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The adaptation of cultural heritage in built environments

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Cultural heritage refers to the historical, scientific and artistic value of artefacts and traditional culture that have been preserved in the process of human social development. It includes tangible cultural heritage, intangible cultural heritage and natural cultural heritage,[1] representing the collective memory of residents and serving as an irreplaceable cultural resource. The built environment generally refers to the man-made or modified physical spaces where people live and engage in activities.[2] Cultural heritage in the built environment is the result of human adaptation to specific built environments over a long period of time. Therefore, cultural heritage in the built environment mainly encompasses cultural heritage related to architecture, infrastructure and open spaces. With the rapid development of cities and the collision of diverse popular cultures, the survival space and condition of cultural heritage in the built environment face severe challenges. In order to sustainably protect the cultural heritage, we need to continuously study its adaptation and give full consideration to the challenges involved.

The concept of adaptation has different interpretations in different disciplines. It can be traced back to Darwin's theory of evolution, where adaptation refers to the survival potential bestowed upon organisms by their genetic material, representing the phenomenon of organisms being suitable for their environment. In the field of sociology, adaptation is seen as the ultimate result of individuals experiencing acculturation,[3] which can be manifested in four ways: integration, separation, assimilation and marginalization.[4] Initially, the definition of cultural heritage adaptation was to modify heritage to accommodate new functions without compromising its cultural significance.[5] This was referred to as enriching the vibrancy of heritage areas.[6] However, with further research, cultural heritage adaptation can be understood as the process and ability of cultural heritage continuously adapting to its environment. In response to the pressure and destruction of cultural heritage spaces caused by rapid urban development, cultural heritage needs to enhance the stability of physical spaces. Therefore, heritage conservation and management have become crucial,[7] leading to discussions on conflicts between heritage interests and compact city planning.[8] Furthermore, in order to adapt to the impact of modern civilization and the diverse changes in people's aesthetic demands, in addition to the protection of physical spaces, it is also necessary to introduce unique and advanced methods such as living heritage conservation[9] and heritage digital twins[10] to enhance the interaction with visitors.

However, different cultural heritages have varying abilities to adapt to environmental changes in built environments. Current research mainly focuses on the role of heritage in the environment, and for the purpose of evaluating the impact of cultural heritage in the economic, social, cultural and environmental domains, the *Cultural Heritage Counts for Europe: full report* proposes a holistic four domain approach.[11] However, little consideration has been given to the reactive effects of the environment on heritage and the adaptation of heritage to these effects, which is manifested in changes in heritage vitality.[12] Different cultural heritages have different levels of vitality, depending on their intrinsic attributes and visitor experiences. For example, the vitality of mining heritage lies in its natural beauty, museums, historical value and architectural features;[13] the vitality of geological heritage lies in visual attractiveness, access, uniqueness/rarity, tour/visit safety and information availability.[14] The differences in vitality amongst different cultural heritages also lead to different levels of competitiveness. The measurement of competitiveness involves both economic and non-economic factors. For heritage museums, in addition to economic factors such as visitor numbers and visitor satisfaction, non-economic

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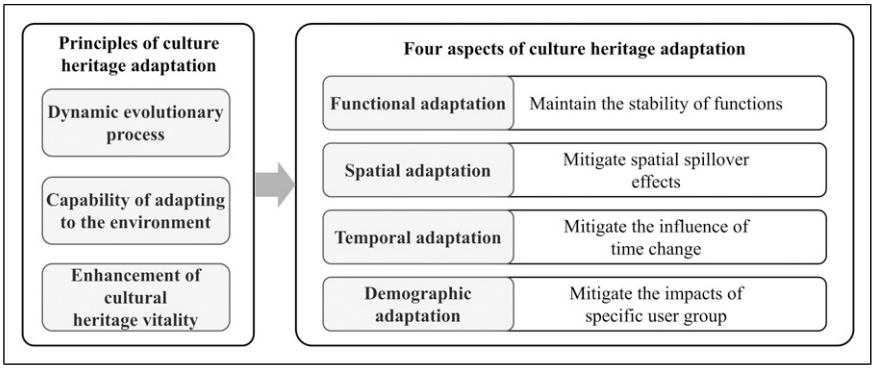

Figure 1. The principles and four aspects of cultural heritage adaptation in built environments.

factors such as cultural communication and improvement of residents' quality of life need to be considered.[15] In general, maintaining the authenticity of heritage and creating the development of cultural heritage knowledge can enhance the vitality of cultural heritage, which is crucial for improving the adaptation of cultural heritage.[16]

From current research, we can characterize the principles of cultural heritage adaptation in built environments (Figure 1): (1) Adaptation is a dynamic evolutionary process; (2) Adaptation, as a capability, corresponds to the attractiveness, competitiveness and potential for sustainable development of cultural heritage; and (3) Adaptation corresponds to the enhancement of cultural heritage vitality. Currently, research on the adaptation of cultural heritage in built environments can be categorized into four aspects: functional adaptation to maintain stability, spatial adaptation to mitigate spatial spillover effects, temporal adaptation to mitigate the impacts of time changes and demographic adaptation to mitigate the impacts of specific user groups. By studying the adaptation of cultural heritage in different aspects, its performance and potential in the face of built environment changes can be better understood and evaluated.

Functional adaptation of cultural heritage in built environments

The functional adaptation of cultural heritage in built environments refers to the ability of heritage to maintain stable functional use in the face of environmental changes, including transportation, housing, commerce and leisure. In terms of functional adaptation, cultural heritage can be classified into three types: stable cultural heritage, variable cultural heritage and comprehensive cultural heritage. Stable cultural heritage refers to the main functional use that has not changed since its construction or has regained its original function after undergoing a functional transformation, such as churches. This type of cultural heritage has strong functional adaptation and is less affected by the environment. Variable cultural heritage refers to the complete transformation of the initial function into other functions, indicating lower functional adaptation, such as burial cultural heritage. Comprehensive cultural heritage sites, including celebrity residences and temple-like buildings, often require the addition of new functional uses to meet the changing needs of users and the times. By integrating new functions while preserving their historical significance, these heritage sites can continue to play a vital role in our cultural landscape and provide valuable experiences for generations to come.

The conservation and utilization strategies of cultural heritage in built environments have a significant impact on their functional adaptation. Adaptive reuse is a common cultural heritage management strategy aimed at preserving the values of heritage buildings and making them suitable for future functional needs.[17] For heritage buildings undergoing adaptive reuse, it is usually necessary to enhance their performance to adapt to new functions. Studies have found that natural-based solutions are beneficial for heritage conservation, such as reducing the damage to heritage buildings caused by water-related risks.[18] Upgrading roof and drainage systems can also adapt to climate change.[19] In terms of user comfort, floor-type fan coil air conditioning systems can improve indoor thermal comfort in cultural heritage buildings.[20] Intelligent control strategies and equipment can effectively improve the comfort of courtyards during winter.[21] The application of adaptive building facades can improve the health of occupants,[22] and microclimate analysis methods can optimize the living conditions of historical buildings and also protect displayed artworks.[23] In addition, material selection, structural joints and technological applications are considered key factors for the success of heritage building restoration.[24]

The transformation of cultural heritage often presents a significant challenge as they strive to maintain their authenticity while adapting to new functions. It is essential to navigate this process effectively, ensuring that functional changes align with the preservation of heritage. In addition to optimizing physical spaces, other crucial factors such as

financial investment, operational management and personnel organization also play a vital role in successful adaptation. Further research is needed to explore these factors and identify appropriate solutions for the future.

Spatial adaptation of cultural heritage in built environments

Spatial adaptation or environmental adaptation of cultural heritage in built environments pertains to ensuring that the functionality and vitality of cultural heritage remain unaffected by the surrounding physical space attributes. These attributes encompass various elements such as the form of the blocks, land use patterns and proximity to commercial centres, amongst others. The goal is to ensure that the cultural heritage can thrive and fulfil its intended purpose irrespective of its spatial context.

The structure of the street where cultural heritage is located has a significant impact on its vitality. Current research mainly focuses on using spatial syntax to calculate 'integration' and 'choice' values of grid conditions.[25] There are also studies that correlate the analysis results with street vitality, the process of tourism development[26] and the impact of urban morphological elements on heritage vitality.[27] Compared to urban blocks, the blocks where cultural heritage is located are narrower and subject to stricter planning controls. Therefore, further consideration is needed to enhance the practical applicability of promoting the vitality of cultural heritage through morphological strategies.[28] However, the vitality of cultural heritage can be preliminarily evaluated by studying the morphology of street and alley spaces.

In the era of rapid development of the tertiary industry, the commercial environment also has a significant impact on the vitality of cultural heritage. Existing research often utilizes point of interest (POI) data,[29] Flickr datasets and Weibo check-in data to analyze the commercial environment where cultural heritage is located. The addition of supporting facilities such as commercial heritage, attractions, recreational heritage, eating points, public toilets and tram-metro stations can significantly increase the attractiveness of heritage.[30] However, current research on commercial spaces primarily focuses on statistical and clustering analysis of POI information, lacking studies on the correlation between the richness of commercial types and the vitality of cultural heritage, as well as the exploration of the negative or positive impact of commercial centres on the vitality of cultural heritage.

Temporal adaptation of cultural heritage in built environments

The temporal adaptation of cultural heritage in the built environment refers to its ability to maintain vitality regardless of the passage of time. Over the course of history, cultural heritage has been impacted by various factors, and its vitality has manifested in diverse ways. Some cultural heritages were disregarded, while others attracted a significant number of visitors. Some maintained a consistent level of vitality, while others underwent a process of decline and eventual disappearance. However, cultural heritage with strong temporal adaptation can maintain high levels of vitality in different eras, demonstrating greater adaptation.

Throughout history, the development of transportation infrastructure has provided a crucial role in shaping the conservation and adaptation of cultural heritage. This long-term human intervention has been one of the primary factors influencing cultural evolution. In urban settings, the transformation of commercial centres and modifications in transportation networks frequently occur simultaneously. Regions with highly interconnected transportation systems often boast a thriving cultural heritage.[31] Conversely, in rural areas, ancient trading towns tend to be situated along transportation arteries or hubs. However, with advancements in transportation modes, many of these historic towns, which once relied on river transportation or horse carriages, have experienced a decline in economic vitality and a significant decrease in population.

In addition, industrial development is also one of the reasons that dynamically affects the adaptation of cultural heritage. For example, there are differences in the spatiotemporal coupling and evolution processes of different traditional villages in terms of their adaptation to tourism development.[32] The adaptation of cities along the Beijing–Hangzhou Grand Canal to changes in river transportation functions also exhibits spatiotemporal differences, which further demonstrate differences in the overall carrying capacity of cities.[33] Currently, research on the temporal adaptation of cultural heritage mainly focuses on the discussion of single influencing factors in a static time frame. Future research should consider the dynamic interaction of various factors in the temporal dimension to understand their impact on the evolution of cultural heritage vitality.

Demographic adaptation of cultural heritage in built environments

Demographic adaptation of cultural heritage in built environments refers to its attractiveness to various target groups. Cultural heritage with a high adaptation level can attract a wider and larger number of people, including residents, tourists and art creators. Generally, mainstream heritage sites are easily discovered and attractive to tourists, while some lesser-known hidden locations are more easily discovered by locals.

Cultural heritage encompasses various types and different types of visitors exhibiting different interests towards it.[34] Based on the characteristics and level of involvement of visitors, they can be classified into different categories. Some scholars suggest categorizing visitors to cultural heritage sites as 'true cultural heritage tourists' and 'spurious cultural heritage tourists'. The former focuses on cultural heritage as the core, while the latter has other motivations.[35] Visitors can also be classified into conventional cultural tourists, spontaneous cultural tourists and absorptive cultural tourists based on their travel motivations.[36] Different motivations can impact visitor engagement, experience and satisfaction.[37]

The evaluation of satisfaction with cultural heritage can serve as a measurement indicator for demographic adaptation. With the rapid iteration of communication devices, people's dependence on social networks deepens, and they enjoy sharing their life experiences on social platforms. This provides scholars with various avenues to study visitors' satisfaction with cultural heritage. Data sources include Two-Step Trajectory data, Six-Footprint Trajectory data, Dianping data and location check-in data. Some scholars conduct semantic analysis using travelogues to study the emotional perception of visitors to terraced agro-cultural heritage.[38] Other scholars use structural equation modelling to analyze satisfaction surveys of visitors to traditional villages, exploring the multiple chain mediation effects amongst visitor engagement, perceived value, place attachment and loyalty.[39]

Current research primarily focuses on the satisfaction of a specific group towards a single cultural heritage, lacking comparative studies between different categories of populations and comparative studies on demographic adaptation towards different cultural heritages. Future research should be based on big data, expand the sample size and extend from case studies to cultural heritage population studies in order to comprehensively understand the satisfaction of different categories of populations and the demographic adaptation towards different cultural heritages. This will help provide more targeted recommendations and strategies to enhance the effectiveness of cultural heritage conservation and visitor experiences.

In general, the built environment cultural heritage faces challenges from urban development and diverse popular culture. In order to protect and sustainably develop cultural heritage, it is necessary to study its adaptation. Existing research suggests that the adaptation of built environment cultural heritage is a dynamic process that reflects a capability and corresponds to the enhancement of cultural heritage vitality. Furthermore, this adaptation can be observed in terms of functional, spatial, temporal and demographic aspects. However, there is still a lack of research on the relationship between these four aspects of adaptation and their contributions to cultural heritage adaptation. Future research should focus on (1) further enriching the connotation of cultural heritage adaptation based on existing knowledge and clarifying its definition; (2) further refining the framework of cultural heritage adaptation and clarifying the connections between functional adaptation, spatial adaptability, temporal adaptation and demographic adaptation; and (3) aiming to guide the enhancement of cultural heritage vitality, exploring more data sources and analysis methods to comprehensively understand the formation mechanism of cultural heritage vitality. By studying cultural heritage adaptation, we can better understand and evaluate its performance and potential in the face of environmental changes, and thus formulate targeted strategies for conservation and sustainable development, fully utilize cultural resources, enhance the contemporary value of cultural heritage, and promote creative transformation and innovative development of civilization.

Authors' contributions

Fang Wang was responsible for the entire research process. Jing He wrote the paper with Fang Wang. Pengcheng Xue participated in the overall design and contributed to the revision and review of the manuscript. Xie Hu offered research ideas and revision of the manuscript.

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