Routledge
Taylor & Francis Group

INTERNATIONAL JOURNAL OF STRATEGIC PROPERTY MANAGEMENT
ISSN 1648-715X / eISSN 1648-9179

2017 Volume 21(3): 318–329
doi:10.3846/1648715X.2017.1325782

A HYBRID MULTIPLE CRITERIA EVALUATION METHOD OF RANKING OF CULTURAL HERITAGE STRUCTURES FOR RENOVATION PROJECTS

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Received 1 June 2016; accepted 16 January 2017

ABSTRACT. Cultural heritage item preservation, renovation and adaptation to the social needs of people, as well as their passing from generation to generation, is a problem relevant from economic, historical, archeological, religious, technological, research and other perspectives. They are typical strategic multi-criteria decision-making problems. The state institutions and the owners and managers of the heritage items invest in their preservation. In fact, every country has a great number of the registered heritage structures. To ensure their effective management and renovation, a lot of implementation projects and strategies should be developed and evaluated. This work requires large investments and time. The paper presents a hybrid model developed for ranking the heritage buildings intended for renovation according to their value. The model for problem solution based on integrated using two MCDM methods Analytic Hierarchy Process and EDAS. A set of the criteria for evaluating the projects, concerning the renovation of cultural heritage items defined.

KEYWORDS: Cultural heritage; Buildings projects; Hybrid; Multi-criteria decision-making; Evaluation; AHP; EDAS

1. INTRODUCTION

Cultural heritage may be considered a distinctive characteristic of any state and its citizens. The preservation of strategic heritage items is a factor, which can ensure the national security of a state. In the time of globalization, cultural heritage becomes closely associated with various economic activities, such as tourism, real estate management, education, etc. (Jureniene, Radzevicius 2014). However, cultural heritage is a system of constituent parts, which are difficult to measure and evaluate and which strongly depend on economic factors. At present, cultural heritage evaluation and preservation are aimed at determining the subjective factors, such as the value, the role and function of a heritage item rather than at searching for the objective truth. The main problem of the heritage preservation and renovation today is to determine, why and for what purposes the heritage item should be preserved. Only when these questions are answered, the appropriate engineering solutions can be sought. At present, the main motivating factors of heritage preservation are defined as follows:

1. Preserving and/or increasing the heritage item's value for research;
2. Preserving and/or increasing the social or symbolic heritage item's value (as perceived by large groups of people);
3. Preserving and/or increasing the sentimental, symbolic heritage item's value (as perceived by small groups of people or individuals).

Republic of Lithuania Law on Protection of Immovable Cultural Heritage (2004) defines cultural heritage property as an essential part of cultural heritage, embracing physical items of cultural value, which continue or ceased to exist. They have been created, built and preserved by the previous generations and are closely connected with some important historical events and the area of their

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location and use. The cultural heritage property includes individual items (buildings), their groups and the areas of their location.

However, under the current environmental conditions and the harmful effect of human activities, the threat to cultural heritage is increasing (Vodopivec *et al.* 2014). The register of the valuable items in Lithuania contains more than 24500 such items, while their number in the state list of the registered heritage items exceeds 8750 items. To preserve the cultural heritage, about 130–150 items are annually renovated. The work associated with cultural heritage items management (including research, preservation, restoration, adaptation to the current needs, etc.) is coordinated with the Cultural Heritage Department of the Ministry of Culture, as well as with municipalities and heritage item managers. The department of the cultural heritage, striving to ensure the appropriate preservation of the cultural heritage property, planned to pay special attention to the wooden architecture structures found in the ethnographic villages. Moreover, the significance level of the structure, the perspectives of its preservation, use, demonstration and visiting by the people, as well as the initiatives of its owners, should be taken into consideration. However, the costs of the heritage structure's preservation often exceed the benefits (Dutta, Husain 2009). Since renovation works are performed simultaneously in more than 130 heritage buildings per year in Lithuania, they may last for more than 36 months, depending on financing. However, a long building renovation period poses a risk to steady financing or can suspend it, leaving the work unfinished. This may happen if the cost of labour and building materials grows, the laws regulating the renovation works or taxes change or contractors and subcontractors become insolvent.

Taking these facts into consideration, the authors of the paper presented the method of more objective selection of heritage buildings, requiring financing of their renovation works, which can help to reduce the time of the work performance.

2. A DESCRIPTION OF THE CRITERIA DEFINING THE CULTURAL HERITAGE PROPERTY, WHICH ARE USED IN MULTIPLE CRITERIA EVALUATION

The preservation and use of cultural heritage for the current social needs, as well as its identification, evaluation, accessibility and academic research into the related problems, make an inherent part of the country's culture. On the other hand, the cultural heritage may be considered to be an economic sector, which creates the value added and should be managed so that all its valuable items would be preserved and the rights of the future generations would not be violated. Urban blight issues have transformed over time. Today, the focus is on the social context and such services as recreation and leisure (Pourahmad *et al.* 2015). Filip *et al.* (2014) emphasized that an almost exponentially increasing interest could be observed in publications analysing multi-criteria decision-making problems over the last decade.

There are many works, in which researchers study cultural heritage preservation problems based on using multiple criteria evaluation and decision making approaches (Zagorskas *et al.* 2014; Kutut *et al.* 2013; Turskis *et al.* 2013; Ksiazek *et al.* 2015; Siozinyte *et al.* 2014; Zavadskas *et al.* 2014). The techniques and planning methods, as well as decision-making methods, develop dynamically (Sivilevicius *et al.* 2008). Preservation of heritage buildings and their adaptation to the current needs of people are closely related to renovation of buildings (Ruzgys *et al.* 2014) and their surroundings (Turskis *et al.*2015; Zavadskas *et al.* 2015), design and management (Turskis *et al.* 2009), as well as refurbishment (Stankevicius *et al.* 2014) and the available information (Zavadskas *et al.* 2009a).

The authors state that, in terms of the sustainable development concept, the key criteria, on which the modern society relies, are economic, environmental and social. Other criteria often mentioned by various researchers refer to historic, cultural and aesthetic aspects of activities or interest. The criteria, describing risks and state of preservation of a building, are also referred to the key criteria. Moreover, Vodopivec *et al.* (2014) used the key criteria and subcriteria for arranging the architectural heritage buildings in the priority order for renovation. Thus, the authors attributed three subcriteria to each of the eight key criteria (referring to social, aesthetic, economic, cultural-symbolic, risk, environmental, preservation state of a building and historical areas).

Tupėnaitė *et al.* (2010) offered to use the criteria for evaluating the buildings' renovation alternatives, taking into consideration macro-, mezo- and micro-levels, because the research has shown that most of the authors give the priority to renovation processes, decision making and the sustainable renovation methods of buildings mostly at the macro- and (sometimes) the micro-level. However, a model aimed at analysing the renovation of buildings and

their territory, which would take into account the interested states and macro- and micro- level criteria, as well as their effect on a building and the environment, has not been developed yet. The discovery of the existence of social preferences, perceived as positive and/or negative predispositions towards some particular social and economic conditions considerably complicated the theory of economic rationality (Morselli 2015). Problems arising in construction projects are complicated and usually involve great uncertainties and subjectivities. An appropriate mechanism for supporting design management practices at an early stage of the project is crucial in terms of adding the value over the scope, time and total investment strategic decisions (Saparauskas *et al.* 2011).

Compared to many other industries, the construction industry is subject to more risks due to the unique features of construction activities, such as long duration of construction projects, characterized by complicated processes, abominable environment, financial intensity, and dynamic organizational structures (Lazauskas *et al.* 2015). The project preparation and realization processes, based on theoretical and empirical studies and the creation of goods, services and technologies, are the most important human activities (Peldschus *et al.* 2010). Besides, the multi-criteria evaluation of buildings before and after refurbishment and/or renovation and the refurbishment efficiency is required (Zavadskas *et al.* 2009b).

The heritage buildings can be divided into four groups, depending on their historical value, architectural value and function as follows:

- The buildings of group 1 have the unalterable structure and facade and the acceptable function;
- The buildings of group 2 A allow only for the modification of the exterior and some functional changes;
- The buildings of group 2 B allow for structural changes and extension, which may be followed by the exterior and functional changes. These alterations should be in harmony with the building's surroundings.
- The buildings of group 3 allow for all kinds of alterations (Dutta, Husain 2009).

Dutta and Husain (2009) analysed the problems of preserving the heritage items having a cultural value, taking into consideration the above four groups of cultural heritage items and applying multiple criteria evaluation methods based on the criteria associated with historical, architectural, social-cultural spheres, as well as accessibility, integrity, public opinion, local responses and practicality. Changes in the macro- and micro-environment, as well as growing awareness, customer requirements and increasing environmental restrictions gave rise to the need for changing the current socio-economic development to a more sustainable process (Urbaniec 2015).

Cultural heritage can be compared with an industry, which controls and plans the operations aimed at preserving the heritage items. Cultural heritage can attract tourists, who are interested in seeing various famous heritage items. Ferretti *et al.* (2014) have offered to evaluate heritage items based on using multiple criteria evaluation approaches, such as ARAS and AHP and taking into account the interests of tourists. The research is aimed at determining the most suitable historical building, which would be reconstructed for tourists. To achieve this, the conditions (e.g. the quality of the adjacent buildings and the environment, the accessibility of a park and airports), as well as the economic activities, flexibility (the possibility of retaining the initial function and the authenticity of a building), the accessibility and conservation (preservation) level, have been considered. Kutut *et al.* (2014) have stated that the effectiveness of conservation of buildings depends on the possibility of making historical places habitable in the process of future urban development.

3. DETERMINING THE EVALUATION CRITERIA USED IN THE ANALYSIS OF THE CULTURAL HERITAGE PROPERTY

3.1. Determining the evaluation criteria of the cultural heritage structures intended for renovation

The term 'heritage' embraces the monuments, buildings and their groups, having a historical, aesthetic, archeological, research, ethnological and anthropological value (Dutta, Husain 2009). Numerous researchers, trying to help preserve cultural heritage items, studied them from economic, social, political, historical and cultural aspects for determining their value.

Thus, Ferretti *et al.* (2014) have stated that cultural heritage is a multifaceted phenomenon. However, it most strongly depends on the economic development of the public sector. According to Vodopivec *et al.* (2014), the value of economic heritage property is perceived as a quantitative criterion expressed in terms of cost. However, the expression of this criterion is also associated with

the indirect economic effect, e.g. the increased flow of tourists. At the same time, the considered criterion can be referred to the social value. Thus, Bielinskas *et al.* (2015) have described the economic value as the ratio of the property cost on the territory of the municipality, where it is located, and its cost on the territory of the neighbouring municipality. The property value, as well as public and private sectors' investments and a mismatch between the labour force and vacancies have been also described in this way. Tupėnaitė *et al.* (2010) considered the economic value in terms of the economic project implementation, embracing meeting the budget, contribution to project implementation, profit generation and the value added, as well as economic efficiency of the project, the financing of project implementation, etc. The necessity for investing in cultural heritage building repair or renovation can be referred to the economic value of the cultural heritage item (Kutut *et al.* 2014).

Another widely discussed cultural heritage value is a social value. It is defined in terms of education, research and management (Vodopivec *et al.* 2014). A social value can be considered, dealing with the number of the unemployed immigrants, crime level, etc. (Bielinskas *et al.* 2015). Tupėnaitė *et al.* (2010) have referred a social value to the macro-level. Moreover, the economic behaviour of humans is socially affected (Ashworth 2010). Besides, the laws, directives and regulations, concerning cultural heritage are associated with the political value (Ashworth 2010). When cultural heritage is considered, historical and cultural values are usually mentioned. A historical value is defined in spiritual-religious and secular terms and in the sense of novelty, while a cultural value is described in archeological and technological terms (Vodopivec *et al.* 2014).

The authors, studying cultural heritage, also take into account the environmental, aesthetic, risk and authenticity factors (Vodopivec *et al.* 2014), as well as scientific, technical (Tupėnaitė *et al.* 2010), internal criteria (the function and age of a building) (Clark, Maeer 2008), recoupment, visual effect (Pankhurst, Harris 2013), accessibility, integrity, practicalness (Dutta, Husain 2009), the situation quality, flexibility, and the conservation level (Ferretti *et al.* 2014).

In selecting the wooden architecture structures for renovation, the Cultural Heritage Department primarily emphasized the importance of the criterion referring to lightning rod installation. Then, the attention was paid to such criteria as the significance level of a building, its valuable features, authenticity, the perspectives of preserving a building in the desired condition, as well as the

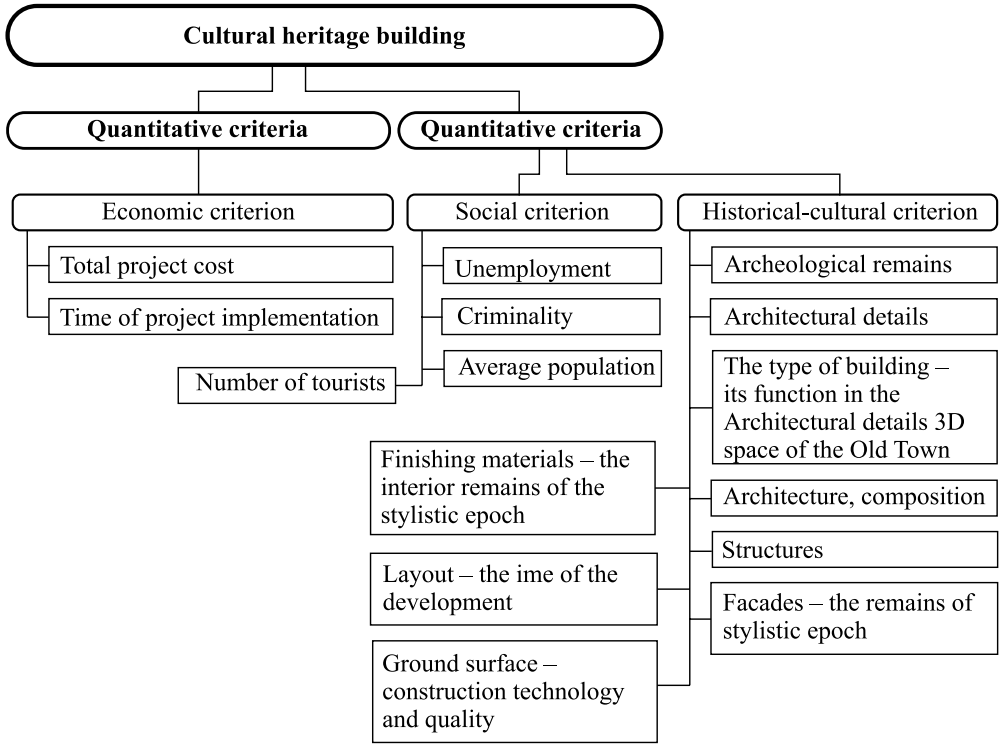

Fig. 1. Quantitative and qualitative criteria and subcriteria used in describing cultural heritage buildings

possibilities of its proper use, demonstration to tourists and other people and the initiatives of the managers of a building and its current state.

The present paper considers the problem of choosing the cultural heritage buildings for renovation based on using quantitative and qualitative criteria (Fig. 1) and subcriteria. The main quantitative criterion is an economic criterion (x_1) of the considered building, which has some subcriteria, such as the total cost of the project (x_{11}) and time of project implementation (x_{12}). The qualitative criterion includes the social and historical-cultural criteria and historical-cultural criteria, (x_2) and (x_3), respectively. The historical-cultural criterion is considered, taking into account subcriteria, describing various features of a building, such as its valuable qualities (x_{21}), architecture (x_{22}), architectural features (x_{23}), the layout (x_{24}), facades (x_{25}), structures (x_{26}), finishing materials (x_{27}) and the ground surface (x_{28}). The social criterion embraces such subcriteria as the unemployment level (x_{31}), the registered crimes (x_{32}), the average annual population (x_{33}) and the number of the local tourists (x_{34}). Social subcriteria are considered, depending on districts (e.g. Panevėžys, Marijampolė, Vilnius or Kaunas districts), where the considered cultural heritage buildings are located.

3.2. A description of the evaluated cultural heritage buildings

To stimulate the performance of the renovation works of cultural heritage buildings and their financing in Lithuania, the buildings of the historical and cultural value of this country have been considered in the paper. Five various cultural heritage buildings, presented to the Cultural Heritage Department as the renovation projects by their managers, have been chosen for the analysis. The aim of the managers was to get the funding for the renovation works required for the cultural heritage buildings.

The renovation works to be performed in Bobriškis Church of Old Believers (Kultūros paveldo departamentas … 2016a). In the 19th century, Bobriškis had become a religious centre of the North-Eastern Lithuania, while the role of the Bobriškis Church for the Old Believer community had grown immensely. The architecture of the Church is characteristic of the wooden churches in the Northern Russia. However, it also has some features of traditional Lithuanian folk architecture. In 2007, Bobriškis Old Believer Church was included in the Register of Cultural Heritage Buildings (Fig. 2). The planned renovation works are aimed at preserving and exposing the most valuable features of the church building, because it is the oldest wooden church of Old Believers in Lithuania.

The renovation works to be performed in Vilnius synagogue, 6, Gėlių str. (Kultūros paveldo departamentas … 2016b). The synagogue was built at the beginning of the 19th century on the site of the former wooden houses belonging to the merchant Zavelij Peisachovichius. In the second half of the 19th century, it had been reconstructed many times and extended. The church was open until 1940. After World War II, storehouses and flats were made in its building, while since the end of the 20th century, the building had been neglected. Now, Vilnius synagogue is included in the Register of Cultural Heritage Buildings (Fig. 3). The renovation works are aimed at preserving the authenticity and valuable features of Vilnius synagogue, as well as making them more prominent.

The renovation works on the roof of Raseiniai Church of Assumption of the Blessed Virgin Mary (Kultūros paveldo departamentas … 2016c). This is the first church built in 1416–1421, at the time of Christenization of Samogitians. In 1663, the church

Fig. 2. Bobriškis Church of Old Believers

Fig. 3. Vilnius synagogue, Gėlių str.

was reconstructed and the Dominican monastery was built, which was extended in 1682. This church is considered to be built in one of the oldest centres of Žemaitija's rural districts. The building is a part of the church and the former Dominican monastery complex. In 1992, the church was included in the Register of Cultural Heritage Buildings (Fig. 4). The renovation works of the roof are aimed at preserving the valuable features of this heritage building and completing all the works of church renovation.

The renovation works of Zypliai manor Craftsmen Home (Kultūros paveldo departamentas … 2016d). Zypliai manor Craftsmen Home belongs to Zyplių manor complex. According to the historical and iconographical data on the manor, it was built as a house of the manager in charge of the premises. In the first half of the 20th century, it was repaired and made the craftsmen home. In 1999, Zypliai manor Craftsmen Home was included in the Register of Cultural Heritage Buildings (Fig. 5). The planned renovation project solutions are aimed at preserving the valuable features of the building and showing them to the public.

The conservation and renovation of St. Stephen Church facades (Kultūros paveldo departamentas … 2016e). The St. Stephen Church is a rare Mannerist architecture monument in Lithuania, which is also important for the history of its culture as

Fig. 4. Raseiniai Assumption of the Blessed Virgin Mary Church

Fig. 5. Zypliai manor Craftsmen Home

Fig 6. St. Stephen Church

the former centre of the monks, St. Roch's followers. The church was built in 1600 on the initiative of Simonas Visockis, a Jesuit priest, in the Southern part of the town near the walls of the cemeteries, which appeared in the time of the plague. A famous architect Laurynas Gucevičius was buried there in the 18th century, which is witnessed by the plate on the external wall of the church. In 1717, St. Roch chapel was attached to the church building. In 1863–1914, the church buildings were used as the town prison. In 1944, the building of the church was connected with a factory and used as a warehouse for storing various materials. The church is a building constructed in the late Renaissance style. It was reconstructed in the period of classicism. In 1992, the church was included in the Register of Cultural Heritage Buildings (Fig. 6). It is planned to preserve the valuable features of the church by renovating it and its territory, to return it to the believers and adapt to the social needs of the community.

3.3. Determining the criteria weights and selecting the cultural heritage buildings for renovation by applying the Analytic Hierarchy Process (AHP) approach

A fundamental problem of the decision theory is associated with the determination of weights for a set of criteria according to their importance (Saaty 1980). A variety of methods have been proposed for eliciting the criteria weights. The "best" method for determining weights can hardly be found. The review of the past works has shown that the Analytic Hierarchy Process (AHP) seems to be the MCDM method commonly used in solving civil engineering decision problems. This method allows for hierarchical structuring of a complicated problem, as well as comparing and quantitatively evaluating the available alternative solutions. It also allows for determining the criteria weights (significances) at a particular hierarchical level.

Table 1. The initial data used for pairwise comparison

Saaty's classical nine-point scale of relative importance								
	Diagonal elements $i=j$	C_i and C_j are equally important	C_i is weakly more important than C_j	C_i is strongly more important than	C_i is demonstratively more important than C_j	C_i is absolutely more important than C_j	Compromise between two judgments	If element C_j dominates element C_j
a_{ij}	1	1	3	5	7	9	2, 4, 6, 8	$a_{ij} = 1 / a_{ij}$
Random Consistency Indices *(IR)* for a number of various criteria (n).								
n	1	2	3	4	5	6	7	*8*
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41

The analysis of a decision making problem by the AHP method starts with the generation of a hierarchical structure, which consists of the aim, alternatives, criteria, sub-criteria and other factors, influencing the final choice. Applying this method, the needs of the interested parties (i.e. managers, state institutions, clients, investors, community members, etc.) should be taken into consideration (Kutut *et al.* 2014). The representatives of all these groups of people evaluate the considered criteria against the scale suggested by Saaty.

Saaty recommends a nine- level dominance scale, which he described based on the Miller's (Miller 1956) magical number seven plus two number (Table 1) (Saaty 1980). The amount of n(n-1)/2 judgments is required for developing the n×n judgment matrix, since reciprocals are automatically assigned in each pairwise comparison procedure. Pairwise comparison is based on the weighting principle, when one criterion is more significant than the other. The criteria and sub-criteria are compared within their groups.

The AHP method is a stepwise procedure:

Step 1. When the representative of an interested party has finished pairwise comparison of criteria, write down the results in the pairwise comparison matrix:

$$A = \left[c_{ij}\right] = \begin{matrix} C_1 \\ C_2 \\ \vdots \\ C_n \end{matrix} \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ 1/a_{12} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ 1/a_{1n} & 1/a_{2n} & \cdots & 1 \end{bmatrix}. \quad (1)$$

Step 2. Normalize the pairwise comparison matrix as follows:

$$\bar{A} = \left[\bar{c}_{ij}\right] = \begin{bmatrix} c_{11}/\sum_{i=1}^{n} c_{i1} & c_{12}/\sum_{i=1}^{n} c_{i2} \cdots c_{1n}/\sum_{i=1}^{n} c_{in} \\ c_{21}/\sum_{i=1}^{n} c_{i1} & c_{22}/\sum_{i=1}^{n} c_{i2} \cdots c_{2n}/\sum_{i=1}^{n} c_{in} \\ \vdots & \vdots \ddots \\ c_{n1}/\sum_{i=1}^{n} c_{i1} & c_{n2}/\sum_{i=1}^{n} c_{i2} \cdots c_{nn}/\sum_{i=1}^{n} c_{in} \end{bmatrix}. \quad (2)$$

After normalizing, the criteria weights (significance values), which, primarily, were expressed by measuring units, have become the dimensionless values. Then, the direction of evaluation (min/max) was determined. At this stage, the values of criteria and subcriteria weights were determined in the maximization or minimization direction (Table 3).

Step 3. Compute the criteria weights:

$$W = \begin{bmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{bmatrix} = \begin{bmatrix} w_1 = \left(\prod_{j=1}^{n} \bar{c}_{1j}\right)^{1/n} / \sum_{i=1}^{n}\left(\prod_{j=1}^{n} \bar{c}_{ij}\right)^{1/n} \\ w_2 = \left(\prod_{j=1}^{n} \bar{c}_{1j}\right)^{1/n} / \sum_{i=1}^{n}\left(\prod_{j=1}^{n} \bar{c}_{ij}\right)^{1/n} \\ w_n = \left(\prod_{j=1}^{n} \bar{c}_{1j}\right)^{1/n} / \sum_{i=1}^{n}\left(\prod_{j=1}^{n} \bar{c}_{ij}\right)^{1/n} \end{bmatrix} \quad (3)$$

Step 4. Determine the largest eigenvalue:

$$\lambda_{max} = \sum_{j=1}^{n} c_{ij} w_j \quad (4)$$

Step 5. Determine the Consistency Index (*CI*):

$$CI = \frac{\lambda_{max} - 1}{n - 1} \quad (5)$$

Step 6. Determine the Consistency Ratio (*CR*):

$$CR = \frac{CI}{RI}, \quad (6)$$

where: *RI* (Table 1) represents the average consistency index over numerous random elements of the same order reciprocal matrices.

Step 7. Ensure that the pairwise comparison matrix is consistent. The matrix is consistent, when, based on the minimal number of its elements, the remaining elements can be obtained. The required condition for achieving a consistent matrix is the transitivity of the significance of its elements. If CR ≤ 0.1, it indicates that the matrix reached consistency. Otherwise, go to the first step.

The experts' team formed to solve this problem. Experts'role in this study was to decide on a set of criteria that should be relevant for application. Fifteen experts are experienced and knowledgeable people from Department of Culture Heritage under the Ministry of Culture, owners of Culture heritage buildings, clients and people from academic institutions. Experts were required to have knowledge and experience in field of culture heritage and its management. During the evaluation process, the main criteria for selection was that candidates had to have more than seven years of experience in culture heritage field.

To select the cultural heritage buildings for renovation, 5 alternatives have been considered. Each alternative with the provided criteria and the calculated values is described in Table 2. These values were obtained from various sources: from the projects provided by the managers of the building, from the register of the Cultural Heritage Department of the Ministry of Culture and from the site of the Statistics Department of Lithuania.

The next stage involves using the method of Evaluation based on Distance from the Average Solution (EDAS).

Ghorabaee *et al.* (2015) proposed a new multi-criteria decision-making method called 'Evaluation based on the Distance from the Average Solution' (EDAS). Later, this method extended to reflect fuzzy environment (Ghorabaee *et al.* 2016).

The EDAS method can be used, when the problem under consideration is described by some conflicting criteria. The steps for using the EDAS method are as follows:

Step 1. Select the most important criteria describing the alternatives.

Step 2. Represent the problem as the decision-making matrix X of preferences for m reasonable alternatives A_i (rows) rated on n criteria (columns):

$$X = \left[x_{ij}\right]_{m\times n} = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix}, \tag{7}$$

where: x_{ij} is the value representing the performance value of the *i-th* alternative in terms of the *j-th* criterion.

Table 2. The alternatives and the criteria used

Criteria	Alternatives						
		Evaluation of criteria, min/max	Renovation work of Bobriškis Church of Old Believers	Renovation work of Vilnius synagogue, Gėlių str. 6	Roof renovation work of Raseiniai Assumption of the Blessed Virgin Mary Church	Renovation and repair of Zypliai manor Craftsmen Home	Conservation and renovation of St. Stephen Church facade
			A_1	A_2	A_3	A_4	A_5
Economic criteria	x_1	*min*					
Total project cost (thousand EUR)	x_{11}	*min*	264.809	552.18	246.3	473.69	279.714
Project implementation time (months)	x_{12}	*min*	36	60	24	60	48
Historical -cultural criteria (valuable features)	x_2	*max*					
Type of valuable features	x_{21}	*max*	2	2	4	1	6
Architecture	x_{22}	*max*	6	8	11	5	17
Architectural details	x_{23}	*max*	0	0	24	0	20
Layout	x_{24}	*max*	3	10	14	11	9
Facades	x_{25}	*max*	15	7	16	15	9
Structures	x_{26}	*max*	7	6	16	10	23
Finishing materials	x_{27}	*max*	2	0	1	3	0
Ground surface	x_{28}	*max*	1	0	0	0	2
Social criteria (according to particular districts)	x_3	*Min / max*					
Unemployment level, %	x_{31}	*min*	10.2	7.3	7.6	10.3	7.3
Crimes, units	x_{32}	*min*	5820	22983	15260	3526	22983
Average annual population, persons	x_{33}	*max*	233228	806333	580134	150459	806333
Number of tourists, thousand persons	x_{34}	*max*	5.7	48.9	44.9	8.1	48.9

Table 3. Initial data

Criteria and subcriteria	Optimal	Weights (based on AHP)	$w[j]$	Alternatives					
				A_1	A_2	A_3	A_4	A_5	A_a
$\boldsymbol{x_1}$	***min***	***0.709***	x_{aj}						
x_{11}	min	0.167	0.118	264.809	552.18	246.3	473.69	279.714	363.3
x_{12}	min	0.833	0.591	36	60	24	60	48	45.6
$\boldsymbol{x_2}$	***max***	***0.167***							
x_{21}	max	0.076	0.013	2	2	4	1	6	3.0
x_{22}	max	0.321	0.054	6	8	11	5	17	9.4
$\boldsymbol{x_2}$	***max***	***0.167***							
x_{23}	max	0.167	0.028	0	0	24	0	20	8.8
x_{24}	max	0.024	0.004	3	10	14	11	9	9.4
x_{25}	max	0.242	0.040	15	7	16	15	9	12.4
x_{26}	max	0.081	0.014	7	6	16	10	23	12.4
x_{27}	max	0.076	0.013	2	0	1	3	0	1.2
x_{28}	max	0.013	0.002	1	0	0	0	2	0.6
$\boldsymbol{x_3}$	***Min/max***	0.061							
x_{31}	min	0.065	0.004	10.2	7.3	7.6	10.3	7.3	8.5
x_{32}	min	0.129	0.008	5820	22983	15260	3526	22983	14114.4
x_{33}	max	0.205	0.013	233.228	806.333	580.134	150.459	806.333	515.3
x_{34}	max	0.601	0.037	5.7	48.9	44.9	8.1	48.9	31.3

Step 3. Determine the average value x_{aj} to all criteria:

$$x_{aj} = \frac{\sum_{i=1}^{m} x_{ij}}{m}. \tag{8}$$

Step 4. Construct the average A_a solution based on the average values of all criteria x_{aj}:

$$A_a = \left[x_{aj}\right] = \left[x_{a1}, x_{a2}, \cdots, x_{an}\right]. \tag{9}$$

Step 5. Construct the matrix D of positive, p_{ij}, and negative, r_{ij}, distances from the average A_a solution (from the average values x_{aj}) for all n criteria (Table 4):

$$D = \left[p_{ij}; r_{ij}\right] = \begin{bmatrix} p_{11}; r_{11} & p_{12}; r_{12} & \cdots & p_{1n}; r_{1n} \\ p_{21}; r_{21} & p_{22}; r_{22} & \cdots & p_{2n}; r_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ p_{m1}; r_{m1} & p_{m2}; r_{m2} & \cdots & p_{mn}; r_{mn} \end{bmatrix}. \tag{10}$$

For beneficial criteria, the values p_{ij} and r_{ij} calculated as follows:

$$p_{ij} = \frac{x_{ij} - x_{aj}}{x_{aj}}, \tag{11}$$

$$r_{ij} = \frac{x_{aj} - x_{ij}}{x_{aj}}. \tag{12}$$

For non-beneficial criteria, the values p_{ij} and r_{ij} calculated as follows:

$$p_{ij} = \frac{x_{aj} - x_{ij}}{x_{aj}}, \tag{13}$$

$$r_{ij} = \frac{x_{ij} - x_{aj}}{x_{aj}}. \tag{14}$$

Step 6. Determine the weighted sum of positive S_{ip} and negative S_{ir} distances from the average A_a solution for all alternatives A_i (from the average values x_{aj}) for all n criteria:

$$S_{ip} = \sum_{j=1}^{n} w_j p_{ij}, \text{ and} \tag{15}$$

$$S_{ir} = \sum_{j=1}^{n} w_j r_{ij}, \tag{16}$$

where: w_j is the weight of *j-th* criterion.

Step 7. Normalise the values of S_{ip} and S_{ir} for all alternatives as follows:

$$P_i = \frac{S_{ip}}{\max\limits_i S_{ip}}, \tag{17}$$

$$R_i = 1 - \frac{S_{ir}}{\max\limits_i S_{ir}}. \tag{18}$$

Table 4. Matrix D of positive and negative distances

			Alternatives				
			A_1	A_2	A_3	A_4	A_5
$\boldsymbol{x_1}$							
	x_{11}	p_{11}	0.271	–0.520	0.322	–0.304	0.230
		r_{11}	–0.271	0.520	–0.322	0.304	–0.230
	x_{12}	p_{12}	0.211	–0.316	0.474	–0.316	–0.053
		r_{12}	–0.211	0.316	–0.474	0.316	0.053
$\boldsymbol{x_2}$							
	x_{21}	p_{21}	–0.333	–0.333	0.333	–0.667	1.000
		r_{21}	0.333	0.333	–0.333	0.667	–1.000
	x_{22}	p_{22}	–0.362	–0.149	0.170	–0.468	0.809
		r_{22}	0.362	0.149	–0.170	0.468	–0.809
	x_{23}	p_{23}	–1.000	–1.000	1.727	–1.000	1.273
		r_{23}	1.000	1.000	–1.727	1.000	–1.273
	x_{24}	p_{24}	–0.681	0.064	0.489	0.170	–0.043
		r_{24}	0.681	–0.064	–0.489	–0.170	0.043
	x_{25}	p_{25}	0.210	–0.435	0.290	0.210	–0.274
		r_{25}	0.681	–0.064	–0.489	–0.170	0.043
	x_{26}	p_{26}	–0.435	–0.516	0.290	–0.194	0.855
		r_{26}	–0.210	0.435	–0.290	–0.210	0.274
	x_{27}	p_{27}	0.667	–1.000	–0.167	1.500	–1.000
		r_{27}	0.435	0.516	–0.290	0.194	–0.855
	x_{28}	p_{28}	0.667	–1.000	–1.000	–1.000	2.333
		r_{28}	–0.667	1.000	1.000	1.000	–2.333
$\boldsymbol{x_3}$							
	x_{31}	p_{31}	–0.194	0.145	0.110	–0.206	0.145
		r_{31}	0.194	–0.145	–0.110	0.206	–0.145
	x_{32}	p_{32}	0.588	–0.628	–0.081	0.750	–0.628
		r_{32}	–0.588	0.628	0.081	–0.750	0.628
	x_{33}	p_{33}	–0.547	0.565	0.126	–0.708	0.565
		r_{33}	0.547	–0.565	–0.126	0.708	–0.565
	x_{34}	p_{34}	–0.818	0.562	0.435	–0.741	0.562
		r_{34}	0.818	–0.562	–0.435	0.741	–0.562
Sum of positive and negative distances from the average solution							
S_{ip}			0.0817	–0.3040	0.4101	–0.2914	0.1037
S_{ir}			–0.0405	0.2766	–0.4239	0.3091	–0.1213

Step 8. Calculate the multi-criteria utility function values for all m alternatives as follows:

$$U_i = \frac{1}{2}\left(P_i + R_i\right). \tag{19}$$

Step 9. Rank the alternatives in the decreasing order of multi-criteria utility function values U_i The alternative with the highest U_i is the best choice among the candidate alternatives. The alternatives can be arranged in the priority order according to this ranking (Table 5).

Table 5. Normalised positive and negative distances, the values of the calculated multi-criteria utility function values and final ranking of the alternatives

	Alternatives				
	A_1	A_2	A_3	A_4	A_5
P_i	0.199	–0.741	1.000	–0.711	0.253
R_i	1.131	0.105	2.372	0.000	1.393
U_i	0.665	–0.318	1.686	–0.355	0.823
Rank A_i	3	5	1	4	2

Based on the calculations and taking into account the determined values of the criteria evaluating cultural heritage items, the order of heritage building renovation projects' implementation is as follows: $A_3>A_5>A_1>A_4>A_2$. The calculations have shown, that based on the considered criteria of problem evaluation, the priority should be given to the renovation works of the roof of the Assumption of the Blessed Virgin Mary Church in Raseiniai, and the largest investment should be made in this project, which would allow for reducing the time of project implementation.

4. CONCLUSIONS

Preservation of cultural heritage items is one of the strategic aims of national security policy. The items for renovation should be objectively and carefully selected. A hybrid multi-criteria evaluation model has been created for solving the problems associated with the strategic management of these items. A set of the criteria for evaluating the projects, concerning the renovation of cultural heritage items have been defined. These criteria include economic, historical-cultural and social issues. The economic criteria are as follows: the total project cost (thousand EUR) and the time of project implementation (months). Historical-cultural criteria (describing valuable qualities) are as follows: the nature of valuable qualities, architectural values, the value of architectural details, layout peculiarities, facade value, the value of structures, the peculiar features of finishing and the ground surface. Social criteria (according to particular districts) are as follows: the unemployment level, criminality, the average population and the conditions for tourism. Sub-criteria - time of project implementation - account for about 70% of the total assessment, which suggests that other sub-criteria have only a very minor role in the result.

The model for problem solution based on using multi-criteria evaluation methods AHP and EDAS. Taking into account the calculations made and the evaluation criteria used in the research, the first

place (the priority) given to the renovation works of the roof of the Raseiniai Church, and the largest investment should be made in this project, which would allow for considerable reduction of the time of project implementation.

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