Reconceptualising the relationships between heritage and environment within an Earth System Science framework

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Abstract

Purpose: This paper questions the common perception within heritage science that the environment is seen primarily as a risk factor that can change or impact heritage. This paper reconceptualises the relationship between heritage and the environment within an Earth System Science Framework, enabling a more sustainable approach for understanding and conserving heritage sites to be implemented.

Design/methodology/approach: To explore the relationship between heritage and the environment, this paper considers how perceptions of the environment within heritage science have been shaped in response to the conservation challenges facing movable heritage. Furthermore, as heritage encompasses a wide array of immovable buildings and sites whose relationships with the environment are complex and nuanced, this paper premises that the environment cannot be considered separately from heritage as it is intrinsically related by: i) providing components of heritage; ii) modifying heritage; iii) being modified by heritage; iv) adding to heritage value and v) acting as a co-creator of heritage.

Findings: This paper proposes that heritage science should learn from, and work within, the well-established Earth System Science framework. This enables interactions and feedbacks between heritage and components of the environment to be explored across a range of scales.

Practical implications: This systems-based approach allows heritage science to consider the environment more holistically and sustainably within its research and practice and better equips it to conserve movable and immovable heritage in the Anthropocene.

Originality/value: This paper provides a novel approach for viewing the relationship between heritage and the environment by using a well-established framework from other highly interdisciplinary fields.

Key words: cultural heritage; natural heritage; environment; holistic; co-creation; systems thinking

1. Introduction

Heritage science is an emerging field that aims to improve interpretation, conservation, engagement with, and sustainable long-term management of natural and cultural heritage through scientific research (National Heritage Science Forum, 2018; Strlič, 2018). It is an inherently multidisciplinary field that builds upon conservation science, focuses on scientific approaches to the conservation of cultural heritage, fits within the broader remit of heritage studies, and engages widely with several disciplines. Cultural heritage includes physical manifestations that UNESCO defines as being significant to the archaeology, architecture, science or technology of a specific culture (UNESCO, 2017) while natural heritage refers to geological, biological and geomorphological features and landscapes that people value.

As a relatively young field, heritage science is rapidly emerging and developing its identity within academic and policy/practice contexts. The need for a sustainable approach to conservation has been widely recognised (e.g. CHCfE Consortium, 2015) but currently, the development of ideas in heritage science has been primarily driven by the ethical and practical considerations surrounding movable cultural heritage (Kennedy, 2015; Viñas, 2002). This has resulted in heritage being abstracted from its surroundings as something that must be protected. In this framework, 'the environment' is often perceived as a factor that can change or impact heritage and poses a risk (e.g. European Commission, 2014 p.5) – it should therefore be mitigated through intervention such as preventive conservation (Lucchi, 2018). Within a moveable heritage context (e.g. museums, galleries), these mitigation strategies are typically implemented as external controls—such as heating,

ventilation, and cooling (HVAC) systems—and barriers (e.g. display cases) implemented in the storage and presentation of heritage. However, immovable cultural heritage (such as buildings and archaeological sites) and natural heritage, which are not feasibly removed from their settings without significant intervention, also need to be considered, resulting in the need for an on-going dialogue to recognise and explore the complex and dynamic relationship between heritage and the environment (Bridgewater and Rotherham, 2019; Wells, 2019).

We propose a new, more sustainable, vision for heritage science based on a clearly articulated relationship between heritage and the environment which would underpin heritage science theory and practice. We believe this reconceptualization of heritage science draws attention to the multifaceted relationships between heritage and environment and, in part, responds to Strlič's call for an understanding of heritage ecologies which he argues provide "a comprehensive model of the relationships between heritage and its physical and social environments [which] would enable a greater understanding of how heritage is created, and what (as well as how and for how long) is to be preserved" (Strlič, 2018 p.7261).

We discuss the implications of this reconceptualization by suggesting an alignment of heritage science with Earth System Science would help advance key areas within the discipline which Strlič also identifies including "the knowledge of multimodal material–environment interactions, as well an understanding of how value and benefits are created, exploited, transferred, or lost." (Strlič, 2018 p.7261). Furthermore, an improved ability to characterise the nature of relationships with stakeholders within wider heritage communities could reduce the 'implementation gap' (Dillon et al., 2014) between science and its application to policy and practice by providing a more holistic understanding of heritage.

2. Heritage within the Earth system

It has long been established that the value and authenticity of heritage is influenced by its location and setting (e.g. Pendlebury et al., 2009). However, within heritage science, the importance of the environment has often been reduced to being considered as a risk. This perception of the environment as a hazard or a potential source of danger has even been the case when heritage buildings and sites have been viewed within their surroundings (Degrigny et al., 2019). We strongly oppose this simplification and thus premise the following:

Premise

Heritage cannot be considered and valued separately from the environment.

In the following sections we articulate five specific and interlinked aspects of this premise.

2.1. Environment as a component of heritage

Heritage cannot be considered and valued separately from the environment as all heritage is formed of components that use resources directly or indirectly sourced from the environment. Environment is found as a component of heritage across a very wide range of scales across a spectrum from making a minor contributor to a heritage object to being instrumental to an entire site and its setting. Geological materials like natural stone, can be transferred from the environment into a cultural heritage context as a building material. Other resources from the environment can undergo significant processing during production resulting in new types of materials such as lime mortar and Portland cement. Although these materials may seem more removed from the environment, the characteristics of the final product are still influenced by the properties of the original material.

Today, the coexistence of natural and cultural components is ubiquitous. This has been widely recognised in the designation of some UNESCO sites as ‘cultural landscapes’ (Rössler, 2006). The environment inherently provides both the setting and the context for

heritage sites. This can fundamentally affect how heritage is initially situated within the landscape. For example, the location of standing stones at Machrie Moor, on the Isle of Arran in Scotland, is dependent on: i) the topography of the landscape, as the stones have been located on a flatter area to maximise the distance of visibility, and ii) the coincidence of the configuration of standing stones during the midsummer solstice with the intersection of adjacent hills (Barnatt and Pierpoint, 1983). The importance of the environment as a component of natural heritage is even more obvious as natural heritage is, by definition, largely made up of geological and biological materials.

2.2 Environment as modifying heritage

As is well known, environmental factors modify and pose risks to heritage through, for example, air pollution affects historic limestone buildings through the reaction of sulphur dioxide with the carbonate stone to produce gypsum encrustations. These crusts, which are often black because of the inclusion of carbonaceous particles (soot), can damage the underlying stonework, look unsightly and require often expensive conservation treatment and removal. Viewing the environment as a modifier of heritage, rather than a risk to heritage, decouples values associated with heritage from the physical change. This enables the use of damage functions (Strlič et al., 2013) that represent unacceptable change. They combine representations of value (including acceptable use and fit for purpose) with dose-response functions of physical change that characterise the relationship between the environment and heritage. At a larger scale, recent ocean acidification linked to climate change and local human activities have been shown to be damaging the Great Barrier Reef off the north east coast of Australia, which is a UNESCO World Heritage site. Here, a complex set of relationships between people, environment and heritage are evident.

2.3 Environment as modified by heritage

In turn, heritage cannot be considered as separate from the environment as the very presence of heritage alters the environment around it. This can occur at a range of scales. In

some cases, such as the Isle of Portland on the south coast of England, the construction of heritage has required the quarrying of large amounts of geological material producing major excavations across the island. This has created new types of landforms through anthropogenic intervention at unprecedented rates relative to naturally-occurring geological processes. Heritage also alters the environment on smaller scales. For instance, historic buildings can cause small-scale topoclimatic variations in wind regimes near their surfaces. This effect is cumulative within dense, urban environments often having large-scale impacts on the environment, such as the urban heat island effect which is an important control on processes that can affect heritage (Guilbert et al., 2019). Linking to the previous section, we can see that there is a dynamic relationship between heritage and environment: the environment is both an influencer of heritage and is influenced by its presence.

2.4 Environment as adding to heritage value

In addition, the environment can go beyond being a component of heritage and enhance its value. For example, heritage-environment interactions can result in physical changes which can enhance the aesthetic or other values of heritage. The formation of gypsum crusts and staining on stone as a result of industrial and transport-related sulphur emissions noted above (del Monte et al., 1984) can cause deterioration of historic materials, but may also contribute to the 'patina of age'. Such patinas are seen as important contributors to the aesthetic of an old building and may also have historical and scientific values as evidence of previous human activities.

As a further example, volatile organic compounds (VOCs) are compounds frequently found in air, which can be products of off-gassing from organic materials. However, VOCs are also drivers of the olfactory (smell) component of air, making them integral to how heritage is experienced (Bembibre and Strlič, 2017). For example, within libraries and archives the smell of 'old books' is considered as a vital part of the heritage value (Sonnenwald and McElligott, 2017).

2.5 Environment as co-creator of heritage

Finally, heritage cannot be considered separately from its environment as the environment demonstrates agency in the production of heritage. This is the dynamic culmination of the aforementioned interactions between environment and heritage. The environment actively contributes to the creation, propagation, and decay of heritage throughout its lifetime, as recently explored by DeSilvey (2017). Within environmental systems, it has long been accepted that environmental processes and human impacts cause landforms to be constantly shaped and re-shaped, with some arguing that the human impact on these systems is so critical they have led to the formation of Anthropogenic landscapes (Bertness et al., 2002). Similarly, environmental processes and human activity are developing a complex narrative of interactive processes involving heritage.

Ruskin considered ruins to be noble, truthful, and tangible results of the passing of time (Ruskin, 1889). This is a direct result of the agency of the environment within the ongoing production of heritage. Not only does the environment provide material for heritage and participate in processes of change, but since the 17th and 18th century has been embodied in the concept of co-creation, in which landscapes are co-developed by environment and heritage– the latter as representations of human activity.

The co-creation of heritage due to environmental processes and human activity is embodied by the much-discussed case of Pompeii (Holtorf and Kristensen, 2015). The financial and resource burden of attempting to conserve this massive site has brought to the forefront the challenges of limiting environmental considerations to risk and the futility of rejecting emerging narratives of heritage sites. The present existence of Pompeii is enabled by a volcanic eruption that occurred approximately 2000 years ago. Large-scale natural disasters would generally perceived as significant threats to heritage sites, but their potential contribution to the formation of new types of heritage, and especially future heritage, must be acknowledged, emphasising the co-creation of the environment within heritage.

3. Implications

In order for heritage science to address the premise of this paper and reconsider the relationships between heritage and environment, some reconceptualization is necessary (Figure 1). There have been suggestions for a 'heritage system services' approach (Gysen, 2018; Leissner, 2013) but this has not yet been formalised. Links between cultural heritage and ecosystem services have been reviewed (Hølleland et al., 2017) and life cycle approaches for cultural heritage have been suggested (Blundo et al., 2014) but neither have not been extended to natural sites. Therefore, neither of these capture the extensive array or the complexity of processes occurring between both cultural and natural heritage sites and the environment. Instead, we suggest that heritage science should align itself more closely with Earth System Science.

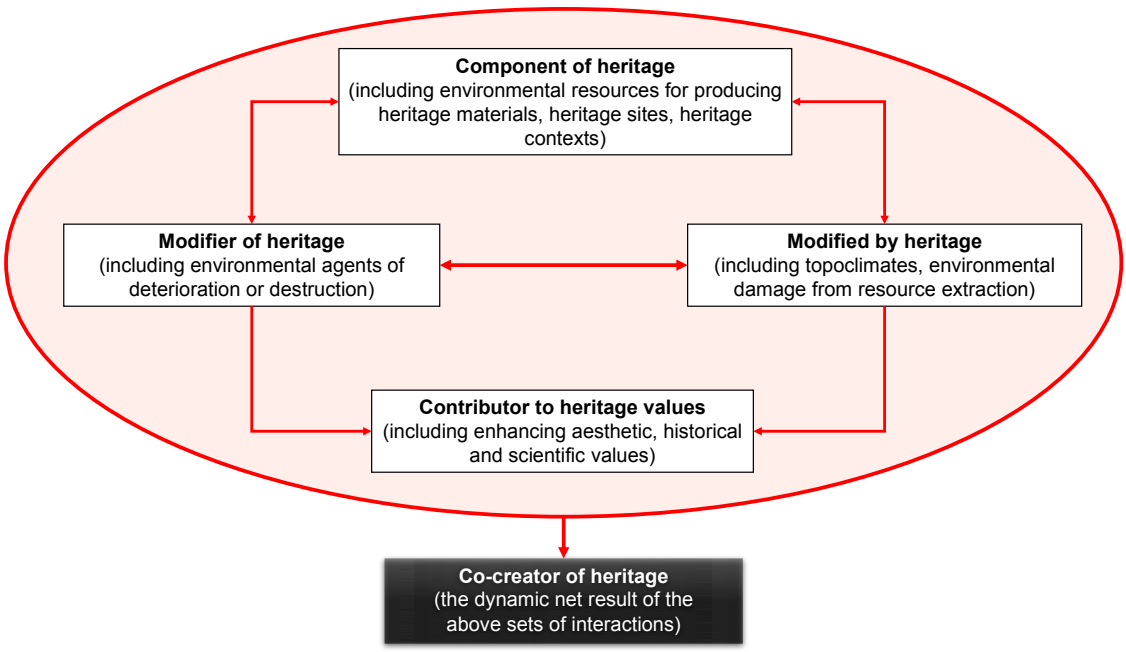

Figure 1. A conceptual diagram showing the link and complexity of processes occurring between heritage and the environment.

The Earth System Science framework considers interactions between components of the environment, as well as the impact of human societies on these components (Kump et al., 2004) as shown in Seitzinger et al. (2015, Fig. 1). It was first utilised in environmental and

geographical sciences and is now commonly applied to a deeply interdisciplinary field which studies how the Earth functions as a whole complex adaptive system, and how humanity contributes to, and in turn is affected by, it (Lenton, 2016). Given the broad range of backgrounds of both heritage scientists and those engaging with heritage science, using the Earth system as a framework could:

i) form an 'interdisciplinary bridge' that links disciplines and normalises discipline specific terminology and approaches within heritage science,

ii) position heritage science more closely with major other fields concerned with the developing relationships between humans and their environment and understanding complex adaptive systems.

Aligning heritage science within Earth System Science also provides heritage scientists with a framework which captures complexity and interactions between 'human' and 'natural' processes which can be easily overlooked - especially for cultural heritage sites. The Earth system is typically divided into four primary 'spheres': the lithosphere (land), hydrosphere (water), biosphere (living things), and atmosphere (air). Each sphere includes several components that are relevant to heritage and sub-spheres, some of which are very relevant to heritage: for example, the hydrosphere would include the cryosphere, the frozen water component which can cause freeze-thaw weathering processes to occur in stone and other building materials. The lithosphere would include soil which for the reburial of archaeological sites can act as a protective layer from atmospheric processes. The anthroposphere, sometimes considered a subset of the biosphere, encompasses the total human presence throughout the Earth system including our culture, technology, built environment, and associated activities (Kuhn and Heckelei, 2010).

These four (or sometimes five, if the Anthroposphere is included) spheres interact in several ways: for example, water within the hydrosphere can evaporate and thus also be found within the atmosphere in the form of humidity (water vapour) or be constrained by man-made constructions such as dams – thus entering the anthroposphere. This

reconceptualisation allows for more nuanced relationships between heritage and environment, that blur the distinction between the natural and cultural, meaning that the distinction between whether a component is considered as heritage (objects of focus) or as part of the environment (factors that might cause change), is determined by value and perspective (Harrison, 2015; Lowenthal, 2005). This more nuanced and holistic perspective should help link heritage sites and objects more clearly with global issues and concerns – allowing heritage scientists to be better placed in tackling the grand challenges facing heritage, such as climate change, providing a clearer understanding of heritage within present environment as well as helping to understand what a sustainable future for our heritage might be.

4. Concluding thoughts

To fully understand how heritage is impacted on and interacts with the Earth system, heritage scientists cannot perceive the environment simply as a risk. Instead, we premise that the environment cannot be considered separately from heritage as the environment is intrinsically related to heritage in five main ways by:

1) Providing components of heritage;
2) Modifying heritage;
3) Being modified by heritage;
4) Adding to heritage value;
5) Acting as a co-creator of heritage.

Aligning heritage science within Earth system science enables heritage to be viewed as a complex adaptive system that is constantly interacting with, impacting on, and being impacted by its surrounding components and processes. This approach provides heritage science with a mechanism for a more holistic and sustainable consideration of the environment within its research and practice.

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References

Barnatt, J. and Pierpoint, S. (1983), “Stone Circles: Observatories or Ceremonial Centres”, *Scottish Archaeological Review*, Vol. 2, pp. 111–15.

Bembibre, C. and Strlič, M. (2017), “Smell of heritage: A framework for the identification, analysis and archival of historic odours”, *Heritage Science*, Vol. 5 No. 2, available at:https://doi.org/10.1186/s40494-016-0114-1.

Bertness, M.D., Ewanchuk, P.J. and Silliman, B.R. (2002), “Anthropogenic modification of New England salt marsh landscapes”, *Proceedings of the National Academy of Sciences*, Vol. 99 No. 3, pp. 1395–1398.

Blundo, D.S., Ferrari, A.M., Pini, M., Riccardi, M.P., Garcıá, J.F. and Del Hoyo, A.P.F. (2014), “The life cycle approach as an innovative methodology for the recovery and restoration of cultural heritage”, *Journal of Cultural Heritage Management and Sustainable Development*, Vol. 4 No. 2, pp. 133–148.

Bridgewater, P. and Rotherham, I.D. (2019), “A critical perspective on the concept of biocultural diversity and its emerging role in nature and heritage conservation”, *People and Nature*, Vol. In press, available at:https://doi.org/10.1002/pan3.10040.

CHCfE Consortium. (2015), *Cultural Heritage Counts for Europe*, Krakow, available at: www.encatc.org/culturalheritagecountsforeurope.

Degrigny, C., Borgarino, P., Cefai, S., Hortal Muñoz, J.E., Irbe, I., Leus, M., Lu, S.-L., et al. (2019), *Integration of Heritage Buildings and Sites in Their Surroundings*, Nova. FCT Editorial, Lisbon, Portugal.

DeSilvey, C. (2017), *Curated Decay: Heritage beyond Saving*, University of Minnesota Press, Minnesota.

Dillon, C., Bell, N., Fouseki, K., Laurenson, P., Thompson, A. and Strlič, M. (2014), "Mind the gap: Rigour and relevance in collaborative heritage science research", *Heritage Science*, Vol. 2 No. 11, available at:https://doi.org/10.1186/2050-7445-2-11.

European Commission. (2014), "Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions — Towards an integrated approach to cultural heritage for Europe", available at: https://ec.europa.eu/assets/eac/culture/library/publications/2014-heritage-communication_en.pdf.

Guilbert, D., Caluwaerts, S., Calle, K., Van Den Bossche, N., Cnudde, V. and De Kock, T. (2019), "Impact of the urban heat island on freeze-thaw risk of natural stone in the built environment, a case study in Ghent, Belgium", *Science of the Total Environment*, Vol. 677, pp. 9–18.

Gysen, K. (2018), "Integration is the magic word", *Annual Meeting of the European Federation of ForitfiedFortified Sites (EFFORTS)*, Venice, Italy.

Harrison, R. (2015), "Beyond 'Natural' and 'Cultural' Heritage: Toward an Ontological Politics of Heritage in the Age of Anthropocene", *Heritage & Society*, Vol. 8 No. 1, pp. 24–42.

Hølleland, H., Skrede, J. and Holmgaard, S.B. (2017), "Cultural Heritage and Ecosystem Services: A Literature Review", *Conservation and Management of Archaeological Sites*, Vol. 19 No. 3, pp. 210–237.

Holtorf, C. and Kristensen, T.M. (2015), "Heritage erasure: Rethinking protection and preservation", *International Journal of Heritage Studies*, Vol. 21 No. 4, pp. 313–317.

Kennedy, C.J. (2015), "The role of heritage science in conservation philosophy and

practice", *Historic Environment: Policy and Practice*, Vol. 6 No. 3, pp. 214–228.

Kuhn, A. and Heckelei, T. (2010), "Anthroposphere", *Impacts of Global Change on the Hydrological Cycle in West and Northwest Africa*, Springer, Berlin, Heidelberg, pp. 282–341.

Kump, L., Kasting, J. and Crane, R. (2004), *The Earth System*, Pearson Prentice Hall, Upper Saddle River, New Jersey.

Leissner, J. (2013), "Do we need a paradigm shift to save our European cultural heritage?", available at: http://www.nkf-s.se/uploads/1/3/6/6/13662894/goteborgchoctober2013jlpresentationeu.pdf.

Lenton, T. (2016), *Earth System Science – a Very Short Introduction*, Oxford University Press, Oxford.

Lowenthal, D. (2005), "Natural and cultural heritage", *International Journal of Heritage Studies*, Vol. 11 No. 1, pp. 81–92.

Lucchi, E. (2018), "Review of preventive conservation in museum buildings", *Journal of Cultural Heritage*, Vol. 29, pp. 180–193.

del Monte, M., Sabbioni, C. and Vittori, O. (1984), "Urban stone sulphation and oil-fired carbonaceous particles", *Science of the Total Environment, The*, Vol. 36, pp. 369–376.

National Heritage Science Forum. (2018), *Strategic Framework for Heritage Science in the UK, 2018–2023*, available at: http://www.heritagescienceforum.org.uk/documents/NHSF_StrategicFramework-FINAL_Web.pdf.

Pendlebury, J., Short, M. and While, A. (2009), "Urban World Heritage Sites and the problem of authenticity", *Cities*, Vol. 26 No. 6, pp. 349–358.

Rössler, M. (2006), "World Heritage cultural landscapes: A UNESCO flagship programme 1992 - 2006", *Landscape Research*, Vol. 4, pp. 333–353.

Ruskin, J. (1889), *Seven Lamps of Architecture*, 6th editio., George Allen, Orpington.

Seitzinger, S.P., Gaffney, O., Brasseur, G., Broadgate, W., Ciais, P., Claussen, M., Erisman, J.W., et al. (2015), "International Geosphere-Biosphere Programme and Earth system science: Three decades of co-evolution", *Anthropocene*, Vol. 12, pp. 3–16.

Sonnenwald, D. and McElligott, J. (2017), "Investigating Human-Rare Historic Book Interaction among Young Adults", *Interaction Design and Architecture(s) Journal*, Vol. 32, pp. 126–149.

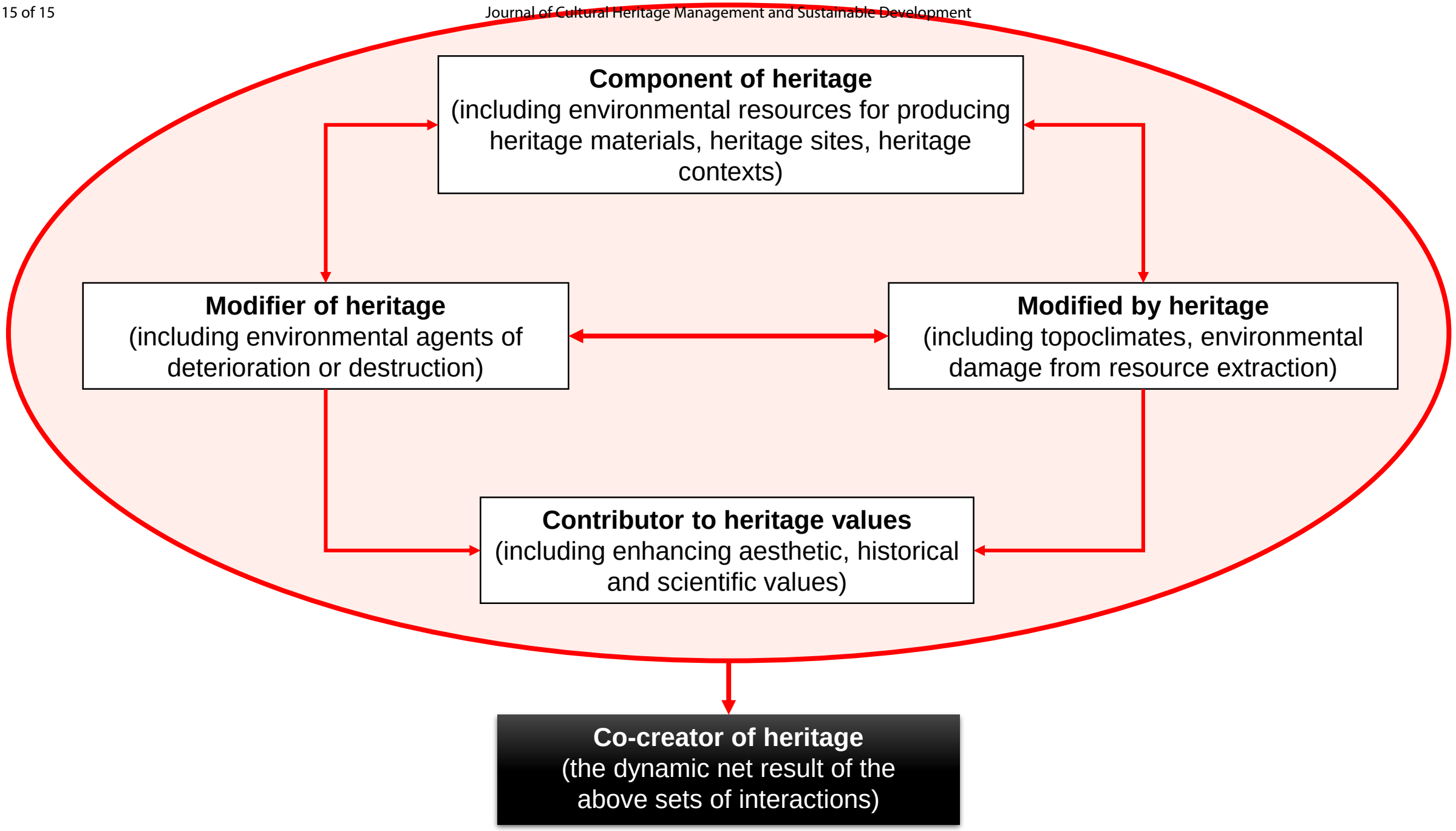
Strlič, M. (2018), "Heritage Science: A Future-Oriented Cross-Disciplinary Field", *Angewandte Chemie - International Edition*, Vol. 57 No. 25, pp. 7260–7261.

Strlič, M., Thickett, D., Taylor, J. and Cassar, M. (2013), "Damage functions in heritage science", *Studies in Conservation*, Vol. 58 No. 2, pp. 80–87.

UNESCO. (2017), "Tangible cultural heritage", available at: http://www.unesco.org/new/en/cairo/culture/tangible-cultural-heritage/ (accessed 27 February 2019).

Viñas, S.M. (2002), "Contemporary theory of conservation", *Studies in Conservation*, Vol. 47 No. Supplement-1, pp. 25–34.

Wells, J.C. (2019), "Science for built heritage", *Science*, Vol. 364 No. 6439, p. 413.


Component of heritage
(including environmental resources for producing heritage materials, heritage sites, heritage contexts)
Modifier of heritage
(including environmental agents of deterioration or destruction)
Modified by heritage
(including topoclimates, environmental damage from resource extraction)
Contributor to heritage values
(including enhancing aesthetic, historical and scientific values)
Co-creator of heritage
(the dynamic net result of the above sets of interactions)