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Using Cultural Heritage in Climate Adaptation: Fields of Application and Functions

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ABSTRACT

Cultural heritage is massively threatened by climate change, but at the same time represents a resource for climate adaptation. An analysis of the literature with regard to fields of application and functions shows that cultural heritage is discussed in almost all fields of climate adaptation. Relevant fields of application include the planning of protective infrastructure as well as technological and behavioral options, education, and informational adaptation measures. The functions attributed to the inclusion of cultural heritage in adaptation measures include informational, emotional, community-building, economic, and aesthetic functions. With respect to the integration of heritage in adaptation processes, different approaches exist, ranging from the preservation of tangible and intangible heritage over the integration of heritage in infrastructure planning to new approaches that focus on proactive engagement with the change and loss of heritage sites or objects. The broad spectrum of at times conflicting approaches demonstrates that the question of how to use cultural heritage in adaptation depends on which adaptation strategies are prioritized. This narrative review structures the vast but only partially explored field and proposes an analysis of the functions of cultural heritage in the different fields of climate adaptation.

This article is categorized under:

i. Climate, History, Society, Culture > Ideas and Knowledge
ii. The Social Status of Climate Change Knowledge > Sociology/Anthropology of Climate Knowledge
iii. The Social Status of Climate Change Knowledge > Knowledge and Practice

1 | Introduction

The interdisciplinary community of heritage scholars has recognized that climate change threatens the material reminders of our past and hence understanding the relationship between climate change impacts and heritage sites and practices is of critical importance (Fatorić and Seekamp 2017). However, heritage might also be of importance for research on climate change, as perceptions of the past inform our understandings of climate change processes, shape our ideas of adaptation options, and affect social constellations that are decisive for the capacity to act (Harvey and Perry 2015). With global warming progressing, the intersection of climate change and cultural heritage is therefore becoming increasingly important, which is also reflected in a rise in publications in the past years (Orr et al. 2021).

The state-of-the-art focusing on the impacts of climate change on heritage sites and objects has been provided by Sesana

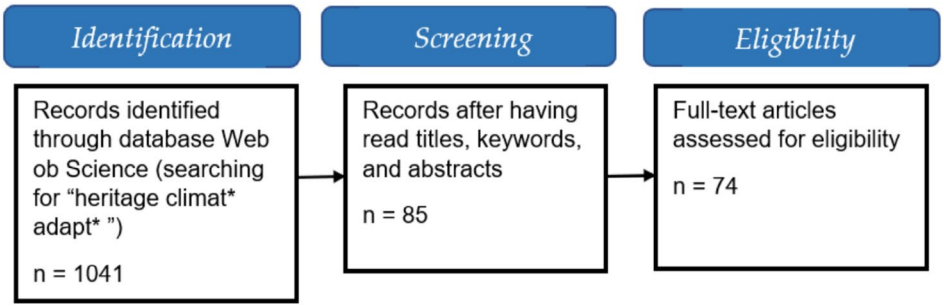

FIGURE 1 | Selection of literature.

et al. (2021). A broader overview on the intersection of climate change and cultural heritage (material and immaterial) is presented by Fatorić and Seekamp (2017) for the time up to 2015 and by Orr et al. (2021) for the following years. These systematic reviews represent an important synthesis of a wide range of research and use thematic analysis and analysis of the meta-characteristics of publications to assess the field. They show that most of the literature focuses on the impacts of climate change on material heritage, but also notice a growing interest in the capacity of cultural heritage to enable climate action (Fatorić and Seekamp 2017; Orr et al. 2021). This review sets out to offer a more practice-oriented overview by specifically reviewing papers that address how cultural heritage can be made useful in the context of climate adaptation, rather than giving an overview on the whole intersection of cultural heritage and climate change.

Despite a growing interest, there is still little knowledge about ways to integrate cultural heritage in adaptation strategies, and the existing knowledge is very heterogeneous in terms of disciplines, methods, and conceptual approaches (Orr et al. 2021). Cultural heritage has diverse interpretations, which complicates any evaluation of its role (Graham 2002) and the same applies to the concept of climate adaptation, which includes a broad spectrum of measures that can be categorized in very different ways (Burton 1996). A delimitation and systematization of the contribution of cultural heritage to climate adaptation is therefore challenging. However, since the use of cultural heritage for climate adaptation is debated in academia and also in the heritage sector, as the report *The Future of Our Pasts: Engaging Cultural Heritage in Climate Action* of the International Council on Monuments and Sites (ICOMOS Climate Change and Heritage Working Group 2019) demonstrates, it seems helpful and worth the effort to create an overview of this heterogeneous field both for the enhancement of heritage development programs as well as for the communication between researchers in this highly interdisciplinary context.

This review therefore provides an overview of the different contexts of climate adaptation in which a contribution of cultural heritage is discussed and the functions ascribed to heritage in these contexts. After the first section on the development of the discourse on the intersection of cultural heritage and climate adaptation, the article focuses in the second section on the categories of adaptation measures (based on Noble et al. 2014) in which a contribution of cultural heritage is debated. This is followed by a third section on the functions of heritage in these contexts. Building on the classification of heritage benefits for climate action in the Netherlands from Fatorić and Egberts (2020), four functions of cultural heritage in adaptation processes are discussed.

Conceptualized as a narrative review, this article aims to structure the vast but only partially explored field. In order to achieve this, the Web of Science database was used to identify publications that deal with heritage and climate adaptation. After a first screening, those publications were excluded that focus on the preservation of heritage threatened by climate change and not on the use of cultural heritage for adaptation. Publications focusing on natural heritage were also excluded at this point. After having read the remaining publications carefully, those publications were selected that fulfilled the expectations of describing a certain function or a specific form of use of cultural heritage in climate adaptation (Figure 1).

These exclusion criteria come with certain vagueness, as the aspect of usage cannot be identified by certain keywords but only by a careful interpretation of the content described. However, despite its limitations, this approach turned out to be the most appropriate for the aim of this study and justifiable in the context of a narrative review. It makes it possible to offer a framework for the various applications of cultural heritage in climate adaptation processes, and to structure the very heterogeneous field. All key areas will be identified, the most important contributions will be named and concise examples will be given. It also sheds light on further potentials in heritage development and climate adaptation strategies and points out connections to contiguous fields of research and research gaps.

2 | Past Perspectives on Cultural Heritage in Times of Climate Change

Explicit discourse on cultural heritage and climate change first appeared in academic literature in the 1990s (Rowland 1999) with discussion on the threat of coastal heritage sites in Australia (Rowland 1992; Sullivan and Hughes 1990). The initial focus was on the threat posed by the effects of climate change to material heritage, such as excavation sites or listed buildings. Other aspects were subsequently raised, such as the question of whether heritage conservation in the aftermath of natural disasters is a luxury or a necessity (Spennemann 1999). With increasing public interest in climate change, the media also discovered the topic of heritage and climate change. When Marzeion and Levermann (2014) published a study on the loss of cultural world heritage to sea level rise, newspapers illustrated

related articles with spectacular photomontages of the most famous heritage sites drowned in water or photos of a flooded Venice. The Guardian even used a still from the blockbuster The Day after Tomorrow showing the Statue of Liberty in the middle of a tremendous thunderstorm. The measure of international attention that the study attracted demonstrates the enormous symbolic power and the societal importance of cultural heritage, which acts as a veritable canary in the coal mine in the context of climate change (Krauß 2015).

However, while the media mainly focused on world cultural heritage as a symbol for the achievements of modern civilization (Krauß 2015), an interdisciplinary discourse on the intersection of heritage and climate change has developed in the academic literature since the first publications in the 1990s. As Orr et al. (2021) show by classifying the literature according to the Web of Science categorization of disciplines, it is mainly researchers from the fields of climate and natural hazards, archaeology, architecture and the built environment, and biodiversity and ecosystems who are concerned with the topic, with publications from the field of culture coming only in fifth place. The body of literature has grown rapidly in the past years and most of the publications focus on vulnerabilities to changing climatic conditions and the preservation of particular buildings, monuments, or sites (Orr et al. 2021).

In addition to the established field of research on climate impacts on material heritage, which has been synthesized by Sesana et al. (2021), new approaches have emerged in recent years. Essential to their development was the realization that an exclusive focus on material heritage does not do justice to the meaning of heritage and also systematically disadvantages the Global South, as intangible forms of heritage like rituals, social practices, or traditional crafts play a larger role than material ones in many countries of the Global South (Brumann 2018). In 2003, this insight was taken into account in the UNESCO Convention on the Conservation of Intangible Cultural Heritage.

This development was complemented by debate on the purpose of preservation, resulting in a significant theoretical evolution in the heritage concept. It led to the recognition that heritage is not a static object, an idea or an activity but a dynamic process—heritage is what is considered as heritage and this changes constantly in the course of history. This perspective is advocated by a growing number of scholars (e.g., Cheape et al. 2009; Harvey 2001; Lowenthal 2005) who focus on "heritage development", understood as the process of engaging communities and stakeholders in articulating the values and meanings associated with "everything we suppose has been handed down to us from the past" (Lowenthal 2005, 81). This also includes negotiating the questions of how to use cultural heritage and what to preserve and pass on to future generations.

Building on such a dynamic understanding of heritage, an increasing number of practitioners are addressing the question of what role material and immaterial cultural heritage can play in advancing climate adaptation and mitigation. In 2018, the Climate Heritage Network was launched as a "voluntary, mutual support network of arts, culture and heritage organizations committed to aiding their communities in tackling climate change and achieving the ambitions of the Paris Agreement" (Climate Heritage Network 2024). Similarly, the report "Future of Our Pasts: Engaging Cultural Heritage in Climate Action" (ICOMOS Climate Change and Heritage Working Group 2019) was released by the International Council of Monuments and Sites.

In various academic disciplines, too, cultural heritage is increasingly researched not only as an endangered asset, but also as a resource for climate action, including adaptation and mitigation. The following section provides an overview of the fields of application in climate adaptation.

3 | Using Cultural Heritage in Climate Adaptation: Fields of Application and Functions

The contexts in which the use of cultural heritage is regarded as a component of climate adaptation are diverse and range from participatory spatial planning processes (Riesto et al. 2022) to agricultural practices (Agnoletti and Santoro 2022) and the development of heritage sites (DeSilvey 2017). In order to create an overview of the fields of adaptation to which cultural heritage contributes, each publication of the selected literature was assigned to one of the categories of climate adaptation measures defined by Noble et al. (2014) in the fifth IPCC report to identify the categories in which cultural heritage plays a role and what this role looks like. Among the many different ways adaptation measures are categorized (Burton 1996), the systematization from Noble et al. (2014) was chosen in order to refer to a widely acknowledged authorized body with an interdisciplinary perspective.

Within this structure, the three main categories "structural/physical," "social," and "institutional" provide an overarching frame for several subcategories. The assignment of the literature to these led to five relevant subcategories, which are described in more detail below and are linked to examples from the selected literature. Noble et al. (2014) emphasize that some adaptation measures are interrelated and that one measure can be relevant to more than one category. Consequently, this also applies to the fields in which cultural heritage plays a role and some forms of engagement with heritage can be assigned to more than one field.

3.1 | Fields of Application

Noble et al. (2014) identify five subcategories to which studies on the employment of cultural heritage in adaptation can be assigned to: *Engineered and built environment*, *Technological and ecosystem-based options* in the category "structural/physical," and *Education*, *Behavioral options*, and *Informational strategies* in the category "social." The category "institutional," which includes economic measures like financial incentives as well as laws and regulations and government policies, is not included here as no studies were found that address explicitly a contribution of cultural heritage to these fields.

The category *Engineered and built environment* includes large-scale infrastructure projects like seawalls or flood levees, which are often at the forefront of adaptation strategies (Dawson 2007)

but also small-scale structures like floating houses (Penning-Rowsell 2020) or cyclone resistant shelters (Rasmussen et al. 2009). *Technological options* apply, for example, to agriculture, food storage facilities, and hazard monitoring technology. They include both "hard" technologies based on complex and capital-intensive technology and "soft" technologies that are rather simple and modular and often understood and owned by local people (Sovacool 2011). Also, indigenous and traditional technologies are part of this category (Glatzel et al. 2012). In contrast to mitigation, where low-carbon technologies are often new, technologies in adaptation are often familiar but only locally known (Irfanullah et al. 2008). Noble et al. (2014) distinguish between technological and *ecosystem-based options* that refer to the use of biodiversity and ecosystem services to help people to adapt to climate change impacts. These include, for example, the use of mangroves and salt marshes as buffers to protect coastal infrastructure (Morris 2007), the use of agro-ecosystems in farming systems (Tengö and Belfrage 2004), and adaptive land use management (Mawdsley et al. 2009). As there are only a few examples in this category that relate to cultural heritage and these also have a technological component, the two categories are combined below in the category *Technological and ecosystem-based options*. *Behavioral options* mean measures in which humans adapt to change instead of adapting their environment. Examples include emergency preparation at household level (Dawson et al. 2011), livelihood diversification (Selvaraju et al. 2006), migration (McLeman and Hunter 2010), and building reliable social networks.

In contrast to large infrastructure projects commissioned by governments, most behavioral options are in the hands of individuals or communities. In some cases, certain measures are promoted by campaigns or incentives (Noble et al. 2014). *Education* includes various aspects such as awareness raising, sharing local and traditional knowledge, participatory action research, social learning, and communication through media (Mochizuki and Bryan 2015; Moser 2014). Noble et al. (2014) give several examples showing how adaptation options are heavily influenced by forms of learning and knowledge sharing, while a lack of education heightens vulnerability (Paavola 2008). *Informational strategies* aim at the establishment and maintenance of early warning systems to ensure awareness of natural hazards and promote timely responses. Examples of adaptation measures include systematic monitoring, vulnerability mapping (de Sherbinin et al. 2019), and participatory scenario development (Larsen and Gunnarsson-Östling 2009).

3.1.1 | Engineering and Built Environment

One of the earliest examples for the intentional integration of cultural heritage into adaptation planning is the program "Room for the River" in the Netherlands which was developed in response to large flooding events in the 90s (van Alphen 2020). Contributing to cultural meaning and aesthetics was an objective from the early stage of plan and a special team was tasked with monitoring progress on cultural issues. As the result of a planning process which involved a multitude of stakeholders and citizens, the program saw the return of various traditional strategies of flood management, such as digging bypasses and living on terps. van Alphen (2020) who evaluated the measures of the program at Noordwaard, therefore speaks of "a paradigm shift in flood management, which ironically has come about through the revival of much older traditions" (p. 319).

There are numerous examples of similar traditional flood management strategies that reduce disaster risk by making space for water and using natural resources. Building settlements on natural or artificial elevations was standard practice in the North Sea area before the first sea walls and drainage systems appeared around 1000 AD (Soens 2018) but also in geographically very different regions such as Ancient Greece (Angelakis et al. 2023). Also today, building codes that prohibit the construction of houses on flood plains are still part of indigenous flood disaster risk reduction strategies (Obi et al. 2021). The practice of constructing artificial embankments and harnessing natural overflow channels emerged in Ancient Egypt in the period between 2648 and 2160 BC and some of the drainage systems from the Mycenaean period (ca 1600–1100 BC) are still in operation today (Angelakis et al. 2023). However, even though the resilient construction of settlements has been in place for centuries and is still a central part of indigenous flood management, it has only fairly recently been rediscovered as part of a wider strategy to manage flood risk and it has not been until the 21st century that the "living with water" philosophy emerged (Proverbs and Lamond 2017).

Apart from flood risk management in spatial planning, cultural heritage also serves as an object to study and learn from in the construction of residential buildings. Tao et al. (2022) conducted a field investigation including historic villages in of the Leizhou Peninsula in China, which is characterized by its typhoon climate. This research emphasizes the significance of traditional windproof construction for climate-adaptive architecture. Similar examples are found inter alia for the passive cooling benefits of traditional roofs in the Mediterranean (Cassar et al. 2023), the climate adapted historical dwellings of Cadiz (Rubio-Bellido et al. 2018), the bioclimatic design of the old city of Aleppo (a UNESCO World Heritage site) (Salkini et al. 2017), traditional hurricane-proof shelters on the Caribbean islands (Hofman et al. 2021) or stilt houses in Thailand (Elnokaly and Pittungnapoo 2022). This field, namely the use of cultural heritage for architecture adapted to climate change, merges seamlessly into the much larger field of climate-adaptive architecture, as traditional architecture adapted to local climatic conditions is also relevant without considering climate change and historic buildings, and traditional methods are only sometimes considered "cultural heritage." Besides the climatic characteristics of heritage buildings, the literature emphasizes the environmental friendliness (Cassar et al. 2023) and the low costs of traditional construction methods and materials (Rubio-Bellido et al. 2018). However, while the advantages of traditional construction methods are stressed, there are relatively few proposals for their upscaling or transfer presented in the literature.

In addition to their importance as objects of study for climate-adaptive architecture, historic built structures can also serve as a direct material resource. The examples given by heritage experts include the restoration of old fortifications for current dike reinforcements and the reuse of historic canals or water mill ponds for rainwater storage (Fatorić and Egberts 2020). Furthermore, examples from the Netherlands demonstrate that

the integration of cultural heritage into the planning of structural adaptation measures can also generate social and aesthetic benefits. In one of the examples given by Riesto et al. (2022), authorities combined funds for the reinforcement of a dike with funding aimed at strengthening the municipality's identity as a historic city by the sea. Another case also concerned the fortification of a dike protecting a village whose inhabitants wanted to preserve its historic character. The active engagement of the inhabitants and consideration of aesthetic aspects from the outset of the project led to a multifunctional dike (including integrated, below-ground parking facilities), constructed in part using traditional techniques and materials. Riesto et al. (2022) highlight these two examples as successful processes for the integration of cultural heritage in adaptation planning. In contrast, they present two examples from Denmark in which conflicts arose between different interests and different types of heritage. In one case, after a period of highly controversial debates, rather new cultural heritage (a museum building) was destroyed to protect older heritage (a Viking ship). In the other one, natural heritage (salt marshes) was destroyed to protect shoreline properties.

These examples show that the integration of cultural heritage into infrastructure planning often requires the negotiation of the relevance of certain heritage. Conflicts of interest can arise both between different types of heritage and between the integration of heritage and other interests. In the examples from the Netherlands, synergies were found between different forms of heritage and other interests. For Riesto et al. (2022), the decisive difference in comparison to the Danish cases is the fact that there was no attempt to protect something static, but the focus was on developing the local cultural heritage according to new infrastructures and vice versa. They come to the conclusion "that there is great potential for future coastal planning to develop other responses to water risks that go beyond the two opposites of either preserving a static image of the past or removing and replacing historical values" (Riesto et al. 2022, 371). van Alphen (2020) makes a similar statement for the Room for the River case. However, the integration of local cultural heritage into the planning of infrastructural adaptation measures still happens on a very small scale (Riesto et al. 2022) and is weakly theorized (for exceptions see: Egberts and Renes 2020; Egberts and Riesto 2021).

3.1.2 | Technological and Ecosystem-Based Options

An essential aspect of cultural heritage is knowledge and knowledge systems that are passed down through generations. It is open to discussion in how far heritage itself can be regarded as knowledge, as Graham (2002) puts it, or if knowledge should rather be considered as an aspect of heritage. However, conserving and transferring knowledge plays a major role in heritage development and the knowledge discussed in the literature on heritage and adaptation exceeds scientific knowledge and includes different knowledge systems like Indigenous or local knowledge (Orlove et al. 2022).

The literature offers several examples of the benefits of knowledge inherent in cultural heritage that can be used in a technical manner for climate adaptation. Heritage-related technological measures include resource and land management practices such as traditional water management measures and management of wild species (Leal Filho et al. 2022), indigenous burning techniques for fire management (Bardsley et al. 2019; Head et al. 2014) and traditional community-led flood management (Bhatia and Shukla 2024). Some of them are based on the use of ecosystems like for example afforestation measures like the cultivation of appropriate tree species such as Palmyra, date trees, and screw pines as a protection from cyclones (Ataur Rahman and Rahman 2015) and agro-silvo-pastoral systems and agroforestry practices as methods to preserve biodiversity in a changing climate (Agnoletti and Santoro 2022). However, those ecosystem-based measures are largely discussed in the literature in relation to indigenous knowledge, with the concept of cultural heritage only being mentioned sometimes.

A large part of the literature on the use of cultural heritage for technological adaptation measures focuses on the use of traditional agricultural practices and old varieties for climate adaptation (Agnoletti and Santoro 2022). This includes the preservation and the continued use or reuse of old varieties such as genotypes of traditionally domesticated types of barley (Schmidt et al. 2023) or local types of durum wheat that show more resistance to drought than recently created cultivars (Slama et al. 2018). Beyond the use of plant genetic resources, animal genetics such as those of Criollo cattle (Spiegal et al. 2023) and the preservation and revival of traditional cultivation practices are discussed as climate adaptation measures. In this context, terms like "agricultural heritage" or "heritage genetics" are employed and "heritage" is partly used as a synonym for "traditional" (e.g., Anderson et al. 2015). The increase of attention that agricultural heritage systems are receiving is testified by the launch of various initiatives like the Globally Important Agricultural Heritage Systems (GIAHS) Programme (Agnoletti and Santoro 2022).

These techniques being part of cultural heritage implies an embeddedness in associated value systems and cultural practices. The various consequences of applying such techniques therefore often extend into different areas. One example is the "Millet Ark" conservation initiative in Taiwan that evolved from a collaboration of academia and mountain-dwelling indigenous farmers on climate adaptation (Lin et al. 2020). As millet is the shared traditional crop of the Taiwanese indigenous peoples, there is a deeply rooted connection between the cultural history, the peoples' connection to the land, and different agricultural practices. Lin et al. (2020) regard this connectedness as the reason for the broad range of effects of the initiative. They registered not only a recovery of climate-robust varieties of millet but also an increase in soil fertility, a recovery of the traditional millet vocabulary, and a change in gender boundaries (Lin et al. 2020). Slama et al. (2018) also emphasize the connectedness of cultural and genetic heritage and conclude that "the culture of old cultivars should be prioritized as a means to preserve genetic heritage" (p. 9). Spiegal et al. (2023) who define their role in their research on heritage Criollo cattle as building "the bridge between mechanistic cattle research and multidisciplinary sustainability research" (p. 4) examine various effects of breeding Criollo cattle such as social effects for the farmers and environmental effects like better soil health. Agnoletti and Santoro (2022) conclude that agricultural heritage systems are closely interwoven with cultural heritage and essential for a resilient agricultural production and the preservation of biodiversity. Similarly, Barrera-Bassols and

Toledo (2005) describe the Yucatec-Maya farmers' knowledge system as interwoven with a holistic understanding of nature, landscapes, health, and spirituality.

In the majority of the studies on technological adaptation options that cultural heritage offers, their application in local contexts is described and their advantages are elaborated, while the possibilities of upscaling or transferring to other places or other cultural contexts are rarely discussed. This contrasts with the IPCC's call for knowledge transfer regarding technological options (Noble et al. 2014). Exceptions are the call for the generation of formal knowledge on indigenous land management practices (Bardsley et al. 2019) and the ambition to increase accessibility to genetic heritage and to related comprehensive information through an international research network (Spiegal et al. 2023).

3.1.3 | Behavioral Options

In addition to spatial transformation and a change of certain technologies and land use practices, climate adaptation involves far-reaching and comprehensive changes to social structures and social values and practices (Wolf 2011). Places become uninhabitable, citizens of coastal towns lose part of their identity when the sea is no longer accessible behind seawalls, labor markets change, and households have to prepare for environmental hazards. Individuals and communities respond to such changes with behavioral adaptation measures like managed retreat or migration, livelihood diversification, or household-level disaster risk reduction measures like storing water and food, increasing the number of building floors in flood vulnerable areas or building flood barriers (Noble et al. 2014).

In this context of behavioral adaptation measures, cultural heritage is discussed mainly in regard to retreat, relocation, and migration as well as reliance on social networks. Few studies focus on culturally embedded techniques of coping with climate-related adverse circumstances like the ability of some indigenous Australian communities to cope with extreme heat (Quilty et al. 2023). Changes in agricultural practices that are also mentioned by Noble et al. (2014) in this category are also relevant but have already been discussed in the section *Technological options*. The same applies to some construction techniques that have been listed under *Engineering and built environment*.

Aktürk and Lerski (2021) have examined the role of intangible cultural heritage in relocation processes and consider it a "catalyst for building resilient communities" (p. 305). They give examples of how maintaining traditions and cultural expression (e.g., mourning practices, traditional food, performing arts, handicrafts) helps displaced people to recover and prevents social disintegration at an individual level as a consequence of loss of identity (e.g., Huang and Hou 2018). In some cases, heritage can also offer economic possibilities for migrated people, for example through traditional crafts (e.g., Allam and Jones 2019; Alvarez 2016). According to Herrmann (2017), the cultural heritage community should advance climate change policy in three ways: "Firstly, by advocating the inclusion of preservation where possible and/or documenting and memorializing the tangible heritage left behind by displaced communities; secondly, providing best practices in the conservation of intangible heritage, traditional knowledge and movable heritage of displaced persons and communities; and, thirdly, facilitating the role of cultural heritage as a tool for resiliency, integration and social cohesion in new sites" (p. 193).

Scholars such as McMichael et al. (2021) and Tabe (2019) point out that the strong attachment to locally anchored cultural heritage also makes migration and planned relocation more difficult. However, they do not see this attachment as an obstacle, but as a legitimate reason to stay in one place even under adverse circumstances, or even as a resource to cope with these adverse conditions. Maldonado et al. (2014) and Tabe (2019) demonstrate the fatal long-term effects of the loss of cultural assets in historical forced relocation processes and speak out against forced relocation. They advocate for an expansion of understandings of migration and adaptation as well as the inclusion of cultural needs and priorities in adaptation and relocation planning. A case study by Lerski (2019) on the role of cultural heritage in adaptation on Barbuda offers an example of how these needs and priorities can be identified. Using a participatory and artistic-driven approach, Lerski collected the inhabitants' key cultural heritage features to harness local knowledge and cultural capital for purposes of biocultural heritage preservation, adaptation and relocation.

Cultural heritage can also be a resource in the organization of community-based flood management. An example is given by Tambal et al. (2024) with the community relief initiative "Nafeer," which was founded by young volunteers in response to the 2013 floods in the Sudanese capital Khartoum. It is based on a traditional method of social mobilization and includes a precise organizational structure for flood measurement, monitoring, logistics, construction, and maintenance of the flood protection system, primary health care, and the collective singing of traditional songs about floods to encourage and motivate people and remind them of their success in coping with past floods. Tambal et al. (2024) conclude that making use of traditional methods of community organization and flood management, which often appear in the local culture and songs of communities living close to water, is particularly important in places with low state capacity and limited financial resources. Krishna et al. (2018) give similar examples, one of them being the *Subak* water management system on Bali (Indonesia), which was recognized by the UNESCO World Heritage in 2012 and is used by programs for disaster risk reduction. The *Subak* system is based on mutual cooperation and consists of specialized institutions with responsibility for water management. It is considered an important part of community life and deeply embedded in cultural and spiritual practices, with some of them dating back to the eleventh century (Krishna et al. 2018). The importance of traditional systems of mutual cooperation is also emphasized by Hofman et al. (2021) who give as one example cultural practices that maintain intra- and interisland sociality in the Caribbean islands and call for the continued integration of cultural heritage in national climate adaptation planning.

Another approach is the use of cultural heritage in dealing with climate-related loss and decay. Precisely because cultural heritage is closely tied to identity and the idea of preservation, authors such as Seekamp and Jo (2020), DeSilvey (2017), and

Holtorf (2018) argue that the acceptance of its decay and transformation holds potential for helping populations to cope with the loss, transformation, and redefinition of identity that climate adaptation requires. Seekamp and Jo (2020) even recommend the adoption of a new type of site (e.g., World Heritage Site in Climatic Transformation) that makes the transformative continuity of tangible and intangible resources visible and offers an opportunity to learn about fragility and finiteness. They argue that a change in heritage policy could enable two different forms of learning from loss: First, by cultivating memories of climate-related disasters and secondly, through the cultivation of heritage values that include the acceptance of constant change.

3.1.4 | Education

Heritage itself and heritage development often include educational components. Knowledge is processed and passed on through museums, memorials, and archaeological sites, but also in songs, myths, and oral history. Contributions to climate adaptation consist of knowledge that is stored in intangible and tangible heritage. On Simeulue Island, traditional songs are used to communicate information about tsunamis and risk mitigation, which has proven effective in protecting the population (Sutton et al. 2021). In Japan, so-called "tsunami stones" erected decades or even centuries ago identify areas at risk and warn against people settling there (Garnier and Lahournat 2022). For the Kalinago and Garifuna on the islands of Dominica and Saint Vincent, orally transferred knowledge about how to monitor environmental changes, how to react to signs of volcanic eruptions and how to prevent losses through strong hurricane winds, is an essential part of their cultural heritage (Hofman et al. 2021).

In addition to such direct transfer of knowledge, where the existential purpose of heritage itself is to impart a certain knowledge, engagement with cultural heritage can generate knowledge. Using examples from Florida, Scotland, and Maie, Dawson et al. (2020) show how citizen science and public engagement approaches in heritage development can provide communities with the tools to address climate change impacts. Nettley et al. (2014) present an example of a short film on the projected sea level rise at a heritage site in Cornwall that was produced by involving residents and stakeholders. Meyer (2020) suggests that we tell different stories about heritage, including critical perspectives on cultural practices, technological innovations, and societal developments contributing to climate change and maladaptation. Focusing on the whole field of climate action and not exclusively on adaptation, Curulli et al. (2023) provide teaching and learning methods, tools, and pedagogical models that can be applied in heritage education in order to address climate adaptation. Their examples are from diverse contexts and include educational approaches for architectural studies in higher education, webinars for professionals working in the arts and cultural and heritage organizations, and educational video games on the climate resilience of built cultural heritage. Curulli et al. (2023) argue that both transdisciplinary, holistic approaches and a dynamic understanding of cultural heritage are essential to harnessing the potential of heritage education in climate action. However, when it comes to climate adaptation (understood as the adaptation of society and not as the adaptation of material heritage to changing climatic conditions), there are still very few approaches within heritage education that explicitly address this issue.

3.1.5 | Informational Strategies

In the field of early warning systems for natural hazards and climate modeling, cultural heritage is discussed as a source of knowledge about past climate changes and responses (e.g., Cacciotti et al. 2021; Fatorić and Egberts 2020; Sesana et al. 2018). Scholars from the field of archaeology argue that the decisive features of societies or urban systems that facilitate or hinder adaptation can be identified by studying how ancient societies (Jackson et al. 2018) or cities (Smith et al. 2023) adapted to environmental changes. Historical weather datasets that can complement modern climate data are also relevant for understanding agricultural dynamics (Raymond et al. 2023). Rabett et al. (2023) argue for the potential of palaeoecology and archaeology for enhancing the present generation of Integrated Assessment Models that simulate alternative future climate scenarios resulting from different policy options. Drawing on a comparison of data on Mid-Holocene inundations in the Red River Basin from the Tràng An Landscape Complex World Heritage Site and projected inundation scenarios for different Shared Socio-economic Pathways, they give recommendations for contemporary local adaptation measures, such as the focus on mangrove restoration in the region. The study shows how incorporating prehistoric evidence in next generation Integrated Assessment Models can enhance the spatial–temporal resolution of coastal vulnerability models and improve the assessment of adaptation options. However, especially for very early periods of investigation, the data record is often incomplete and simple correlations between climatic and cultural changes observed in the archaeological record should not be drawn (Jones et al. 2019; Petrie 2017; Wright 2010).

Among historians and archaeologists, there has been considerable interest in linking climate events and periods of cultural transformation identified in archaeological sequences (Büntgen et al. 2016). Still, historical perspectives have limited influence in adaptation research, and this seems to relate to the lack of interdisciplinary collaboration with historians and archaeology in this field, and to the disjunction between modern and pre-industrial societies (Jackson et al. 2018). Rabett et al. (2023) also call for interdisciplinary and transdisciplinary research and advocate for the enhanced integration of knowledge from archaeological and palaeoecological research into policy-driving models.

The monitoring of heritage sites can also be used to obtain data on ongoing local damage and risks caused by climate change. Dawson et al. (2020) outline three examples of how the combination with citizen science approaches can not only collect more data, but also combine data collection with educational components.

3.2 | Functions

The classification of literature on the mobilization of cultural heritage for climate adaptation shows that the fields of

application are diverse. In these contexts, cultural heritage serves different functions, such as strengthening social coherence or imparting knowledge. Fatorić and Egberts (2020) were the first to conduct a systematic investigation of these functions, which they term "heritage benefits," through an expert survey. However, their study only refers to the Netherlands and includes both adaptation and mitigation, without making a clear distinction between the two. The five functions they found were used in this review as a basis to identify functions of cultural heritage for climate adaptation on a global scale. For this purpose, the functions attributed to cultural heritage in the literature were assigned to the categories of Fatorić and Egberts (2020). This made it possible to consider the extent to which this classification is also valid for climate adaptation in the global context. Four of their five categories, namely informational, social, economic, and aesthetic benefits, have been examined, while the fifth (environmental benefits) was excluded because it addresses mitigation (emissions reduction) and not adaptation.

3.2.1 | Informational Functions

Informational benefits turned out to be the most salient benefits regarding climate action in the Netherlands (Fatorić and Egberts 2020). The consulted experts ascribe these benefits to diverse heritage types that can convey a story of the past through their physical and visual presence and document the changing climate and risk management. The most prominent examples in the study are traditional flood mitigation structures that have inspired numerous modern adaptation measures and the use of historical maps and archival documents to study past water management techniques. Fatorić and Egberts (2020) also note the educational capacity of cultural heritage.

Informational functions also play a crucial role at the global scale. For the field *Engineering and built environment*, van Alphen (2020) even describes how considering traditional water management techniques contributed in the Netherlands to a paradigm shift from a 'protect-closed' approach to a more open concept that adheres to the old flood protection principle of "not with force, but with sweetness" (p. 320). The examples from the fields *Technological and ecosystem-based options* and *Informational strategies* focus largely on the use of knowledge incorporated in cultural heritage and also in the field of *Education*, knowledge transfer is essential even though here, heritage is not only understood as a store of knowledge but also as a boundary object that can help to catalyze interest in climate impact among stakeholders and the public.

However, the informational functions for adaptation on a global scale go beyond the ones reported by Fatorić and Egberts (2020). They include the transfer of indigenous or local knowledge that is part of a vital cultural practice and is not gained by studying heritage sites or objects (e.g., Sutton et al. 2021). Besides, informational value is not limited to technical knowledge. Particularly in adaptation processes in which decision-makers are not themselves part of the community in question, like for example in some cases of relocation, a look at cultural heritage can contribute to an understanding of the reality of life, the needs, and the values of local people (e.g., Lerski 2019).

3.2.2 | Emotional and Community-Building Functions

In the study by Fatorić and Egberts (2020), experts commonly stressed that cultural heritage can strengthen cultural identity and social cohesion, and contribute to the development of a collective and shared history and memory. They considered heritage is a stimulus for a sense of place through a connection between social life and the built and natural environment. Fatorić and Egberts (2020) call these functions 'social benefits'. In order to specify this category and account for the fact that other functions, such as aesthetic ones, also have social components, this category is referred to here as 'emotional and community-building functions'. This also highlights the emotional component, which tends to be overlooked in the development of adaptation strategies and the related discourse (Bowden et al. 2021).

In the literature on cultural heritage and climate adaptation on a global scale, various scholars emphasize this potential of cultural heritage to strengthen cultural identity and a sense of belonging (e.g., Lombardo et al. 2020; Sesana et al. 2018), which in turn can enhance community resilience to climate change impacts (Ghahramani et al. 2020). In his analysis of four case studies, Laven (2018) comes to the conclusion that "heritage development can be a constructive, empowering force for enhancing community-level resilience" (p. 176). He points out the importance of developing a common narrative that links the past with the present and goals for the future to make meaning of sociocultural transitions. This idea was already formulated by Edson (2004, p. 345):

> ... in the best of circumstances, heritage enfranchises the emotionally and culturally disenfranchised. It allows humankind to transcend individual destiny to achieve continuity. [...] They [the heritage resources] help to generate an environment where the people can acquire an awareness of continuity that exists in human creation, glimpse a past that they receive with admiration and gratitude, and project the future to which they will transmit the results of their own endeavours.

The discourse on emotional and community-building functions in climate adaptation overlaps here with the general discourse on cultural heritage and resilience (e.g., Tavares et al. 2021), which will not be covered in detail here. However, the three main approaches to resilience are considered briefly in order to shed light on the different understandings of emotional and community-building functions of heritage in the academic literature. Davoudi (2018) refers to these approaches as persistence, adaptation, and transformation.

Understanding resilience as persistence, cultural heritage is a valuable asset which needs to be conserved for future generations; it contributes to identity, cohesion and thus to resilience. This perspective has also become established in the context of

heritage protection and management. Discussions in this field concern the challenge of protecting cultural heritage from climate change impacts in order to support the associated communities in the face of climate-related and other challenges (e.g., Jigyasu et al. 2013; UNESCO 2015).

However, various studies emphasize that the capacity of cultural heritage to strengthen social cohesion and a sense of place is primarily linked to participatory processes of engagement with cultural heritage and not to its mere existence (e.g., Hofman et al. 2021; Laven 2018; Riesto et al. 2022; van Alphen 2020). In these studies, heritage needs to be developed and adapted to a changing climate and changing communities in order to contribute to community resilience.

A third approach, in which resilience is regarded as the capacity to accept constant change and act accordingly, is advocated by scholars such as DeSilvey (2017), Holtorf (2018), Koslov (2016), and Harvey and Perry (2015). They call for the recognition of the inevitability of the loss of cultural heritage in times of ecological destabilization and are looking for ways to deal constructively with this loss. With concepts such as adaptive release (DeSilvey and Harrison 2020) or curated decay (DeSilvey 2017), they propose using new approaches in heritage development to avoid seeing change as a loss and to use cultural heritage to grapple with constant change and its implications for identity and community structures. The response to the 2004 tsunami disaster in Banda Aceh, Indonesia, can serve as an example of such a way of dealing with loss. The tsunami destroyed almost all the settlements on the coast of the affected region but carried a fishing boat inland, which landed on the roof of a house and remained there after the water receded. The boat was turned into a symbol of the community's resilience during the rebuilding process, replacing older heritage narratives that had divided the community in the past due to their intertwining with religion and colonialism (Rico 2016).

Community-building functions are emphasized in studies concerning the fields of engineering and built environment, technological options, behavioral options, and education. The emotional function of helping to deal with change and loss is primarily linked to the fields of behavioral options and education in the academic literature, while the development of a sense of place is discussed in the field of engineering and built environment.

3.2.3 | Economic Functions

The third category in the structure of Fatorić and Egberts (2020) is economic benefits. They note that the adaptive reuse and the transformation of cultural heritage have created new economic value for society. Their examples relate on the one hand to the restoration or reuse of historical infrastructure such as water channels or dikes, which represent an economic resource insofar as the construction of new infrastructure can be expensive and resource-intensive. On the other hand, reference is made to tourism as a source of income. The experts consulted in the study aim to promote forms of tourism that are less affected by climate change than, for example, coastal or mountain tourism. Fatorić and Egberts (2020) see in this strategy a diversification of income sources, which is considered an essential part of climate adaptation (Noble et al. 2014). Tourism also plays a role in the case studies by van Alphen (2020) and Egberts and Riesto (2021), whereby the inclusion of cultural heritage in infrastructural adaptation measures is seen as an opportunity to gain or at least preserve tourist appeal. In studies on cases outside the Netherlands, cultural heritage—understood as cultural capital—is also ascribed an economic function in the context of migration and relocation, as it can contribute to income generation (Allam and Jones 2019; Alvarez 2016).

3.2.4 | Aesthetic Functions

In his study on examples from Denmark and the Netherlands, van Alphen (2020) also ascribes an aesthetic function to cultural heritage. By including the local cultural heritage into the planning of protective coastal infrastructure, existing landscape qualities had been enhanced and the cultural significance of the landscape strengthened. However, aesthetics is hardly ever mentioned in the literature on heritage and adaptation. This supports the findings of Fatorić and Egberts (2020) who identify aesthetic benefits as one of five categories of benefits but consider them less salient.

While all four functions play a role in the fields *Built Environment* and *Technological and Ecosystem-based options*, only certain functions are attributed to cultural heritage in the other fields (see Table 1). For example, economic functions are not discussed with regard to the fields *Education* and *Informational options* and aesthetic functions are only described in the fields *Built environment* and *Technological and ecosystem-based options*.

4 | Discussion and Outlook

A growing body of literature shows that cultural heritage is not only threatened by climate change but also represents an important resource for adaptation. When analyzing this role, it is difficult to distinguish the field from neighboring discourses, as the concept of climate adaptation overlaps with fields such as disaster risk reduction and migration, and the concept of cultural heritage overlaps with fields such as indigenous or traditional knowledge. However, analyzing the literature against the background of the categories of adaptation measures identified by Noble et al. (2014) shows that cultural heritage is relevant in various categories. These categories are not clear-cut but provide a practicable overview of the fields of application discussed in the academic literature. The functions attributed to cultural heritage in these fields include informational, emotional, community-building, and economic functions as well as aesthetic ones, and in most use cases several functions are addressed simultaneously. It has been criticized that the primarily normative and political issues raised by adaptation are treated in a de-politicizing technological manner that excludes social and emotional aspects and participatory approaches (Klepp and Chavez-Rodriguez 2018). The fact that in most of the use cases several of the described functions are addressed suggests that the inclusion of cultural heritage in adaptation strategies might offer a means to broaden this narrow focus and facilitate more holistic approaches.

TABLE 1 | Examples of the functions of cultural heritage in the different categories of climate adaptation.

Fields of application	Built environment	Technological and ecosystem-based options	Behavioral options	Education	Informational options
Functions					
Informational	Learning from historic buildings and infrastructure about climate-adaptive architecture (Tao et al. 2022)	Learning from Indigenous knowledge about climate-adaptive land management (Bardsley et al. 2019)	Identifying cultural needs, local knowledge, and priorities in relocation planning (Lerski 2019)	Using traditional songs to communicate signs and rules of behavior for the occurrence of natural hazards (Sutton et al. 2021)	Studying how ancient societies adapted to environmental changes in order to learn about the features that facilitate or hinder adaptation (Jackson et al. 2018)
Emotional and community-building	Referencing to the past in order to offer a stepping stone for residents to get involved in spatial planning processes and to identify with the changed environment (Riesto et al. 2022)	Strengthening connections between the individual and the community, and between people and the environment through the use of techniques with a cultural and social meaning (Lin et al. 2020)	Helping displaced people to recover and prevent social disintegration through maintaining traditions and cultural expression (Huang and Hou 2018)	Making the transformative continuity of tangible and intangible heritage visible and graspable in order to learn to cope with fragility and finiteness (Seekamp and Jo 2020)	
Economic	Reuse of historic infrastructure like canals or water millponds for rainwater storage (Fatorić and Egberts 2020)	Providing local economic benefits through tourism, local products, and resilient agricultural systems (Agnoletti and Santoro 2022)	Using traditional crafts to create economic possibilities for migrated or relocated people (Allam and Jones 2019)		
Aesthetic	Enhancement of landscape qualities and strengthening of the cultural significance of the landscape (van Alphen 2020)	Contributing to the identity and the attractiveness of landscapes through the use of traditional agricultural techniques (Agnoletti and Santoro 2022)			

Different—and at times conflicting—approaches to the integration of heritage in adaptation processes exist. On the one hand, the preservation of cultural heritage is advocated for when it comes to the application of traditional techniques anchored in heritage or the strengthening of community resilience through existing cultural practices. On the other hand, some scholars advocate for the adoption of new and creative approaches to heritage development that embrace change and loss of cultural heritage as inevitable occurrences. Noticeably, such approaches are discussed primarily for tangible heritage and mostly in regard to countries of Northern Europe, while the role of heritage for behavioral adaptation options is discussed predominantly in regard to intangible heritage and the Global South. A differentiated consideration of the individual fields of application and associated adaptation challenges could provide context-specific information on the utility, feasibility, and ethical considerations of the different approaches.

Moreover, further research is needed to provide information on their procedural and institutional integration in adaptation strategies and processes. This also raises the question of the extent to which relevant knowledge anchored in cultural heritage can be transferred and how it can be organized in the different fields of application. On the one hand, the integration of cultural heritage in adaptation strategies is supposed to do justice to the local specifics with their respective cultural and social contexts. On the other hand, there are culturally anchored, locally specific technologies and practices that might make a valuable contribution in other places.

It also seems worth further research to examine the literature with regard to differences between examples from the Global North and the Global South. The fact that the integration of cultural heritage into the planning of protective infrastructure is only discussed in cases from Northern Europe, for example, points not only to differences in thinking about cultural heritage with respect to different global regions, but also to associated different ideas about climate adaptation that underlie power asymmetries. The requirement to take aesthetic and emotional aspects into account when building protective infrastructure seems to be made only for high-income countries while forms of adaptation that require major behavioral changes on the individual level are discussed exclusively for low-income countries or for low-income population groups in countries with a higher income level. The differences between tangible and intangible heritage in the various categories also deserve further investigation, as well as the adaptation categories that are not addressed in the heritage-related literature and the interfaces of specific fields of application and functions for which no examples were found.

This overview of a broad spectrum of perspectives also demonstrates that the question of whether cultural heritage represents a resource or an obstacle also depends on the prioritization of values in different understandings of climate adaptation, different cultural identities, and different social classes. A strong attachment to a community or place—as part of one's culture and identity—can act both as a barrier to adaptation (e.g., by discouraging migration to a safer place) and as a resource (e.g., by helping staying populations to cope with increasingly difficult conditions). The conservation of a heritage site can be regarded as important in order to use it as a source of information or its potential can be seen in what its decay can teach about change and loss. Depending on which adaptation strategies are prioritized, both the preservation and the conscious abandonment or transformation of cultural heritage can be considered useful for climate adaptation. Clearly, climate adaptation is closely linked to the questions of what is worth preserving and which cultural and technological means should be prioritized. These questions must be negotiated within society, and so the interface between cultural heritage and climate adaptation points not only to the cultural but also to the political dimension of climate adaptation.

Author Contributions

Teresa Erbach: conceptualization (lead), funding acquisition (lead), investigation (lead), methodology (lead), project administration (lead), writing – original draft (lead).

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Conflicts of Interest

The author declares no conflicts of interest.

Data Availability Statement

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

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