Sustainable Management of Cultural Heritage. The Science of Conservation in the Transition Towards a Global Sustainable Model

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Abstract. Sustainability is a moral principle. Programming on behalf of societies, in the individual areas of human growth, becomes necessary in order to ensure their sustainable function and to achieve aligned and controlled growth. To achieve the principles of sustainable development, humans are constantly developing tools trying to manage the ever-changing information about the planet, the human community and technology and to define strategies that support the sustainable development and consumption of goods. Conserving cultural heritage for the next generations concerns the viability of our planet and is necessary for the smooth progress of technological development in ways that do not disrupt the future survival. The protection of the natural/anthropogenic environment is closely linked and the responsibility corresponding to the field of cultural heritage conservation, in terms of local/environmental level, has not yet been investigated thoroughly. Environmental protection through options and strategies is a new issue in Conservators' Community.

Keywords: Sustainability · Cultural heritage · Sustainable conservation and materials · Collections management sustainability · Future preservation · Sustainable standards

1 Introduction

Sustainability is a moral principle. The concept of sustainability emerged in the 1990s [1] and takes various forms through science, society and technology. Since then, there has been an urgent need to preserve all human achievements and the survival of the planet as well as the natural and anthropogenic environment. Nowadays, societies have understood that planning in all sectors of human development is needed in order to achieve their sustainable operation and their aligned and controlled development. In this context, the ecological footprint in the field of Cultural Heritage Preservation and Conservation for its impact on the local and environmental level and the formulation of sustainable proposals for the future has not yet been sufficiently explored and environmental protection through choices and strategies remains a new issue for the conservation community.

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2 Relation Between Environment, Culture and Conservation. The Protection of Cultural Heritage Through Sustainability

The social responsibility and participation of those involved in the global development of the 21st century, including private or public bodies, as well as institutions and companies is the objective to protect and promote cultural heritage.

The natural and anthropogenic environment form an inseparable unity, which interact with each other and the imbalance of the first from the uncontrolled human activities[1] leads to a reduction in physical reserves and consequently to the incapability to support human life and the built environment. Climate change and its negative impacts degrade the ability of all countries to achieve sustainable development. Our experience[2] has shown that the disconnection of natural from cultural environment leads to the inefficiency of the states' actions and creates many problems regarding the cooperation of the involved and co-competent services. However, the main issue is the proper balance between the anthropogenic and the natural environment, given the current degree of development of western and western-style societies, the planning of cities, the scales of urban development, the choices made in recent years for the renovation of historic centers and the preservation and promotion of culture heritage of a region support the principles of cultural sustainability and their transmission to future generations [4].

Cultural sustainability includes the preservation of all the elements of the past in cities, villages, settlements, monuments and archeological sites, historical / mythical sites[3] and also embraces all forms of intangible culture and their values, all the values that accompany the material culture of each place and region [4], since the choices of the inhabitants influence the environment and shape the cultural content of that society. The protection of cultural heritage is an issue that has engaged the scientific community for at least 90 years and is beyond the scopes of this article. Cultural sustainability and its contribution towards the increased relations between countries, improvement of the life quality and the transfer of cultural heritage to the future generations have been of particular concern to the scientific and political community the past years. Museums integrated with society should co-create cultural capital to improve the quality of life, holistically, for both current and future generations [5].

The principle of subsidiarity [6] is part of the cultural sector, which on one hand is a strong and important pillar in the preservation of cultural goods for future generations, on the other hand, a guarantor of progress, development and sustainability. Sciences are called to apply new technologies and change data, adopting sustainable practices, as part of their effort to create conditions for sustainable, inclusive and sustained economic growth and shared prosperity, considering different levels of national development and capacities in its three dimensions – economic, social and environmental – in a balanced

[1] Such as mining activities, the indiscriminate exploitation of natural resources, the excessive use of chemicals and pesticides, the pumping of water until the aquifer is depleted [2, 3].

[2] The Greek Ombudsman has long been concerned with the protection of cultural heritage and has proposed the cooperation of the relevant ministries, identifying problems and possible solutions for the creation of a grid of logistics for the cultural stock of Greece (reports on Thission and the Historic Center of Athens).

[3] L. 3028/2002,2nd article.

and integrated manner, the effort for sustainable protection of cultural heritage[4] is also included [7–9].

The conservation of the cultural heritage for future generations applies to the sustainability of our planet and is necessary for the smooth evolution of technological development in ways that do not disrupt the ability to survive in the future. [4, 10]. In the agenda of 2031[5] UNESCO is working in a similar context, urging the creation of sustainable cities emphasizing on their cultural elements. The documentation and protection of cultural heritage are linked to technological development and strategies adopted to achieve sustainable goals [4, 10].

In Greece, the protection provided by the provisions of Law 3028/2002 concerning the cultural heritage of the country and combines the protection of the cultural man-made environment with the protection of the natural environment, emphasizing the equal importance of both parameters[6].

3 Conservation at the Services of Sustainability

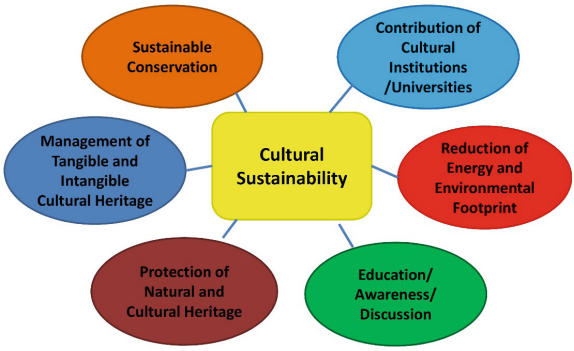

Fig. 1. Essential parameters for cultural sustainability. (Mavromati Eleftheria – Karatzani Anna, all rights preserved 2021).

The Chart of Venice, the Dublin Declaration, the Oslo Symposium and the 1997 Thessaloniki Declaration highlighted the need to combine environmental and sustainable development issues. Sustainability in conservation science becomes functional and connected to society and culture [6, 11–14]. To this end, appropriate public education and awareness, should be recognized as one of the pillars of sustainability along with legislation, economy and technology [6, 13, 15].

In the 2016 Paris Convention, the conservation of global natural and cultural heritage was incorporated and great importance of the term was given. A few years later, in the Amsterdam Declaration, the science of conservation emerged as a key factor in the preservation of cultural monuments that are important to humans [16]. The conservation

[4] See the Greek Ombudsman's documents, professors of NTUA and other universities efforts. The importance of sustainability and protection of cultural resources for future generations and the proposal to manage the collections in the light of the holistic treatment of monuments, with the contribution of available technology engaged an ongoing doctoral research by Mavromati Eleftheria, entitled "*Conservation study and proposals of sustainable management for the masks at the National Theatre of Greece*", supervised by Karatzani Anna, University of West Attica.

[5] The 11th goal of the 2030 agenda refers to the creation of sustainable cities and environment.

[6] Law 3028/2002, articles 1 to 3 et seq., In which the protection refers both to the protected culturally monuments and to their surrounding area.

in all aspects of natural resources, the atmosphere and the restoration of environmental quality depend worldwide on choices made in a variety of areas of human activity and conservation science is seeking ways to incorporate sustainability in practice and education [6, 12, 13, 15] (Fig. 1).

3.1 Good Practices of Sustainable Conservation

The integration of the concept of sustainability in conservation science is certainly a fact that experts in many countries have not yet taken notice of. However, several European and American universities and institutions for the management and conservation of cultural monuments, follow rules that lead to a more rational organization of goods and materials in order to preserve cultural and other monuments with the smallest possible energy and environmental footprint [6, 12, 17]. The flow and quality of information on the environment, the factors affecting it and their negative impacts become known, with the aim of choosing alternative practices and options with the least negative impact on the natural and man-made environment possible [15].

Knowledge of options follows: a) the optimal use of the available data for sustainable outcomes, b) the choice of personal and scientific steps leading to the change in the data currently available, c) the discovery and adaption of new fields that lead conservation science into new areas, d) the implementation of good practices[7] the use of natural resources (water, energy and materials) [18, 19], e) the use of circular waste management systems in museums, collection and management (tools and materials for second use, waste collection and management [15, 18, 20], f) the development of websites and a platform for the provision of data[8] [21], g) the creation of a network for dialogue, exchange of views and provision of information and advice[9].

Regarding the creation and disposal of materials, Life Cycle Assessment, already applied to the recycling of materials for cars, industrial products, etc., is also applied to museums and conservation laboratories. Environmental impacts arise at every stage,

[7] At California Academy of Sciences for example, the green living roof of the institution provides the building excellent insulation, which reduces energy needed for heating and cooling; it captures the excess rain water, which reduces pollutants carried into the ecosystem and turns carbon dioxide into oxygen. The roof is also bursting with native plants that provide an ecosystem for birds and insects. Similarly, universities in Northern Europe are looking for alternative sources of deionized water and find solutions by melting snow or purifying water with the help of the sun [15]. At the National Theatre of Greece, where the PhD research on theatrical masks is carried out, they reuse props, masks and garments, with appropriate alterations, thus reducing the overconsumption of materials, the mismanagement of human resources and the waste of materials and objects. Typical examples of alternative materials can also be found in the article by Balliana et al. [18].

[8] The STiCH platform which is being prepared, will provide data on the energy footprint of materials, their composition and various data with which the Conservator will be able to choose the most environmentally friendly material [17].

[9] A network called “Sic: Sustainability for Conservation” has been set up in Europe, which aims to inform and train students and scientists to use their knowledge in the environment where they work, study and act. Volunteer conservators also become ambassadors to bring the concept and sustainable practices to the community.

from the manufacture, purchase, use and disposal of materials as well as recycling or reuse [12, 18]. Consequently, safety specifications are given for each material, the environmental footprint is controlled at each stage of the life cycle and is expected and the multiple environmental impacts resulting from each stage of the maintenance process are ensured in such a way that they do not constitute shifting loads from one impact to another. All stages are reexamined and lead to decisions on the policies to be followed. The cycle therefore follows the subsequent chain, during which supplementary chains are interconnected [15]: 1) decision-making, action, sustainable material productions and use, 2) product manufacturing with green impact, 3) inform, use and distribution of the ecofriendly product, 4) recycling or disposal when its circle is finished.

For conservation science, the selection of pure/specific materials, with precise quality and manufacturing performance specifications, ex. in the field of textile or paper conservation, including environmental footprint control, is part of the process and adoption of good sustainable conservation practices. Focusing on the protection of the natural environment through the selection of materials with the least negative impact inevitably leads to the challenge of maintaining a balanced cultural and natural heritage [12, 19, 20].

A good example of sustainable management in the field of conservation concerns the packaging of monuments for storage or transport. Throughout the process, consideration and decision making, selection of materials, alternatives are explored, standards and available sustainable materials are considered, reassessment is made, if necessary, with the aim to protect monuments and natural resources alongside [17, 20]. The same happens during the conservation of stone monuments, for which the use of supporting and filling materials is chosen for their interior and exterior, after taking into consideration a number of factors such as a) toxicity and air pollutants for the visiting public and workers, conservators, archaeologists, etc., b) the impact on the natural environment in various ways, c) the ratio between the quantity of material and the negative impact on the environment, d) the preservation of the flora and fauna of the area, in the case of archaeological sites[10], e) the source of the materials and the damaging effect of the construction on animals, plants and humans [17].

3.2 Sustainable Management Using Computer Systems. The Example of the Theatrical Masks at the National Theatre of Greece

According to the contemporary archiving data, for the preservation of cultural heritage objects, collection, digitization, categorization, electronic storage and remote access are compulsory [22, 23]. The Greek National Theater has created a digital archive[11] (Fig. 2), containing the performance programs, newspaper clippings, photographic material, audio documents (since 1950), video recordings (since 1994) and musical scores.

[10] Typical examples of archaeological sites where the flora and fauna of the surrounding area of the monuments is protected are the Acropolis in Athens and the archaeological site of Eleusis.

[11] The project was implemented under the calls 65 and 172 of the Information Society and was co-financed by the European Regional Development Fund (80%) and by national resources (20%). The Digitized Archive of the National Theatre of Greece includes its collections from 1932 to 2005, with rare and sometimes unique material.

Additionally, in the context of the collaboration with the Ministry of Culture and Sports, a large number of costumes and ten (10) masks have been recorded and have been declared as monuments of contemporary culture.

In the context of the sustainable collection management and through this ongoing doctoral research for the conservation and preservation of the mask collection from the Historic Cloakroom (declared or not), which have both historical and artistic value, either in their material form or as entries in the NT digital archive and other sources, the following actions are proposed and gradually implemented: a) Gathering and addition of all the masks in the digital archiving system, b) creation of spreadsheets in the form of electronic condition survey cards for each mask that include the object information and documentation images[12], c) creation of graphs and diagrams and the inference of statistical data for the masks of the Historical Cloakroom, d) 3D documentation of the masks with a 3D modeling program [23], e) data input and archiving of the masks following specific criteria in combination with their common characteristics, f) formatting and integration of the data collected into the digitized archive of the NT or on a separate digital platform, g) provision of descriptive, structural and managing metadata of 3D modeling through the digitized NT file, [23], e) key words and criteria searching of each mask, emergence, study and ability to print digital information.

Fig. 2. Digital archive of the Greek National Theatre, accessed on 28.10.2021, http://www.nt-archive.gr/.

4 Proposals for Aiming the Goals of Sustainability at the Scientific Area of Conservation

A comprehensive approach to a sustainable conservation program is a matter of study, administrative coordination and successful implementation of recycled and environmentally and human-friendly materials. In the context of sustainable management of natural resources[13], private and public as well as university conservation laboratories should

[12] Mask information, condition, performance title and actors, materials, conservation actions, etc.
[13] Such as soil, water, natural areas and coastal zones.

work towards exploring ways of reducing the consumption of natural resources, materials and objects that have a negative impact. Achieving green conservation requires sensitivity, knowledge and strategy.

In particular, it is proposed to: 1) rational management of materials and available resources used in the protection of cultural heritage and choice of eco-labelled materials, materials with reduced environmental impact or materials labelled "green"[14]; 2) revision of traditional practices for obtaining raw materials from the environment and selection of alternative materials in order to preserve its integrity. We need to make decisions about the sustainability of monuments so we need to be aware of their origins, their history their values as well as the conservation materials[15], for deciding about their condition and how to treat them in the present and how to sustain them in the future; 3) integrated control of all stages in conservation science regarding the pollution caused (atmospheric, water or soil), holistic management of pollutants, research into cleaning, recycling, reuse and the creation of standard procedures for the final disposal of conservation waste (Fig. 3) [20]; 4) compliance with EU Directives in order to reduce the environmental footprint; 5) improving infrastructure and technical means, selection of 'green' technologies and machinery and comparative economic control, which determines choices through long-term planning and economic payback, while ensuring environmental benefits; 6) using renewable energy sources and reducing energy consumption in museums and conservation workshops; 7) design and selection of materials and conservation practices with a positive impact on the environment[16]. 8) comparative study between single-use and multi-use materials and selection of those with the least negative environmental impact; 9) selection of materials that are friendly to cultural monuments[17], which can be removed and allow reversibility to a certain extent and rework ability, i.e.re-intervention on cultural monuments by future conservators [24, 25]; 10) choice of materials that are friendly to conservators, with low toxicity and an increased rate of safe use and replacement of traditional materials [18, 19, 26, 27]; 11) actions to promote and preserve cultural heritage [28, 29] while protecting the overall natural and cultural landscape [23, 25]; 12) re-using the man-made landscape and use of the built environment (housing estates, listed buildings, monuments, industrial sites) and their natural environment through the process of conservation, in order to make sustainable use of the historic cultural heritage [19, 30]; 13) dissemination to the scientific and local community of environmental information and good practices[18] by creating electronic information tools (platforms

[14] Green materials have been extensively discussed in the article by Balliana et al. [18] → 18. Also, ICCROM recommends the sustainable dimension through which actions for the preservation of cultural heritage should be carried out, by reducing the energy footprint of cultural institutions, seeking alternative renewable energy sources, environmentally sustainable building design, passive climate control, LED-lighting technology and use of green chemistry [12] → 12.

[15] Indirect background: linked industrial processes, economic models, national resource etc.

[16] It can be applied at all stages of conservation, in the selection of conservation materials, conservation tools, storage and display of cultural objects. Biocides for example must follow the lines of the REACH Regulation and the principles of prevention and precaution. The aim is human and environmental sustainability and sustainable development.

[17] See the article by Sousa M. et al. [35].

[18] In Balliana et al. [18], it is proposed to inform conservators about "green" alternative products and their protocols and the holistic approach of any restoration project.

etc.), sustainable material and process standards (ISO) and data provision, which help to make common, more efficient and rational decisions for the environment and the cultural heritage of the planet [31]; 14) development of strategies by museums, universities and public institutions, which are urged to play a leading and dominant role in the science of conservation [15, 28, 32, 33]; 15) integration in academic programs of courses on sustainability and holistic management of materials and monuments. In particular, a critical role will be played by training young archaeologists, conservators, engineers, etc. from the very beginning of their studies, in green technology, familiarizing them with sustainable materials and seeking new methods of preserving cultural heritage that are compatible with the natural environment and are enhancing the quality of human-made structures [21]; 16) creation of data libraries with these tools and uploading on the websites of cultural and academic institutions the actions that have been applied and tested and can be adopted by the global community to achieve sustainable results, 17) a communication channel between consultants, representatives and institutions (private and public) in the cultural sector and environmental policy representatives of the EU Member States, collaboration between leadership, organizers, partners, suppliers, contractors, and participants [12], in order to share responsibility, partnership and implementation of sustainable measures and practices effectively.

Fig. 3. Zero waste by ICCROM, https://www.iccrom.org/resources/going-zero-waste-promoting-sustainable-consumption-and-production-cultural-heritage, available online, accessed on 22.05.2021.

5 Opportunities and Perspectives of Sustainable Conservation (Conclusions)

Achieving sustainability in all scientific fields of human activity is the challenge that all nations, governments [29] and institutions are urged to take up in order to meet the goals of a sustainable future for the planet. To achieve the principles of sustainable development, nations are constantly developing tools and defining strategies that support sustainable development and consumption of goods. Action plans are developed for rapid and radical change in behaviors and lifestyles, including changing patterns of production and consumption, reforming their laws and institutions to achieve maximum

global warming reduction, upgrading ecosystems and protecting biodiversity and cultural heritage.

The science of conservation in conjunction with the environment, cultural monuments and sustainable protection is not incidental and conservation is an integral part of the dual action to protect the natural and cultural environment[19], emphasizing the equal importance of both parameters in parallel [34]. Conservation is supported by specific educational, legislative and political practices aiming at safeguarding world culture in perpetuity, with the participation of the younger generations in particular. Conservation should then be viewed through the lens of a process, and not merely an end goal to succeed environmental sustainability. We have to think creatively, determine our personal choices, and create new paths to scientific behavior, ethics and practices. We may be the last to have the opportunity of saving the planet and preserving cultural remains is one way to sustainable future.

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