Received 29 November 2024
Revised 25 February 2025
2 April 2025
15 May 2025
Accepted 16 May 2025

Cost-benefit approach for seismic retrofit of cultural heritage: basis for Old Cairo Religions Complex conservation

Raul Berto, Chiara Bedon and Stefano Bozza
Department of Engineering and Architecture, University of Trieste, Trieste, Italy
Hesham E. Abdel Hafiez
National Research Institute of Astronomy and Geophysics - NRIAG, Cairo, Egypt
Marco Fasan
Department of Engineering and Architecture, University of Trieste, Trieste, Italy, and
Hany M. Hassan
National Research Institute of Astronomy and Geophysics - NRIAG, Cairo, Egypt and National Institute of Oceanography and Applied Geophysics - OGS, Sgonico, Italy

Abstract

Purpose – This paper focuses on the relevance of cost-benefit considerations in case of seismic retrofitting of cultural heritage. Particular attention is paid to historic monuments in Egypt, and on the Religions Complex in Old Cairo. This multidisciplinary study explores methods that have been used in the past, to draw up a preliminary concept of proactive conservation that seeks to combine structural, economic and cultural dimensions of the conservation of assets.

Design/methodology/approach – The literature analysis aims at understanding economic evaluation procedures and detailed circumstances for the seismic retrofit of historic buildings. The selected case studies look at religious monumental buildings which are notoriously complex and challenging to deal with because of their high architectural and cultural values, structural vulnerability, need for conservation strategies.

Findings – The examined case studies reveal a need for different intervention strategies for structures like churches, mosques and minarets. They also show how material properties, existing damage and architectural forms may dictate a required methodology. From an economic point of view, the study highlights the importance of combining approaches such as the travel cost method and the contingent valuation (CV), to include both use and non-use values of cultural heritage.

Originality/value – This investigation merges structural engineering with economics to deal with the intricate problems of conservation of cultural heritage. Such an approach is commonly required for monumental buildings management in areas with heritage sites that are particularly vulnerable to seismic activities. The presented methodology, most importantly, can be extended to other sites.

Keywords Cultural heritage, Monumental buildings, Seismic retrofit, Economic valuation, Multi-target analysis

Paper type Research paper

"CoReng" ("Conservation of the Religions Complex in Old Cairo through the integration of geosciences and earthquake engineering"), a Particular Relevance Italy–Egypt bilateral project (2024–26), is partly financially supported by the Italian Ministry of Foreign Affairs and International Cooperation (Grant number: EG24GR01) and by the Egyptian Science, Technology and Innovation Funding (STDF) Authority (Grant number: 47530).

Journal of Cultural Heritage Management and Sustainable Development
Vol. 16 No. 7, 2026
pp. 312-339
Emerald Publishing Limited
e-ISSN: 2044-1274
p-ISSN: 2044-1266
DOI 10.1108/JCHMSD-11-2024-0282

Introduction

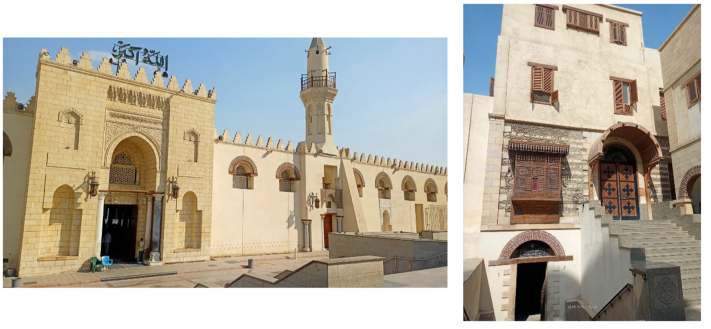
Decisions concerning interventions for the conservation of architectural heritage can be controversial (Wright and Eppink, 2016). A values-based approach to cultural heritage management, also referred to as "values-centred theory" (Mason, 2008), is rooted in the basic economic principle of opportunity cost, which becomes a binding factor in decisions related to the allocation of resources to cultural heritage (Peacock, 1995). This view is consolidated in the literature, where it is generally acknowledged that cultural heritage holds economic value for society and consequently should be properly incorporated into processes of conservation and urban transformation (Nijkamp, 2012).

This paper aims to compile a sample of relevant studies which present methods that can be used to estimate the economic value of building assemblies (or individual buildings) of recognised historic and cultural significance. The goal is to synthesise possible key findings that could be integrated in research efforts to estimate the economic value of the Religions Complex in Old Cairo, as well as other relevant sites. The study does not, therefore, aim to carry out a systematic literature review on the topic, but rather to identify and compare the most relevant existing approaches for the economic evaluation of cultural sites.

This research is carried out within the framework of the current "CoReng" Italy–Egypt bilateral project (2024–2026) entitled "Conservation of the Religions Complex in Old Cairo through the integration of geosciences and earthquake engineering". Accordingly, the aim is to outline the analytical methods available for the economic valuation of monumental buildings, given that they assume great importance in the decision-making processes related to preservation strategies. Particular attention is paid to construction and architectural solutions that are typical of countries in the Middle East, especially Egypt, like minarets, mosques, etc., and that are characterised by specific architectural style. This review forms an integral part of the CoReng working plan, whose major goal is the implementation of a general integrated methodology in which structural engineers, seismologists, geophysics and architects can work together efficiently towards the seismic vulnerability assessment and preservation of the Religions Complex in Old Cairo (Plate 1).

To this end, this paper briefly recalls relevant studies in which specific retrofit tasks are addressed for monumental (religious) buildings with severe seismic vulnerability. While there is diversity in the building systems and monuments discussed, these studies lack a broader, multidisciplinary view of the topic.

In addition to purely structural considerations, this paper also analyses economic valuation methods, an intriguing but highly demanding area of cultural heritage conservation. The results are discussed highlighting the main features, as well as advantages and disadvantages of economic valuation methods. The research tasks are presented in Figure 1.



Amr Ibn Al-As Mosque (a)

Mari Girgis Church (b)

Plate 1. Examples of some monumental buildings in the Religions Complex in Old Cairo, Egypt. Source: Authors' own work

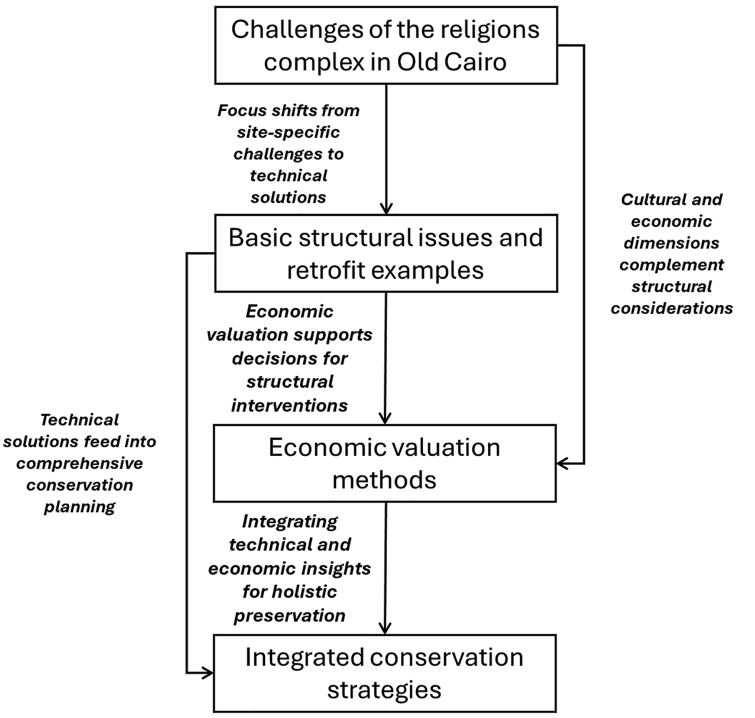


Figure 1. Tasks of present study. Source: Authors' own work

The Religions Complex in Old Cairo

Old Cairo, or Fustat, was the original site of the Arab Muslim conquest of Egypt. Over the centuries, it became a thriving centre for various cultures and religions. The Religious Complex emerged as a testament to the tolerance and diversity that characterised the region (Figure 2). The construction of its constituent buildings spanned several centuries, reflecting the changing political and social landscape of Egypt, as well as the evolution of architectural styles and construction skills.

The Mosque of Amr ibn al–As (Plate 1(a)) is one of the main components of the Complex and was the first mosque built in Egypt. It reflects early Islamic architecture and has undergone several expansions over the centuries. The Hanging Church, a Coptic Orthodox Church, is also renowned for its intricate architecture and rich history, making it a popular pilgrimage site for Christians worldwide (Plate 2). The Ben Ezra Synagogue is one of the oldest synagogues in Egypt and has served Cairo's Jewish community for centuries, undergoing numerous renovations. The Complex also includes smaller churches, chapels, and Islamic schools, further highlighting the area's religious diversity.

The Complex is a unique historic and religious site located in the heart of Cairo, sacred site for Christians, Muslims, Jews. The Complex, as well as Old Cairo as a whole, attracts tourists from around the world who are interested in history, religion, and culture (Plate 3).

Not only is the Complex extremely rich in historic significance with a key role in promoting dialogue between different communities and cultures, but it also represents a rather intriguing structural engineering issue, namely, the protection and preservation of its constituent buildings. The Complex faces both natural and human-made hazards, such as earthquakes and deterioration. Cairo's rapid urbanisation has put pressure on the Complex, leading to issues like pollution and encroachment (Hassan *et al*., 2025). The influx of tourists can sometimes

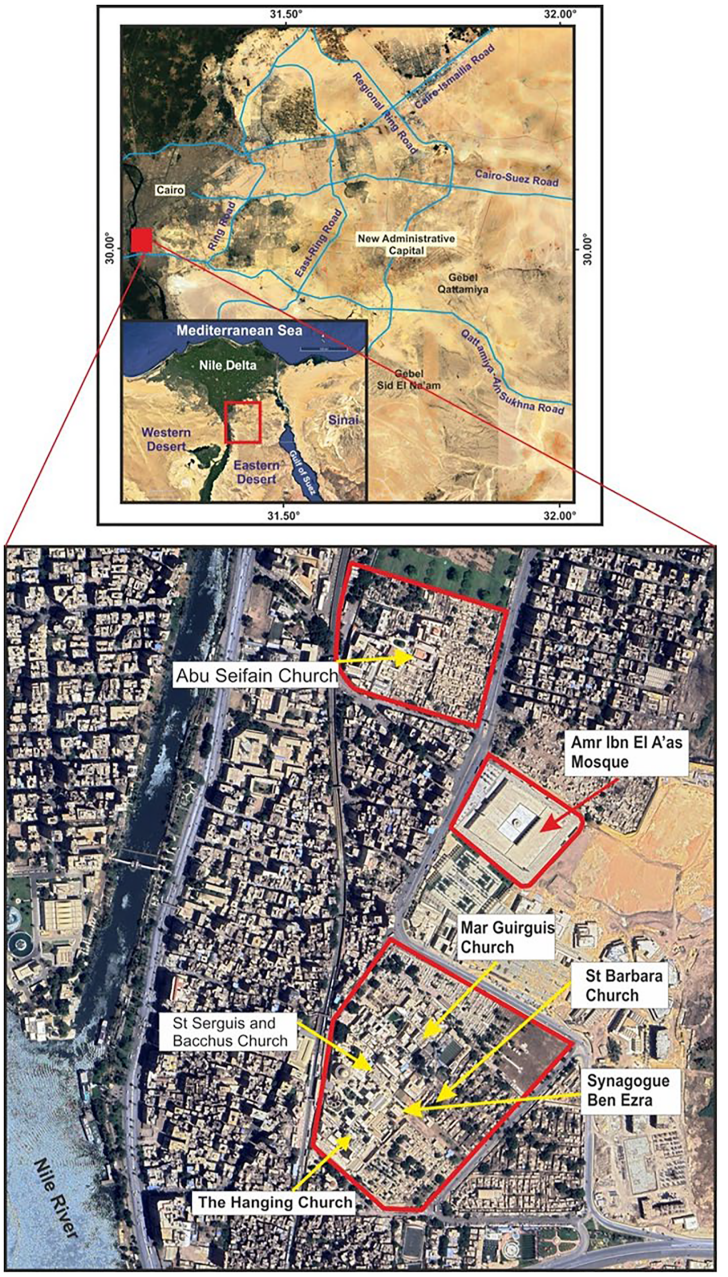


Figure 2. Plan view of the Religions Complex in Old Cairo, Egypt, with evidence of its monumental buildings. Source: Authors' own work

strain the infrastructure and cause damage to delicate buildings. Additionally, maintaining and preserving the Complex requires significant financial resources. For these reasons, government agencies, international organisations, are working to protect these historic sites and promote their significance.

(a)

(b)

Plate 2. Hanging church in the religions complex of Old Cairo, Egypt: (a) exterior and (b) interior views. Source: Authors' own work

The challenges faced by the Complex require indeed a multidisciplinary analysis of the problem and the elaboration of a multi-target solution to conserve its monuments. The state-of-art highlights the need for intervention strategies that respond to the architectural, cultural and structural specificities of a unique site. Among various ongoing efforts, this paper contributes to one of the open tasks of "CoReng" project.

Basic structural issues and examples for the seismic analysis and retrofit of historic/monumental religious buildings

The structural retrofit of cultural heritage and monumental buildings is notoriously more challenging than ordinary constructions due to a combination of multiple uncertainties and technical challenges.

There are very few examples of a general scientific approach for the multidisciplinary analysis and conservation of cultural heritage sites. Studies tend to efficiently focus on seismic vulnerability, hazard and risk assessments of monuments (Lagomarsino and Cattari, 2015), but limited space is often afforded to a discussion of non-structural aspects.

Plate 3. Religious, historical and cultural coexistence in Old Cairo, Egypt. Figures freely reproduced from Pixabay and Unsplash

Furthermore, conservation in the Middle East partly faces the additional challenge of emerging technologies with the lack of extensive literature research resources for their generalised implementation. This is not the case for European countries, for example, where a wide number of literature studies can be found on structural health monitoring aspects and retrofit interventions on a large set of churches, belltowers and many other historic religious buildings.

In any case, it should be noted that several studies have looked at the seismic structural assessment of cultural heritage sites worldwide. As such, a possible correlation could be found between different places and structural typologies, considering for example churches or mosques (Rossi *et al.*, 2015; Karaton and Aksoy, 2018), towers (Peña *et al.*, 2010; Torelli *et al.*, 2020; Romero-Sánchez *et al.*, 2023) and minarets (Gurbuz and Kocaman 2024, Abdel-Wahab *et al.*, 2024).

Masonry towers are commonly recognised as one of the most vulnerable historic structures. Earthquakes have clearly proven that churches (Lagomarsino, 2009) and mosques (Karaton and Aksoy, 2018) are also vulnerable to seismic activity. For this reason, the interest in their structural behaviour has progressively increased in the last decades (Torelli *et al.*, 2020).

It should be noted that architectural and structural typologies that are typical of religious constructions usually differ depending on the country and historical period they were built in, and equally vary in terms of which features have a primary role for structural health monitoring purposes, seismic vulnerability analyses, retrofit interventions. Moreover, in most cases, the geometry of historic religious buildings is quite complex, due to a lack of technical documents or access to specific places. As such, accurate *in situ* measurements (using laser scanners or photogrammetry techniques) are often needed to properly construct an accurate geometrical model and the corresponding structural model. Although some authors use the real geometry to construct detailed finite element (FE) models (e.g. Gürbüz and Kocaman, 2024),

simplifications of the geometrical features are commonly accepted in practice (Milani *et al*., 2012; Valente and Milani, 2018). A certain amount of approximation in results is also accepted, due to the relatively high complexity and intrinsic uncertainty of the task.

A number of studies focus on minarets in the Middle East. A literature analysis reveals various investigations based on numerical models. Abdel-Wahab *et al*. (2024) established a detailed 3D model for the minaret of Abou-Ghanam El-Beily Mosque, in Bela (Egypt). This study stands out for its use of terrestrial laser scanner analysis to investigate the minaret. The assessment of its seismic vulnerability condition is supported by numerical analysis.

The Abou-Ghanam El-Beily minaret reflects the majority of cases, in that its structural components suffer from major geometrical irregularities and/or defects, and even preliminary damage or deterioration. Naturally, all of these aspects influence structural numerical analyses. Abdel-Wahab *et al*. (2024) reported an out-of-plane deformation of the minaret (25.25 m tall) of about 17 cm at its top. A preliminary numerical study was carried out with a shell-based model (SAP2000), to emphasise the implications of the deformation for the minaret, in terms of expected seismic response. This numerical analysis, whilst promising, was limited to ideal boundaries and loads.

Examination of similar studies presents a range of other uncertainties, often resulting from the poor documentation of connections and joints, materials, possible past retrofit interventions (both partial and complete). Moreover, minarets vary widely in terms of features, and a large-scale investigation may be required to obtain more robust observations (Hassan *et al*., 2025).

A morphological and geometrical study was carried out by Beldjilali (2024), for a large set of historic minarets in Algeria (Figure 3). The study built on previous research that had compared 21 minarets. Beldjilali's investigation is well-structured and drew attention to

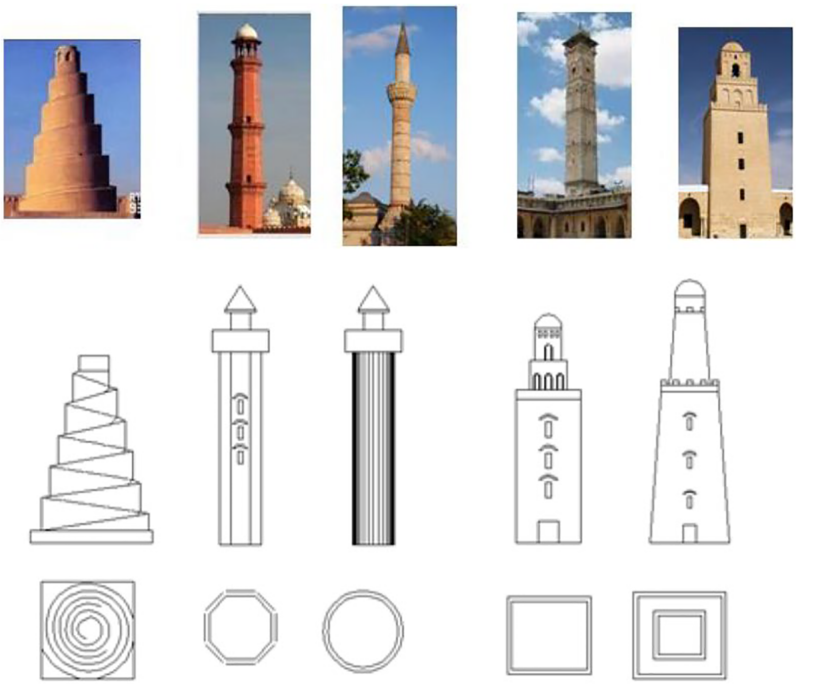


Figure 3. Some results of the morphological analysis of minarets in Algeria, according to Beldjilali (2024). Figure reproduced from Beldjilali (2024) under the terms and conditions of a CC-BY 4.0 license agreement

geometrical aspects, architectural characteristics, ornamental components as well as localisation and historic features of the selected systems. On the other hand, the study excluded any kind of comparative analysis in terms of materials or seismic capacity, etc. In any case, the document serves as the basis for a large-scale analysis that could be further extended to other applications.

The study by Gürbüz and Kocaman (2024) faces the vulnerability and retrofit of a single minaret, but with a careful consideration of seismic aspects. They detail a numerical investigation for the Erzurum Murat Pasha Mosque's minaret (Turkey), based on a 3D assembly described in ANSYS. The study includes modal, pushover and time-history simulations. Most importantly, attention is paid to the minaret in its present condition as well as to its seismic response after a possible retrofit (Figure 4).

It is thus clear that the assessment of historic buildings, and of cultural heritage sites in general, requires a robust methodology that can account for multiple aspects, performance indicators, and expertise from multiple scientific fields.

Romero-Sánchez *et al.* (2023) proposed a methodology for a single historic tower based on a strong multidisciplinary approach (Figure 5). The approach, whilst very detailed, focuses on pure structural performances, disregarding possible considerations about additional influencing or interconnected aspects.

Finally, there are no doubts that the complexity of any structural analysis progressively increases with the size of the building.

Karaton and Aksoy (2018) focused on the seismic assessment of an 891 year-old historic mosque, and described the structural model in ANSYS (Figure 6). Close attention was paid to the non-linear dynamic analysis of the mosque's response under various seismic events by observing the corresponding damage propagation. The mosque, heavily damaged due to an earthquake and resulting fire in 1,114, was rebuilt between 1,117 and 1,125 but remains extremely vulnerable to seismic events. The model was calibrated in material properties using non-destructive field tests. The study highlights the need for further extended investigations for the mosque's preservation.

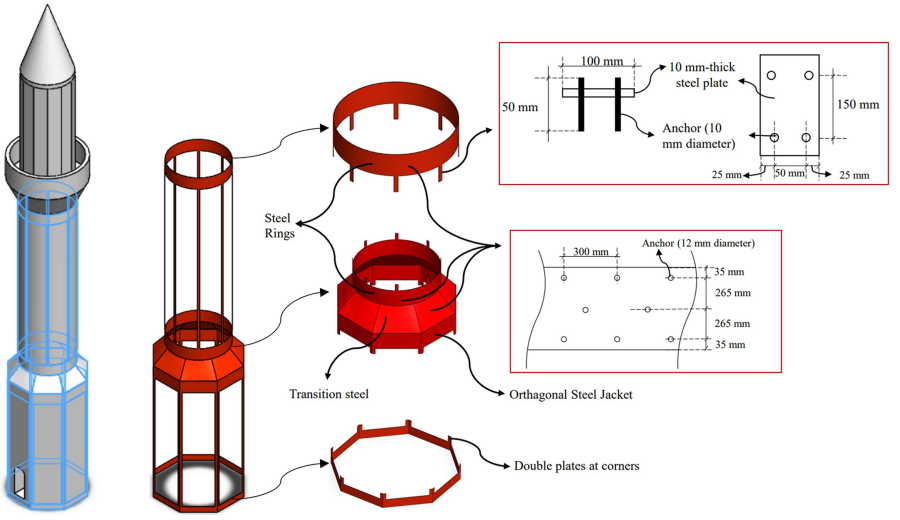


Figure 4. Proposed structural retrofit Erzurum Murat Pasha Mosque's minaret in Turkey. Figure reproduced from Gürbüz and Kocaman (2024) with permission from ®Elsevier, copyright license number 5906460549954, November 2024

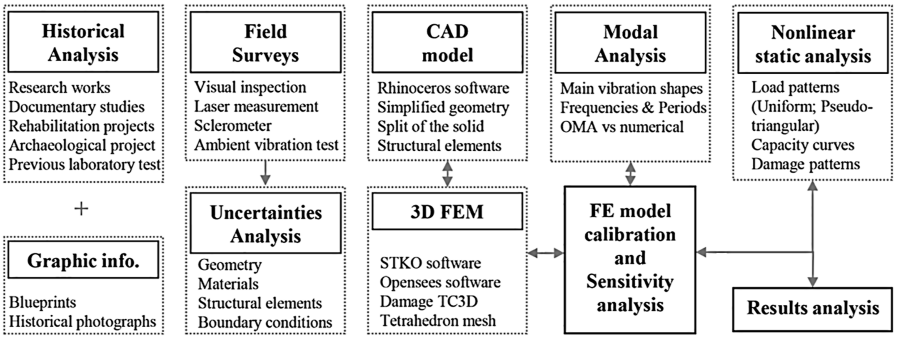


Figure 5. Methodology suggested by Romero-Sánchez *et al.* (2023). Figure reproduced from Romero-Sánchez *et al.* (2023) under the terms and conditions of a CC-BY 4.0 license agreement

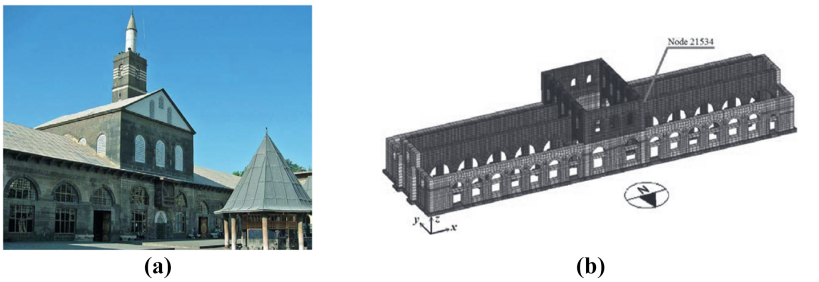


Figure 6. Diyarbakir Grand Mosque: (a) general view and (b) structural numerical model. Figures reproduced from Karaton and Aksoy (2018) with permission, under the terms and conditions of a CC-BY license agreement

The importance of cultural heritage conservation is also emphasised by Rossi *et al.* (2015), with a specific focus on the Great Mosque of Algiers. The study reports a sound numerical analysis of the structure alongside some consideration of its seismic vulnerability and possible rehabilitation. Technical strategies are taken into account to address the present deficiencies of the system. The overall approach falls into the well-known performance-based assessment of monumental buildings.

Even fewer studies have been conducted into larger sites of more than one building. Relevant examples can be found in Guardiola-Víllora *et al.* (2023), which looked at residential buildings in Spain, a multiscale inventory for the masonry buildings of Pla del Remei which were built in 1939. The approach follows the general guidelines proposed by the PERPETUATE network (Lagomarsino and Cattari, 2015).

All these case studies highlight the need for multidisciplinary solutions that go beyond the technical structural sphere.

Available methods for the valuation of cultural heritage

The importance of analysing and optimising any structural retrofit intervention becomes clearer when multifunctional aspects are taken into account in addition to structural mechanics. As such, a typical problem requires the use of a sound and robust cost-benefit approach that can efficiently account for the real boundaries and influencing parameters of a given historic building. In order to establish a powerful interdisciplinary conservation strategy for the Religions Complex in Old Cairo (as well as for its successive application to other sites), it is thus necessary to find and adopt an efficient approach that could help decision-makers.

Adopted methodology

The methodology used in this study is structured in four phases: research, screening, study analysis, evidence synthesis.

We began our research by defining our parameters to papers contained in the Scopus database, using the following search string: TITLE-ABS-KEY ((“stated preferences” OR “revealed preferences”) AND (Church OR castle OR mosque OR monuments OR “cultural heritage”) AND (LIMIT-TO (DOCTYPE,“ar”).

The research field was narrowed to valuation approaches focused on stated and revealed preferences for assets similar to the Complex of Old Cairo, namely churches, mosques, and monuments. However, to avoid overly restricting the search, a more general keyword – “cultural heritage” – was included, along with the keyword “castle,” which, although not representative of building types found in Old Cairo, is considered relevant for economic valuation purposes. Additionally, the search was limited to journal articles, to filter for peer-reviewed works of a higher quality.

With these search criteria, the initial sample of 28 papers was reduced by excluding all works that did not actually evaluate cultural heritage (18), leaving a remaining sample of 10 papers. This sample was then expanded in two ways. Firstly, through an analysis of the bibliography of each paper, to identify any other relevant study not found in the initial Scopus search. Secondly, through an analysis of articles that cited the articles in the reduced sample. In both cases, only journal articles were included. The final expanded sample contained 17 articles.

Analysis

Table 1 provides a summary of the findings from the analysis of the 17 selected articles. Basic methodological assumptions, operational phases and most important findings are briefly described.

Discussion of results

The selected literature in Table 1 provides an overview of the methods that can be used to estimate the economic value of cultural heritage, highlighting the strengths and limitations of each approach. These studies offer a solid basis for more generalised considerations and for the discussion of economic evaluation methods in cultural heritage, with particular attention to their practical application and possible implications for heritage management.

However, each method has specific strengths and limitations that must be carefully considered for a comprehensive and accurate selection.

The travel cost method (TCM) (see Merciu *et al*., 2021; Poor and Smith, 2004; Torres-Ortega *et al*., 2018 and Table 1) is effective for calculating the direct use value of visitors, estimating aggregated benefits and consumer surplus. This method is based on observable data, allowing an empirical estimate of the economic value of cultural sites. TCM is therefore particularly useful for calculating the value of cultural sites based on actual travel expenses, detecting consumer surplus, and facilitating the economic justification for conservation investments. Since it is based on actual travel behaviours, TCM avoids biases related to hypothetical responses, increasing the reliability of the estimate. However, TCM may underestimate the value attributed by local residents, for whom travel costs are minimal, meaning that results cannot be applied so generally. Moreover, this method does not consider non-use values, which represent a significant part of the total value of cultural heritage. Azevedo (2020) identified an interesting and innovative approach in a study that looked at social media data to estimate the recreational value, demonstrating how geotagged photos can provide insights into visit rates and visitor perceptions. This approach leverages spontaneous, unfiltered information, making it particularly suitable for real-time analysis at low costs. On the other hand, using geotagged data offers insight into a limited pool of visitors as not all visitors use social media. The data collected may therefore be severely affected by this assumption.

Table 1. Analysis of literature documents

#	Scopus citations (10/01/2024)	Title	Authors, year	Objective	Method	Main findings	Case study location
1	100	Travel Cost Analysis of a Cultural Heritage Site: The Case of Historic St. Mary's City of Maryland	Poor and Smith (2004)	Estimating the value of benefits for visitors to a cultural heritage site	*Method:* The paper uses zoned TCM to estimate the consumer surplus for visitors *Phases* 1. Data collection through questionnaires distributed to visitors 2. Calculation of travel costs for each origin zone 3. Estimation of visitor demand using three functional forms (linear, semi-logarithmic, log-logarithmic) 4. Calculation of individual and aggregate consumer surplus	The average annual consumer surplus per visitor ranges from approximately $8.00 to $19.26, depending on the functional form used. The estimated annual aggregate benefits range from about $75,492 to $176,550	Historic St. Mary's City, Maryland, USA
2	76	Combining the travel cost and contingent behaviour methods to value cultural heritage sites: Evidence from Armenia	Alberini and Longo (2006)	Estimating the use values of domestic visitors for cultural heritage sites in Armenia	*Method* 1. *TCM:* Use of actual travel data to estimate demand for visits to cultural heritage sites 2. *Contingent behaviour method:* Use of hypothetical questions to estimate the number of visits respondents would make under improved conditions (monument conservation, infrastructure, and service improvements) 3. *Econometric model:* Panel data model that combines actual and stated travel data to estimate a travel demand function	The use values associated with the four monuments studied are significant. Conservation programs and initiatives that enhance the cultural experience or facilitate access to the monuments are appreciated by domestic visitors and would encourage higher visitation rates	Garni, Haghardzin, Khor Virap, Tatev, Armenia

(*continued*)

Table 1. Continued

#	Scopus citations (10/01/2024)	Title	Authors, year	Objective	Method	Main findings	Case study location
3	76	Valuing cultural heritage in developing countries: comparing and pooling contingent valuation and choice modelling estimates	Tuan and Navrud (2007)	Estimating the social benefits of restoration and conservation programs for the My Son World Heritage Site in Vietnam, for both foreign visitors and residents	*Method* 1. *Contingent valuation (CV):* respondents are asked about their WTP (willingness to pay) for the benefits received. Use of binary logit models to estimate valuation functions 2. *Choice modeling (CM):* individuals choose between multi-attribute goods. Use of multinomial logit (ML) models to estimate utility functions 3. *Pooling of CV and CM:* comparison and combination of the results, using hypothesis tests on scale parameters and preference parameters	Both the CV and CM methods are suitable for estimating the economic benefits of the conservation of My Son's cultural heritage. The two methods produce very similar results, demonstrating convergent validity. The combined models show that the parameters in the CV and CM models are not different, and the error variances are not different	My Son World Heritage Site, Vietnam
4	69	The market value of cultural heritage in urban areas: an application of spatial hedonic pricing	Lazrak *et al.* (2014)	Investigating the impact of cultural heritage, particularly historic buildings and cultural sites, on property values in cities	*Method:* spatial autoregressive model to analyse the effect of cultural heritage on property prices *Phases* 1. Data collection on real estate transactions and listed prices 2. Specification of the spatial weight matrix to identify spatial dependencies between sold properties 3. Analysis of the effect of historic buildings and cultural sites on property prices using a spatial hedonic price model	Buyers are willing to pay 26.9% more to purchase a historic building. Surrounding homes are worth 0.28% more for each additional historic building within a 50-m radius. Homes sold within a conservation area earn a premium of 26.4%, confirming the existence of a "historic ensemble" effect	Zaanstad, Paesi Bassi

(*continued*)

Table 1. Continued

#	Scopus citations (10/01/2024)	Title	Authors, year	Objective	Method	Main findings	Case study location
5	66	Valuing the Protection of Aboriginal Cultural Heritage Sites	Rolfe and Windle (2003)	Evaluating the values associated with the protection of Aboriginal cultural heritage sites in Central Queensland	*Method:* CM technique to estimate non-use values for the protection of Aboriginal cultural heritage sites *Phases* 1. Development of survey attributes through focus groups with Aboriginal participants and the general community 2. Presentation of choice sets to respondents, with varying levels of cultural heritage protection, healthy vegetation, kilometres of healthy waterways, and unallocated water 3. Analysis of the collected data using a logistic regression model to estimate compensation values and marginal value changes for each attribute	The values for the protection of Aboriginal cultural heritage sites vary significantly between Indigenous and general communities. General communities show negative values for high levels of protection, but positive values for small increases in protection compared to current levels	Fitzroy Basin, Queensland, Australia

(*continued*)

Table 1. Continued

#	Scopus citations (10/01/2024)	Title	Authors, year	Objective	Method	Main findings	Case study location
6	63	Valuing cultural heritage in a multi-attribute framework: microeconomic perspectives and policy implications	Mazzanti (2003)	Analysing built cultural heritage and implementing experiment-based valuation tools to inform cultural policy decisions	*Method:* multi-attribute valuation methods based on discrete choice experiments *Phases* 1. Definition of attributes and levels of built cultural heritage 2. Development of a choice experiment based on hypothetical scenarios of change compared to the status quo 3. Data collection through direct interviews with visitors to the Borghese Gallery Museum in Rome 4. Econometric analysis of the data using a conditional logit model to estimate the coefficients associated with the attributes and calculate the WTP for hypothetical changes	Visitors express a preference for increased conservation activities and the addition of complementary cultural services to the main exhibit. The WTP for these changes is positive, indicating an increase in economic surplus	Galleria Borghese, Rome, Italy

(*continued*)

Table 1. Continued

#	Scopus citations (10/01/2024)	Title	Authors, year	Objective	Method	Main findings	Case study location
7	54	Information and Willingness to Pay in a Contingent Valuation Study: The Value of S. Erasmo in the Lagoon of Venice	Alberini *et al.* (2005)	Eliciting the WTP for a public program aimed at preserving the lagoon, beach, and infrastructure of St. Erasmo Island	*CV method* • *Questionnaire:* Composed of four sections, including questions on knowledge and use of the Venice Lagoon, recreational use, travel costs, an evaluation scenario with payment questions in referendum format, and demographic characteristics • *Sampling:* Telephone interviews with a random sample of residents from the Veneto region, stratified by distance from the Venice Lagoon • *Split-sample experiment:* One group of respondents received a reminder about the reasons for voting in favour or against the program before the payment question • *Statistical analysis:* Weibull regression models to estimate the average and median WTP, with internal validity tests based on individual characteristics and lagoon use	The average WTP for the program is €66.61 per household, with a median WTP of €20.39. The estimated total benefits for the Veneto Region range between €41 million and €107 million, suggesting that the benefits of the programme outweigh the costs	Sant'Erasmo island in the Venice lagoon

(*continued*)

Table 1. Continued

#	Scopus citations (10/01/2024)	Title	Authors, year	Objective	Method	Main findings	Case study location
8	52	Valuing aboriginal artifacts: a combined revealed-stated preference approach	Boxall *et al.* (2003)	Examining the value of Aboriginal cultural resources using combined revealed (RP) and stated preference (SP) methods	*Method:* combined RP and SP approach to assess changes in visitor behaviour. Phases 1. *Collection of RP data* on actual visits to existing canoe sites 2. *SP experiment* where canoeists were asked about the possibility of changing their site choices in response to the presence of "pristine" and "vandalised" rock art 3. *Use of a random utility model (RUM)* to analyse RP and SP data, accounting for state dependence and correlation between the data	The "pristine" rock art significantly increases the value of canoe trips, with an average welfare increase of about $61-$77 per trip. The vandalized rock art is valued significantly less	Nopiming Provincial Park, Manitoba, Canada
9	35	Economic Valuation of Cultural Heritage: Application of Travel Cost Method to the National Museum and Research Center of Altamira	Torres-Ortega *et al*. (2018)	Analysing the economic value of the National Museum and Research Center of Altamira	*Method:* two approaches of TCM to obtain the demand curve for the museum. Phases 1. *Data collection* on visitors and travel costs 2. *Application of the individual TCM* and the *zonal TCM*. 3. *Estimation of the demand curve and consumer surplus (CS)*	The estimated annual economic value of the National Museum and Research Center of Altamira ranges from 4.75 to 8.00 million euros per year. The consumer surplus per visit is estimated at 31.95 euros (individual TCM) and 18.55 euros (zonal TCM)	National Museum and Research Center of Altamira, Spain

(*continued*)

Table 1. Continued

#	Scopus citations (10/01/2024)	Title	Authors, year	Objective	Method	Main findings	Case study location
10	17	Exploring preferences and non-use values for hidden archaeological artefacts: a case from Denmark	Lundhede *et al.* (2013)	Evaluate preferences and non-use values for hidden archaeological artifacts	*Method:* choice experiment (CE) method to evaluate preferences and non-use values for hidden archaeological artifacts. *Phases* 1. Definition of restoration project attributes 2. Description of management alternatives 3. Data collection through questionnaires 4. Analysis of respondent preferences using the random parameters logit model The considered attributes include • Protected area (230–1750 ha) • Biodiversity (low, medium, high) • Protection of archaeological artifacts (continuous destruction, reduced destruction, permanent protection) • Public access (limited, extended) • Additional payment in annual taxes (0–200 EUR)	The Danish population has a significantly positive WTP for the protection of archaeological artifacts and for increased biodiversity. The WTP for the permanent protection of artifacts is estimated to be approximately €156 per person per year	Store Aamose, Denmark

(*continued*)

Table 1. Continued

#	Scopus citations (10/01/2024)	Title	Authors, year	Objective	Method	Main findings	Case study location
11	16	Valuing the Cultural Monuments of Armenia: Bayesian Updating of Prior Beliefs in Contingent Valuation	Alberini and Longo (2009)	Evaluate the economic value of the conservation of cultural monuments	*CV method:* questionnaire to gather the WTP of Armenian households for the preservation of cultural monuments. Bayesian updating model of prior beliefs. Analysis of responses through WTP regressions	The average WTP for the conservation program is 4125 AMD. The WTP is higher among visitors to the monuments compared to non-visitors. Uncertainty about the future of the monuments is associated with a lower WTP. The WTP is positively influenced by income, education, and marital status	Armenia

(*continued*)

Table 1. Continued

#	Scopus citations (10/01/2024)	Title	Authors, year	Objective	Method	Main findings	Case study location
12	16	Preference heterogeneity in relation to museum services	Colombino and Nese (2009)	Analyse individual preferences for museum services associated with different cultural heritage management strategies, taking into account the heterogeneity of preferences	*Method:* standard multinomial logit (ML) model and the mixed logit (MXL) model to analyse the stated preference data collected through a survey *Phases* 1. Data collection through a survey at the Paestum archaeological site 2. Presentation of alternative scenarios with different combinations of museum services and ticket prices 3. Estimation of parameters using the standard multinomial logit model 4. Estimation of parameters using the mixed logit model to account for preference heterogeneity 5. Comparison of models based on their explanatory power	The services for which visitors are most willing to pay are guided tours and extended opening hours, followed by the availability of educational workshops for children. Preferences vary significantly within the population, with a good percentage expressing a positive reaction to a café-bar within the site	Archaeological site of Paestum, Salerno, Italy

(*continued*)

Table 1. Continued

#	Scopus citations (10/01/2024)	Title	Authors, year	Objective	Method	Main findings	Case study location
13	13	Economic Valuation of Cultural Heritage Using the Travel Cost Method: The Historical Centre of the Municipality of Bucharest as a Case Study	Merciu *et al.* (2021)	Present a complex analysis of the values associated with the use of historical buildings in the historic centre of Bucharest and their correlation with the corresponding conservation measures	*Method* 1. *Zonal TCM:* Classifying data based on the visitors' origin areas, taking into account the distance travelled 2. *Individual TCM*: Estimating the demand for recreational goods for each individual in a specific tourist destination. Structured questionnaires are used to identify the factors influencing tourists' willingness to visit the historic centre of Bucharest *Statistical analysis*: analysis of *covariance (ANCOVA/ANACOVA)* and *correlation analysis* to evaluate the influence of different predictors on the number of visits and the travel cost	The demand for a cultural heritage site is inversely correlated with travel costs and distance. Demand is also influenced by other factors such as the level of satisfaction with the tourist experience, income, and the motivations of tourists. The travel cost method is useful for analysing the relationship between the significant value of using historical monuments and the conservation process	Historical Center of Bucharest, Romania
14	10	Using social media photos as a proxy to estimate the recreational value of (im) movable heritage: the Rubjerg Knude (Denmark) lighthouse	Azevedo (2020)	Estimate the recreational value	*Method* 1. *Zonal TCM:* Geotagged photos from Flickr to estimate zonal visitation rates and calculate the recreational economic value of the lighthouse 2. *Digital reputation analysis:* Assessing the impact of eWOM (electronic word-of-mouth) generated by photos shared on social media	The estimated economic value of the lighthouse ranges from 5.5 million to 133 million euros, demonstrating that the cost of the rescue operation is only a small percentage of the expected recreational value. The digital reputation analysis revealed a high positive rating of the lighthouse as a tourist attraction	Rubjerg Knude Lighthouse, Denmark

(*continued*)

Table 1. Continued

#	Scopus citations (10/01/2024)	Title	Authors, year	Objective	Method	Main findings	Case study location
15	9	The effect of cultural capital on the probability to visit cultural heritage attractions	Apostolakis and Jaffry (2007)	Examine the impact of different dimensions of cultural capital on the likelihood of tourists visiting cultural heritage attractions	*Method:* discrete choice experiment to evaluate tourists' preferences for future policy initiatives *Phases* 1. *Data collection:* Questionnaires were distributed in hotels to gather responses 2. *Choice presentation:* Participants were presented with 18 choice alternatives, each described in terms of six product attributes 3. *Data analysis:* A binomial logit model was applied to estimate regression coefficients and marginal effects	Advertising attractions in tourists' home countries, improving congestion levels, and using audiovisual materials to present exhibits increase the likelihood of visits. In contrast, congestion and higher entrance fees decrease the likelihood of visits	Heraklion Archaeological Museum e Knossos Palace, Crete, Greece

(*continued*)

Table 1. Continued

#	Scopus citations (10/01/2024)	Title	Authors, year	Objective	Method	Main findings	Case study location
16	6	Valuing Urban Cultural Heritage in African Countries: A Contingent Valuation Study of Historic Buildings in Port Louis, Mauritius	Bertacchini and Sultan (2020)	Estimate the economic benefits of conserving and rehabilitating historic buildings	*Method:* CV to estimate the WTP of residents and foreign tourists *Phases* 1. *Data collection:* A survey was conducted from October 2015 to January 2016 2. *WTP elicitation:* A double bounded dichotomous choice (DBDC) approach was used to elicit WTP. 3. *Analysis of respondent" characteristics:* Examined socio-demographic characteristics and attitudes of respondents 4. *Valuation function estimation:* Valuation functions were estimated based on respondents' socio-demographic characteristics and attitudes 5. *Aggregate benefit calculation:* Aggregated benefits were calculated to justify investments in urban heritage conservation	The average WTP for residents is approximately 10.5 USD, while for foreign tourists, it is around 13.8 USD. The aggregated benefits from the preservation of historic buildings can range from 1.5 million to 3.6 million USD for residents and from 16.3 million to 22.6 million USD for foreign tourists, depending on the assumptions considered	Historic Buildings in Port Louis, Mauritius

(*continued*)

Table 1. Continued

#	Scopus citations (10/01/2024)	Title	Authors, year	Objective	Method	Main findings	Case study location
17	2	Compensation for elimination: an innovative technique for evaluating the monetary value of cultural heritage sites	Ben-Malka and Poria (2020)	Propose an innovative technique to evaluate the monetary value	*Method* 1. *CFE:* Based on the concept of willingness to accept (WTA), participants are asked to state the minimum amount of money they would be willing to accept as compensation for the complete elimination of a cultural heritage site. Double dichotomous choice questions are used to reduce biases 2. *Comparison with WTP and TCM:* A discussion on the limitations of traditional methods like WTP and TCM, which often underestimate the non-use values of cultural heritage sites	The CFE technique may better reflect the non-use values of cultural heritage sites compared to traditional methods. CFE can highlight the uniqueness of heritage tourism and the need for responsible and sensitive management of cultural heritage sites	Not specified

Source(s): Authors' own work

The contingent valuation (CV) method (see Alberini *et al*., 2005; Alberini and Longo, 2009; Bertacchini and Sultan, 2020; Colombino and Nese, 2009; Tuan and Navrud, 2007 and Table 1) elicits individuals' willingness to pay (WTP) for the conservation of cultural heritage, including non-use values. CV is consequently ideal for estimating non-use values and quantifying the importance of heritage for non-visitors, extending the estimate beyond direct recreational benefits. Most importantly, it can be applied to various types of cultural assets, regardless of their location or accessibility. However, responses may be influenced by social pressure, leading to overestimates of WTP for goods perceived as good or necessary for the community. The accuracy of the CV approach can be affected by how the scenario is framed, with responses potentially diverging from individuals' actual choices.

The choice modelling (CM) method (see Apostolakis and Jaffry, 2007; Lundhede *et al*., 2013; Mazzanti, 2003; Rolfe and Windle, 2003; Tuan and Navrud, 2007 and Table 1) allows for the estimation of detailed preferences and values of different aspects characterising cultural goods. In particular, this method assesses how various attributes influence the perceived value of a cultural site, so that conservation interventions can be designed with a clear target. With the ability to include different attributes and levels of choice, CM provides a more complex view of public preferences. On the other hand, constructing and analysing choice scenarios requires significant resources and careful design to avoid biases. Moreover, since they are based on stated preferences rather than observed behaviours, responses may not reflect individuals' actual choices, reducing the accuracy of the estimates.

The hedonic pricing (HP) method (see Lazrak *et al*., 2014 and Table 1) has limited application for this type of goods, as it can only capture a small part of the use value (specifically, the value related to the prices of surrounding real estate that benefit from the externalities of cultural sites). It does not capture the non-use component of the value.

The compensation for elimination (CFE) technique, as proposed by Ben-Malka and Poria (2020), is an innovative method based on willingness to accept (WTA) that estimates how much people would want to be compensated for the removal of a cultural site. CFE focuses on non-use values, capturing the emotional and cultural importance that people attribute to historical assets, beyond direct monetary value. This method can better reflect the uniqueness of cultural heritage and the need for responsible and sustainable management. However, the interpretation of WTA can be complex, and responses may exhibit significant variability among respondents, as highlighted in Ben-Malka and Poria (2020). Since the logic of WTA differs from that of WTP, the obtained results are difficult to compare with studies using methods that estimate WTP.

Finally, of particular interest are the so-called hybrid approaches (see Alberini and Longo, 2006; Boxall *et al*., 2003 and Table 1) which combine stated and revealed preferences in order to overcome the limitations of both approaches.

Next steps for old Cairo

According to Figure 2, the size and complexity of Old Cairo site requires a step-by-step analysis to develop a sound, multi-targeted conservation strategy. This could be achieved by starting from a single monument (i.e. at the building scale) and extending and optimising the approach to the large-site scale. A key step in planning the methodology would include prioritising monuments that require swift interventions. Hassan *et al*. (2025) highlighted, for example, the multiple factors that can affect the structural vulnerability of monumental buildings on a daily basis. Selections of priority buildings could be based on an alternative source.

For example, Table 1 shows that TCM is most frequently used and could also be adopted in Old Cairo to gather initial feedback. A simple web search on its monumental buildings, as well as on general conservation tasks in Old Cairo, could also reveal some useful data. Table 2, in this sense, compares the results of web searches for the topics related to the Religions Complex.

Table 2. Results of a web search (February 21, 2025) about the Religions Complex, its monumental buildings and Old Cairo heritage conservation (total number of items)

		Microsoft bing search results	Yahoo search results
Complex level	Mosque of Amr ibn al–As	3,630.000	4,020.000
	St Sergius and Bacchus Church	1,410.000	1,700.000
	St Barbara Church	820.000	697.000
	Al–Sultan Hassan Mosque and Madrasa	464.000	707.000
	Abu Seifain Church (St Mercurius)	242.000	401.000
	Religions/Religious Complex	176.600	234.000
	Hanging Church	99.600	142.000
	Mari Girgis Church	79.500	104.000
	Ben Ezra Synagogue	55.500	99.600
General/large-site level	Old Cairo religious monuments	402.000	281.000
	Old Cairo UNESCO heritage	398.000	465.000
	Old Cairo heritage preservation	344.000	370.000
	Old Cairo tourism	235.000	268.000
	Old Cairo monuments conservation	195.000	139.000
	Old Cairo	178.000	277.000
	Old Cairo conservation	111.000	149.000
	Historic Cairo	92.000	113.000

Source(s): Authors' own work

The data in Table 2 only accounts for the relevant impact and value of historic monuments and cultural heritage in Old Cairo.

According to recent government data shared by the Minister of Tourism, Egypt attracted up to 15.78 million international visitors in 2024 (Business Today Egypt, 2025), and record numbers are expected for 2025 and for the next 10 years. Statistics and projections data suggest that by 2026, tourism in Cairo alone could contribute a whopping USD 2.4 billion of the city's economy, cementing its status as a global tourism powerhouse. The faith-based tourism market plays an important part in these figures (Future Market Insights, 2023) and was valued at USD 1.33 billion in 2023 and is projected to hit USD 3.67 billion in 2033. These figures underline the need for major efforts in the conservation and valorisation of historic religious monuments.

Conclusions and future developments

The structural retrofit of cultural heritage sites and monumental buildings is a very intriguing task. Not only does it present a challenge in terms of structural aspects, but it also requires a robust multidisciplinary analysis. Historic religious buildings represent, in most cases, a priceless good for the community in terms of historic, cultural, religious, economic and touristic value. Their conservation is therefore even more challenging than ordinary constructions, due to a combination of multiple uncertainties, technical issues of retrofit and repair.

This paper has focused on the Religions Complex in Old Cairo, which represents, for several reasons, a unique historic and religious site that bears witness to the harmonious coexistence of different faiths over the centuries.

Various existing methods for estimating the economic value of cultural heritage have been analysed for their possible application to the Religions Complex. However, they present both advantages and limitations. TCM is useful for estimating the direct visitation value, but it does not capture non-use values and may not adequately reflect the value perceived by residents. CV is suitable for estimating non-use value but is susceptible to biases. CM provides a detailed

view of preferences, but can be complex and costly. CFE is useful for assessing the emotional importance of heritage, but the results are difficult to compare with other methods. Hybrid approaches do not follow codified methods but aim to overcome the limitations of the different approaches.

For estimating the economic value of the Religions Complex, a combination of these methods could be particularly interesting, integrating TCM and CM. Clearly, this approach must consider the costliness of implementation, both in terms of conducting surveys (CM) and gathering visitor data (TCM).

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Corresponding author
Chiara Bedon can be contacted at: chiara.bedon@dia.units.it