E.; Badetti, E.; Picone, M.; Ghirardini, A.V.; Hristozov, D.; Brunelli, A.; Marcomini, A. Guiding the development of sustainable nano-enabled products for the conservation of works of art: Proposal for a framework implementing the Safe by Design concept. *Environ. Sci. Pollut. Res.* **2019**, *26*, 26146–26158. [CrossRef]
46. Fornari, A.; Rossi, M.; Rocco, D.; Mattiello, L. A Review of Applications of Nanocellulose to Preserve and Protect Cultural Heritage Wood, Paintings, and Historical Papers. *Appl. Sci.* **2022**, *12*, 12846. [CrossRef]
47. Vega-Bosch, A.; Santamarina-Campos, V.; Colomina-Subiela, A.; Carabal-Montagud, M.-Á. Cryogenics as an Advanced Method of Cleaning Cultural Heritage: Challenges and Solutions. *Sustainability* **2022**, *14*, 1052. [CrossRef]
48. Tomás Ferreira, J.; Bartoletti, A.; França de Sá, S.; Quye, A.; Shashoua, Y.; Casimiro, T.; Ferreira, J.L. Proof-of-Concept Study on the Feasibility of Supercritical Carbon Dioxide-Assisted Consolidation Treatment for a Pair of Goalkeeper Gloves on Synthetic Latex-Based Foam Mock-Ups. *Sustainability* **2024**, *16*, 1562. [CrossRef]
49. Macchia, A.; Biribicchi, C.; Carnazza, P.; Montorsi, S.; Sangiorgi, N.; Demasi, G.; Fernanda, P.; Cerafoli, E.; Colasanti, I.A.; Aureli, H.; et al. Multi-Analytical Investigation of the Oil Painting “Il Venditore di Cerini” by Antonio Mancini and Definition of the Best Green Cleaning Treatment. *Sustainability* **2022**, *14*, 3972. [CrossRef]
50. Böhme, N.; Anders, M.; Bridarolli, A.; Chevalier, A.; Reichelt, T.; Schuhmann, K. New treatments for canvas consolidation and conservation. *Herit. Sci.* **2020**, *8*, 16. [CrossRef]
51. Gulotta, D.; Saviello, D.; Gherardi, F. Setup of a sustainable indoor cleaning methodology for the sculpted stone surfaces of the Duomo of Milan. *Herit. Sci.* **2014**, *2*, 6. [CrossRef]
52. Pascoal, P.M.; Borsoi, G.; Veiga, R.; Faria, P.; Santos-Silva, A. Consolidation and chromatic reintegration of historical renders with lime-based pozzolan products. *Stud. Conserv.* **2015**, *60*, 321–332. [CrossRef]
53. Tamura, M. A shortage of agar: The sustainability of a common conservation material. *WAAC Newsl.* **2017**, *39*, 1. Available online: <http://www.waac-us.org/newsletter-archive> (accessed on 21 May 2024).
54. Cheney, J.E. *Extracting Isinglass from Fresh Air Bladders of Sustainable Canadian-Sourced Wild Atlantic Sturgeon*; CAC ACCR: Ottawa ON, Canada, 2021; Volume 46.
55. O’Hern, R.; Griswold, G.; Haude, M.E.; Tsang, J. An Introduction to How the Manufacturing and Disposal of Adhesives and Paints Affects Our Environment. *AIC News* **2015**, *40*, 14–17.
56. Haude, M.E.; O’Hern, R.; Nunberg, S. Plastics are Forever: Wraps, Tools, Films, and Containers Used in Conservation. *AIC News* **2011**, *36*, 3–5.
57. My Green Lab. Available online: www.mygreenlab.org (accessed on 21 May 2024).
58. Sustainability in Conservation. Available online: <https://www.siconserv.org/> (accessed on 21 May 2024).
59. Ki Culture. Available online: www.kiculture.org (accessed on 21 May 2024).
60. Anastas, P.T.; Warner, J.C. *Green Chemistry: Theory and Practice*; Oxford University Press: Oxford, UK; New York, NY, USA, 1998.
61. Tang, S.L.Y.; Smith, R.L.; Poliakov, M. Principles of Green Chemistry: Productively. *Green Chem.* **2005**, *7*, 761–762. [CrossRef]
62. European Commission. Safe and Sustainable by Design Framework. Available online: https://research-and-innovation.ec.europa.eu/research-area/industrial-research-and-innovation/key-enabling-technologies/chemicals-and-advanced-materials/safe-and-sustainable-design_en (accessed on 21 May 2024).
63. Gwendoline, R. *Fife (Ed.). Greener Solvents in Conservation: An Introductory Guide*; Archetype in association with Sustainability in Conservation: London, UK, 2021; Volume xi, 75p, ISBN 9781909492844. Available online: <https://siconserv.wpeng.com/greener-solvents/greener-solvents-hand-book/> (accessed on 21 May 2024).
64. Available online: <https://siconserv.wpeng.com/greener-solvents/greener-solvents-research-platform/> (accessed on 21 May 2024).
65. UN. *Transforming Our World: The 2030 Agenda for Sustainable Development*; Resolution Adopted by the General Assembly, 25 September 2015; UN: New York, NY, USA, 2015; pp. 1–13.
66. Paris Agreement to the United Nations Framework Convention on Climate Change, 12 December 2015, T.I.A.S. No. 16-1104. Available online: <https://unfccc.int/documents/184656> (accessed on 21 May 2024).
67. Available online: <https://www.inp.fr/formation-continue/choisir-sa-formation-continue/catalogue/developpement-durable-nouveaux-materiaux-conditionnement-decouvrir-tester> (accessed on 21 May 2024).
68. Available online: https://www.instagram.com/p/CRO6rqpMRGa/?utm_source=ig_web_button_share_sheet (accessed on 21 May 2024).
69. Available online: <https://www.google.com/maps/d/viewer?mid=1mGTxnHWVlwZasVRjCkVhM67z4H43anEr&usp=sharing> (accessed on 21 May 2024).
70. Available online: <https://www.kiculture.org/ki-books/> (accessed on 21 May 2024).
71. Pinheiro, A.C. *Sustentabilidade Social: Um guia passo a passo para a sustentabilidade*; Translated from the original Ki Book Social Sustainability; Ki Culture: Amsterdam, The Netherlands, 2023; Available online: https://www.researchgate.net/publication/380793170_Ki_Book_em_Sustentabilidade_Social_-_Um_gui_a_passo_a_passo_para_a_sustentabilidade_Traduca_o_do_original_em_ingles (accessed on 21 May 2024).

72. Pinheiro, A.C. *Resíduos e Materiais—Cuidados com as coleções. Acondicionamento, Armazenamento e Transporte Vol. I*; Translated from the original Ki Book Waste and Materials Vol I; Ki Culture: Amsterdam, The Netherlands, 2023; Available online: https://www.researchgate.net/publication/380793373_RESIDUOS_MATERIAIS_CUIDADOS_COM_AS_COLECOES_Acondicionamento_Armazenamento_Transporte_Um_Guia_Passo-a-Passo_para_Sustentabilidade_Volume_I_Traducao_do_original_em_ingles (accessed on 21 May 2024).
73. Available online: <https://www.iiconservation.org/sustainability-and-climate-action-community-challenge-programme> (accessed on 21 May 2024).
74. Available online: <https://ocm.icrom.org/> (accessed on 21 May 2024).
75. Available online: <https://www.icon.org.uk/groups-and-networks/sustainability-network.html> (accessed on 21 May 2024).
76. Available online: <http://www.curatingtomorrow.co.uk/> (accessed on 21 May 2024).
77. Available online: <https://lfcg.co.uk/> (accessed on 21 May 2024).
78. AIC Sustainable Practices. Available online: https://www.conservation-wiki.com/wiki/Sustainable_Practices (accessed on 21 May 2024).

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