Research on Building Conservation Assessment Based on Comprehensive Evaluation Models

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Abstract: This paper is based on the Building Protection Evaluation model to address the natural hazard risks faced by cultural heritage buildings. Firstly, the background and purpose of the BPE model are introduced, i.e. to develop an integrated conservation strategy for buildings by comprehensively assessing their historical value, cultural value, economic value and community value. The main issues facing buildings are then presented, including how natural hazards affect building safety and its value, and how conservation measures can be optimised to maximise cost-effectiveness. The modelling process used the Delphi method to determine the weights and the FCE scoring algorithm for comprehensive scoring to develop individual conservation plans for different buildings. Finally, a case study of Piazza San Marco in Venice demonstrates the effectiveness of the BPE model in practical application, highlighting its importance and usefulness in the protection of cultural heritage.

1. Introduction

In today's context of globalisation and rapid urbanisation, cultural and historical buildings are facing unprecedented challenges and threats. These buildings are not only an important part of the urban landscape, but also carry the historical memory and cultural identity of nations and communities. However, they also face increasing risks due to natural disasters, climate change and human factors, which pose urgent needs and challenges for their conservation and maintenance. In the field of architectural conservation, how to scientifically and comprehensively assess the historical, cultural, economic and community values of buildings, and to develop effective conservation strategies on this basis has become a major issue nowadays. Previous research literature has shown that traditional conservation approaches are often too one-sided, failing to adequately consider multidimensional values and their interrelationships, leading to unequal distribution of resources and poor results when conservation resources are limited [1-2].

Some scholars have pointed out that traditional conservation methods often neglect community participation and assessment of economic benefits, which makes conservation measures lack social support and economic feasibility in the implementation process [3]. Other scholars further emphasized the importance of comprehensive assessment methods, proposing that historical, cultural and economic values should be combined to develop a more comprehensive conservation strategy [4]. In addition, studies have shown that the use of conservation resources can be significantly improved through risk assessment and cost-benefit analysis to ensure fairness and effectiveness in resource allocation [5].

Traditional conservation methods are often too one-sided, failing to fully consider the multidimensional values and their interrelationships, resulting in uneven distribution of resources and poor results when conservation resources are limited. The aim of this paper is to propose a comprehensive evaluation model, Building Protection Evaluation Model (BPE), to systematically assess the value of cultural and historical buildings by combining various methods, such as historical data analysis, risk assessment and cost-benefit analysis, and to propose a scientific conservation strategy accordingly. Specifically, this paper will explore how to provide comprehensive data support

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and decision-making basis for preservation decisions through the assessment of the historical, cultural, economic and community values of buildings, combined with risk assessment techniques. Through the research in this paper, we aim to provide new ideas and methods for the conservation and sustainable use of cultural and historic buildings to meet the increasingly complex and diverse challenges, and to ensure the long-term and effective conservation of these valuable cultural heritages, as well as their continued contribution to society and the economy.

2. Building protection evaluation model

2.1. Formulation of the Architectural Value Assessment Model

We have developed an architectural valuation system that encompasses four principal criteria: historical value, cultural value, economic value, and community value. Historical value is assessed through indicators such as the age of the building, significant historical events, and associations with notable historical figures. Cultural value is evaluated based on architectural style, artistic merit, and cultural symbolism. Economic value is measured by the building's contribution to tourism, job creation, and commercial viability. Community value considers the extent of community engagement, educational impact, and the role in fostering a sense of community identity.

2.2. Calculate weights through Delphi

BPE flow-process diagram is shown in Figure 1.

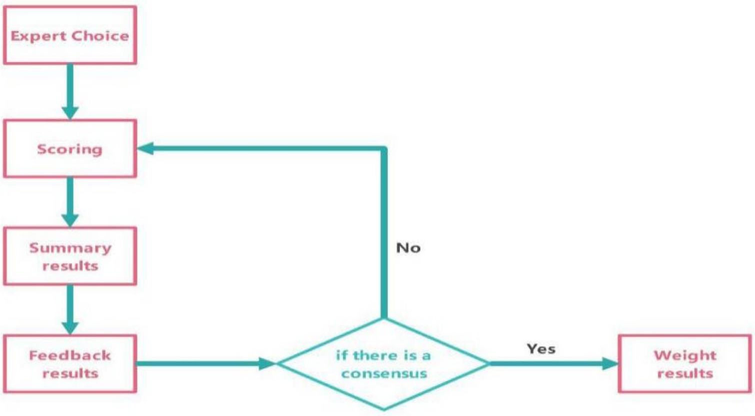

Figure 1 BPE flow-process diagram

Table 1 Proportions of Weights

Major Criteria	Weight	Sub-criteria	Weight
Historical Value	0.28	Age of Building	0.098
		Historical Events	0.112
		Association with Historical Figures	0.07
Cultural Value	0.23	Architectural Style	0.092
		Artistic Value	0.0575
		Cultural Symbolism	0.0805
Economic Value	0.31	Tourist Attraction	0.186
		Employment Opportunities	0.0775
		Commercial Activities	0.0465
Community Value	0.18	Community Participation	0.0828
		Educational Value	0.0432
		Community Identity	0.054

Proportions of Weights are shown in table 1.

2.3. FCE Score Ranking

Table 2 Systematic weighted valuation methodology to calculate a composite building score

Input: Sub-criteria and their weights under each major criterion
Output: The final comprehensive evaluation score of the building
1. Initialize an overall score variable to 0.
2. For each Sub-criteria
   Weight-Score= Weight×Score
   Overall-Score += Weight-Score
3. Repeat the above steps for all Sub-criteria
4. The loop through each major criterion ensures that the contributions of all criteria are accounted for in the final score, following a systematic and weighted evaluation approach.

The FCE methodology facilitated the determination of individual scores for each secondary indicator[4-5], culminating in a final aggregate score. Subsequently, rankings were derived from these scores, with the results detailed in table 2.

2.4. Risk Assessment

Based on the likelihood of natural disasters and the extent of potential harm, we conduct a risk evaluation of the buildings within the community to establish protective measures' prioritization. Historical data pertaining to the incidence and associated losses from natural disasters in the community have been meticulously gathered for this evaluation. As exemplified by the frequency and damage caused by tornadoes in U.S. states, which are illustrated in Figure 2 and Figure 3, we derive our findings.

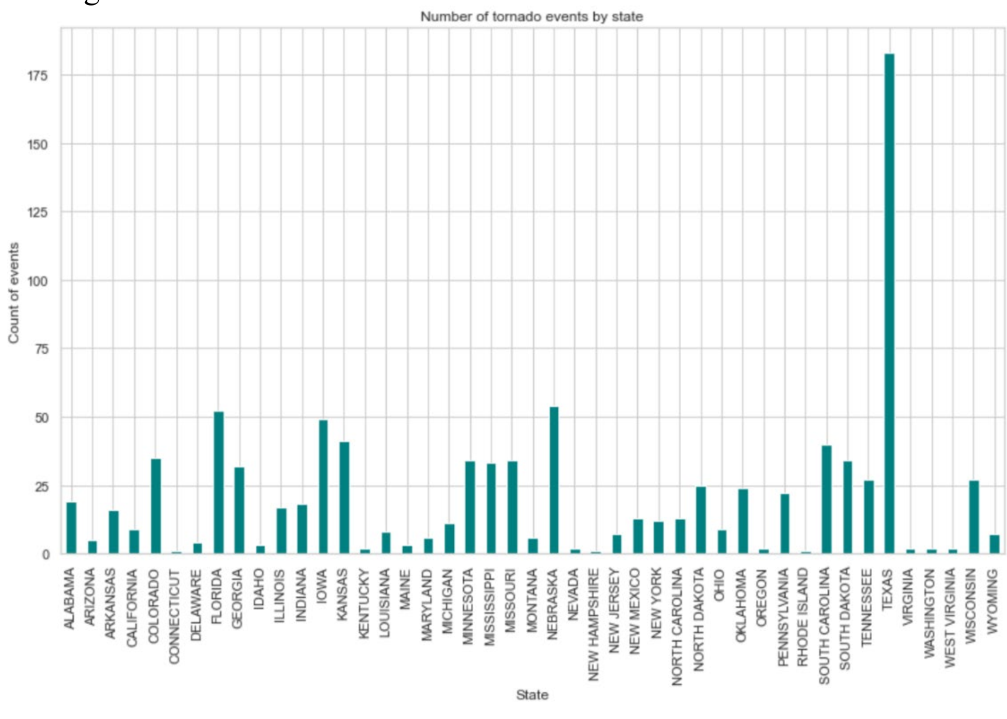

Figure 2 Number of tornadoes per week in the United States

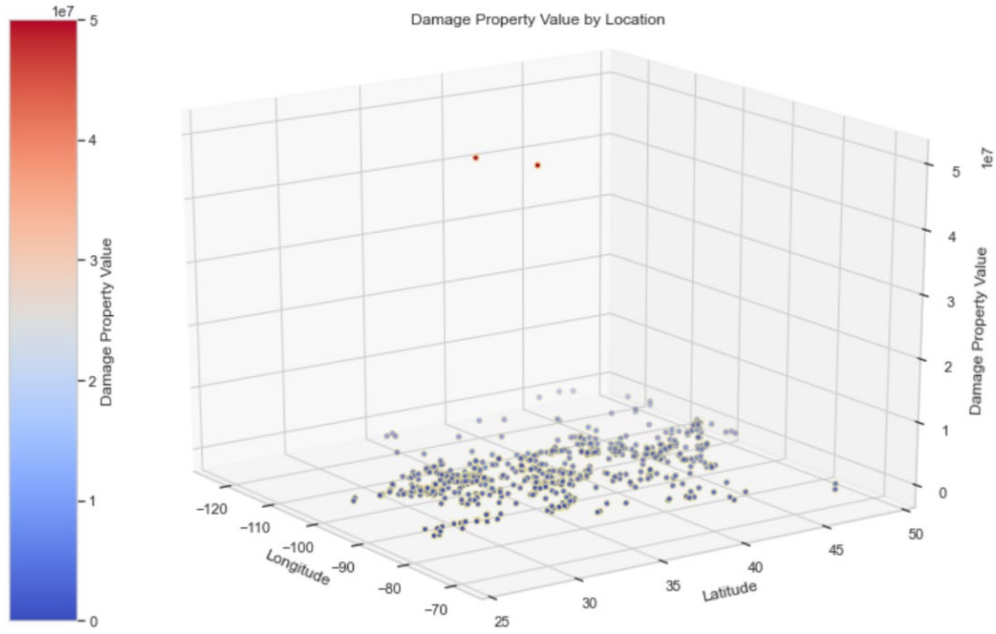

Figure 3 Damage property value by location

Subsequently, we categorized the tornado intensity into five discrete levels: F0, F1, F2, F3, and F4, wherein F0 denotes the least severe and F4 the most severe. Ranking was determined by the frequency of occurrence of F4 tornadoes, thus elucidating the states with the poorest records as illustrated in Figure 4. Consequently, it becomes imperative to focus vigilance and allocate protective resources preferentially to these jurisdictions [6-7].

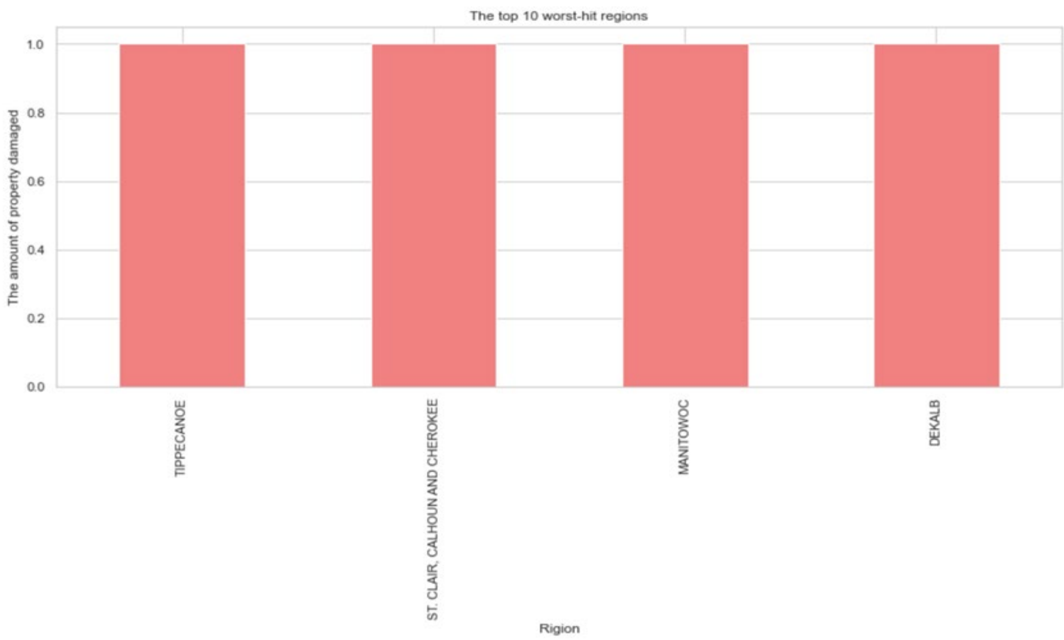

Figure 4 Calculation of protection costs for each indicator

2.5. Cost-benefit analysis

When assessing the costs associated with protection, our analysis prioritized the examination of maintenance and repair expenditures, long-term conservation expenses, and the financial implications of relocation [8-9].

Cost-benefit analysis assesses the economic worth of a project by measuring and contrasting its aggregate costs with its aggregate benefits. Consequently, this analytical approach facilitates the determination of optimal preservation strategies for cultural architecture.

Below is the cost-benefit ratio calculation formula.

$$\frac{C}{B}=\frac{C_T}{B_T}=\frac{\sum C}{\sum B} \tag{1}$$

C: cost

B: benefit

Under typical conditions, options for which the ratio C/B is below 1 tend to be more cost-effective and should be given priority. Should all ratios be below 1, the option with the lowest ratio is to be selected.

2.5.1. On-site conservation(Cost-Benefit Comparison)

$$\frac{\boldsymbol{C'}}{\boldsymbol{B'}}=\frac{\boldsymbol{C_1}+\boldsymbol{C_2}\times\boldsymbol{m}+\boldsymbol{C_3}}{\boldsymbol{B_1}\times\boldsymbol{m}} \tag{2}$$

C_1: Repair Cost(dollars)

C_2: Maintenance Cost(dollars/year)

C_3: Loss of tourism revenue attributed to construction activities(dollars)

B_1: Increased tourism revenue(dollars/year)

m: Evaluation Period(year)

2.5.2. Ex-Situ Conservation (Cost-Benefit Comparison)

$$\frac{\boldsymbol{C''}}{\boldsymbol{B''}}=\frac{\boldsymbol{C_4}+\boldsymbol{C_5}+\boldsymbol{C_6}\times\boldsymbol{m}}{\boldsymbol{B_2}\times\boldsymbol{m}} \tag{3}$$

C_4: Migration Cost(dollars)

C_5: Reconstruction Cost(dollars)

C_6: New maintenance costs(dollars/year)

B_2: New tourism revenue(dollars/year)

m: Evaluation Period (year)

By comparing the ratios $\frac{C'}{B'}$and $\frac{C''}{B''}$, one can derive a decision regarding the appropriateness of relocation based on the given data.

2.6. Develop a protection plan

Taking into account the equilibrium of diverse interests, we perform an all-encompassing assessment that includes the perspectives of local inhabitants, advocates for historical and cultural conservation, and proponents of economic growth. By evaluating the cost-effectiveness of two primary strategies—conservation on-site and conservation through relocation—we derive the ultimate conservation strategy.

The subsequent content presents an analytical comparison of these two methodologies:

2.6.1. Evaluation of on-site conservation

This method is characterized by either reinforcing the structure of the building or managing its surrounding natural environment, primarily suitable for buildings with significant historical value or those that are immovable[10].

It maximizes the restoration of the building's integrity. For cultural heritage buildings with considerable size, high aesthetic value, and strong appeal, they can be strategically developed into tourist attractions, thereby commercializing cultural resources and generating revenue. However, the costs can be substantial. Many immovable buildings are challenging to develop due to their low commercial value and fail to achieve a critical mass necessary for creating a clustering effect, leading to a cycle of "repair-vacancy-decline-repair".

2.6.2. Evaluation of relocation protection

Relocate those immovable and highly valuable vernacular architectural heritages, using methods such as disassembly and reassembly, and rebuild them exactly as they were, at a different location.

The scientific relocation facilitates a more effective preservation of historical culture. However,This process may detach cultural buildings from their original cultural context and regional customs, potentially compromising the "authenticity" and historical "integrity" of the architectural heritage.

3. Model application cases: St. Mark's Square

3.1. Background

The St. Mark's Square in Venice is renowned worldwide for its unique cultural and historical value, yet it also faces serious threats due to the rising water levels and frequent floods in Venice. In recent years, extreme weather events have exacerbated this issue.

3.2. St. Mark's Square Risk Assessment

We have conducted a search for the extreme weather disasters in Venice from 1905 to 2023, tallying the number of occurrences affected by extreme weather and the total amount of loss each time. Based on our ICUD Model, we have predicted the expected losses for the next seven years, which are presented in Table 3, and visualized as Figure 5.

Table 3 Expected annual losses in Venice.

Year	Expected loss
2024	280833300
2025	942016700
2026	1364286000
2027	1633971000
2028	1806207000
2029	1916206000
2030	1986458000

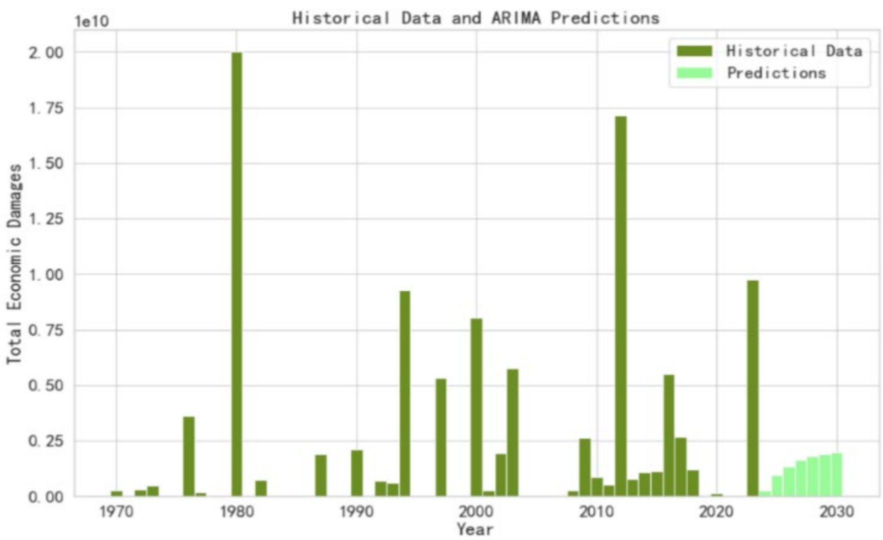

Figure 5 Calculation of protection costs for each indicator

The calculated present value of the anticipated total losses over the ensuing seven years amounts to (unit: million dollars).

$$\boldsymbol{TL = 7902} \tag{4}$$

Based on the projected total losses over the ensuing seven years, we aim to equip community managers with preemptive strategies against economic downturns. Furthermore, these forecasts can be utilized to solicit support from governments and international agencies, thereby providing a clearer demonstration of the return on investment ratios to investors. This approach will facilitate enhanced protection measures for St. Mark's Square, ensuring its long-term preservation.

3.3. Valuation of St. Mark's Square

We utilize PCE for scoring

Historical Value: High, reflecting its ancient heritage and recognition as a World Heritage Site.

Cultural Value: Extremely High, as it epitomizes the splendor of the Italian Renaissance.

Economic Value: High, due to its magnetism for global tourism and substantial contribution to the local economy.

Community Value: Moderate, cherished by the residents of Venice yet vulnerable to the perils of climate change.

For each dimension, we assigned a score on a scale of 1 to 5, with 5 representing the highest merit. The scores were as follows: Historical Value: 4, Cultural Value: 5, Economic Value: 4, and Community Value: 3. Averaging these scores yielded an overall rating of 4.05 for St. Mark's Square, indicating a commendable aggregate value, particularly notable for its exceptional cultural significance. Consequently, our findings underscore the critical need for its preservation, with an emphasis on in-situ conservation due to its unmatched cultural importance.

A cost-benefit analysis was also conducted to weigh the potential investments against the long-term benefits of such preservation efforts.

in situ conservation

The cost of establishing a flood protection system and the improvement of underwater infrastructure is estimated at 3235 (million dollars). We compare the estimated costs with the amount of losses caused by extreme weather over the next seven years.

Given that the cost of upgrading flood defenses is far lower than the total losses likely to occur over the next seven years, investing in upgraded flood defenses is an economically rational choice.

relocation

Given the impracticability of removal and the close connection between St Mark's Square and its surroundings, this option was considered inapplicable.

4. Conclusions

This study systematically analyses the multidimensional values of cultural and historical buildings and explores effective conservation strategies through the introduction and application of the Building Preservation Evaluation (BPE) model. In the process, we focused on the following aspects:Firstly, by establishing an assessment system including historical value, cultural value, economic value and community value, we effectively quantified the contribution of each indicator to the value of the building, which provided a scientific basis for conservation decisions.Secondly, through risk assessment, we evaluated the potential threats to the building from natural disasters and human factors, and formulated targeted conservation priorities and emergency response strategies to minimise possible losses.Finally, through cost-benefit analysis, we assessed the economic feasibility of different conservation options and made recommendations for optimal resource allocation to ensure maximum conservation benefits with limited resources.

In summary, this study not only highlights the importance of multidimensional value assessment in the conservation of cultural and historic buildings, but also demonstrates how integrated assessment models can be used to optimise conservation decisions to meet increasingly complex and diverse challenges. Future research can further explore new data collection methods and assessment techniques to enhance the accuracy and applicability of the models for better conservation and transmission of our valuable cultural heritage.

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