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EVALUATION OF CULTURAL HERITAGE IN MUŠNIKOVO VILLAGE: FUZZY AHP APPROACH

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Summary: The main aim of this paper consist of the application of the Fuzzy Analytic Hierarchy Process to determine the most important criteria in the process of cultural heritage preservation. Among all criteria used in the process of evaluation of more than 450 years old orthodox church in the region of city of Prizren, the importance of the exceptional quality from the artistic aspect of frescoes, distance from the main road, and high degree of the implementation of digitization process stand out.

Key words*: Cultural heritage, church, Prizren, Fuzzy Analytic Hierarchy Process.*

JEL classification: *http://www.aeaweb.org/jel/jel_class_system.php*

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ЕВАЛУАЦИЈА КУЛТУРНОГ НАСЛЕЂА У СЕЛУ МУШНИКОВУ: ФАЗИ АХП ПРИСТУП

Резиме**:** *Glavni cilj ovog rada je primena Fuzzy Analitičkog Hijerarhijskog Procesa (FAHP) kako bi se utvrdili najvažniji kriterijumi u procesu očuvanja kulturnog nasleđa. Prilikom evaluacije očuvanja pravoslavne crkve starije više od 450 godina u regionu grada Prizrena, kriterijumi koji se izdvajaju kao najvažniji su izuzetan umetnički kvalitet fresaka, udaljenost od glavnog puta i stepen sprovedenog procesa digitalizacije.*

Кључне речи: *Културно наслеђе, црква, Призрен, Фази Аналитички Хијерархијски Процес*

1. Introduction and History

Cultural heritage encompasses both material and immaterial elements of significant cultural, artistic, scientific, or historical value, forming the essence of a nation's identity and providing inspiration for future generations. This heritage includes physical artifacts such as buildings, monuments, archaeological sites, and works of art, which reflect the history, traditions, and beliefs of past eras. These tangible aspects of heritage offer a direct connection to the past. In contrast, intangible heritage comprises oral traditions, traditional stories, poetry, customs, languages, music, folk dances, and religious ceremonies, representing the cultural practices and expressions that are passed down through generations. Churches epitomize a fusion of religion, art, architecture, and history, serving as vital repositories of national heritage. The artworks within churches-such as frescoes, icons, stained glass windows, and mosaics depicting saints, angels, and other religious themes-are integral to cultural heritage. Beyond their role in religious practices, churches often serve as centers for the preservation of traditions, customs, and culture. Therefore, it is crucial to invest in their preservation, protection, and restoration. Digitizing religious buildings can significantly promote cultural tourism, which has increasingly become a key factor in maintaining these sites (Sančanin, B. 2019). By attracting visitors who appreciate their beauty and historical significance, cultural tourism helps sustain the upkeep of churches. To make cultural heritage more accessible to a broader audience, defining clear criteria for evaluating and ranking heritage elements can be beneficial. This can be effectively achieved through methodologies such as the Analytic Hierarchy

Process, and some of its new variants, which helps in systematically assessing and prioritizing heritage elements.

Nestled to the east of Prizren, located in the south of Metohija, along the upper reaches of the Bistrica River-named after the central village of the area-lies the Sredačka (Sretečka) župa. This parish is first mentioned in the chrysobulls of Kings Dragutin and Milutin from the 13th century, as well as in the document issued by Emperor Dušan in the 14th century. Throughout the Middle Ages, the villages within this parish were affiliated with either the Hilandar Monastery or the Holy Archangels Monastery, depending on the ruling authority of the time, as can be seen from the names of vilages and places: Manastirica (contains the word 'monastery'), Kraljev dvor (literal translation 'King's Court'), and Kaluđerica (literal translation 'nun'). The parish, roughly elliptical in shape, extends about 17 km in length, 2 km in width, and is situated approximately 1000 meters above sea level. It encompasses 13 villages, distributed as follows: Rečane, Sredska, Mušnikovo, and Gornje Selo are located in the Bistrica Valley; Lokvica, Stružje, Manastirica, Nebregošte, Gornje Ljubinje, Donje Ljubinje, and Drajčiki are situated on the left side; while Planjane and Živinjane are on the right side. This region, as it was stated by the well-known scientist Jovan Cvijić, is rich in natural resources, with extensive pastures and forests covering around 80% of the area. It benefits from abundant water throughout the year, as the snowfields of the Šar Mountains supply numerous springs, streams, and rivers (Tanasković, 1992).

2. On the Orthodox Church of the Holy Apostles Peter and Paul

Perched in the Mušnikovo village, on the elevation known as Ravnjište, from which one can view Ošljak and even catch glimpses of the still-snowy Šar Mountains during the summer, stands the Church of the Holy Apostles Peter and Paul. This church was constructed on the site of an earlier structure, believed to have been originally built in the 14th century but later destroyed by the Turks. The current church, a single-nave rectangular building with a semicircular inner apse, was erected in 1564 (see Picture 1). This date is confirmed by an inscription found in the Table of Oblation, which reads: "By the will of the son, with the help of the Holy Spirit, this divine temple was built with the effort and assistance of the Holy Apostles Peter and Paul in the year 7072" (Jastrebov, 1882).

Picture 1: The Church of the Holy Apostles Peter and Paul, Mušnikovo village

Source: Authors (2024)

Sunlight filters through three small windows, illuminating the stone altar and two side niches inside the church. Opposite the altar on the rectangular porch, which was added in 1920, is an arched door with a lunette. During the restoration in 1866, the western wall was demolished, the nave was expanded by the thickness of the wall, and the building was extended westward. The façade was also updated, replacing the original triangular gable with an overhanging, stepped gable (Lukić, 1968-1971). Art historian Predrag Pajkić (1956) points out that the Church of St. Peter and Paul in Mušnikovo is notable for its artistic quality, especially when compared to other village churches built after the restoration of the Patriarchate of Peć. Pajkić speculates that Patriarch Makarije Sokolović or someone from his circle might have founded this church, as it produced significant artistic work shortly after the renovation of the Patriarchate of Peć. The church is believed to have been painted by artists from the Italo-Cretan school at the end of the 16th century, though only a small portion of the original frescoes remains. On the south wall, the apostles Peter and Paul, as can be seen in Picture 2, are depicted embracing each other with their arms around each other's shoulders. Paul is portrayed as a thin, elderly man with an elongated face, dressed in a red

chiton and blue cloak, while Peter is shown as an older man with gray hair, clad in a blue robe and a shoulder cloak. This fresco demonstrates the artistic skill of the medieval painters.

Picture 2: The fresco Apostles Peter and Paul, The Church of the Holy Apostles Peter and Paul, Mušnikovo village

Source: Authors (2023)

The church was officially recognized as a cultural asset of national significance by the Institute for the Protection and Scientific Study of Cultural Monuments AKMO in Priština, with decision number 508 issued on December 20, 1956. From 2022, restoration efforts included improving drainage and waterproofing, installing new stone slabs on the roof, and paving the surrounding walkway. As a consequence of this works, the lower part of the north wall plaster crumbled, and some fresco fragments appeared (see Picture 3). It can be assumed that the unholly, in their communist times, as was the case with many churches, covered the frescoes with a thick (approximatelly 1.2 cm) layer of plaster. The moves of the scientists of the Institute for the protection of Cultural Monuments of Serbia are awaited.

Picture 3: The newly appeared fresco, The Church of the Holy Apostles Peter and Paul, Mušnikovo village

Source: Authors (2024)

A bell tower, likely constructed by local residents in the late 19th century, stands to the west of the church. The bell, weighing 560 kg, bears an inscription around the coat of arms of the Kingdom of Serbia: "Balkan Foundry-Belgrade, to the Church-Temple of St. Petka in Mušnikovo, Prizren, pledges this bell with voluntary contributions. Thank you, contributors. 10th August 1880" (Slavković S. & Slavković, D. 2015). As the belfry lacks state protection, it is more prone to deterioration. During the last two years it is being restored through the voluntary contributions of local residents. Following the significant exodus of the Orthodox community from the village in the summer of 1999, Slavka Ugrinović maintained the church until her passing. Today, investing their free time and effort, and often money, the church is cared for by Snežana and Dragoljub Slavković.

3. Methodology

For more than a half of century one of the useful tools to deal with uncertainty and imprecise linguistic statements, the fuzzy sets theory, represents a significant support to decision-making problems (Zadeh, 1975a, 1975b). Primarily, the aim of fuzzy sets, generalization of non-fuzzy sets, was the mathematical presentation of linguistic variables, enabling the decision-maker to make a model for partially unknown or incomplete information (Chou et al, 2013). In crisp set theory, the element belongs to a set or not, while in the theory of fuzzy sets the membership function (MF), usually denoted by μ is introduced. It serves to map each element of the universal set into the interval [0,1], determining the degree of belonginess of an element to a fuzzy set.

Let all fuzzy sets defined on the set of real numbers $\mathbb{R}$ be denoted as FS ($\mathbb{R}$). The number $G \in FS\ (\mathbb{R})$ is a fuzzy number if there exists $x_0 \in \mathbb{R}$ so it holds $\mu_G(x_0) = 1$ and for every $\lambda \in [0,1]$, $G_\lambda = [x, \mu_{G_\lambda}(x) \geq \lambda]$ is a closed interval (Milošević et al, 2020).

The fundamental part of triangular fuzzy number (TFN), its membership function, is defined as follows

$$\mu_{TFN}(x) = \begin{cases} \dfrac{x-l}{m-l}, & l \leq x \leq m \\ \dfrac{u-x}{u-m}, & m \leq x \leq u \\ 0, & otherwise, \end{cases}$$

where inequality $l \leq m \leq u$ holds. Numbers l, m and u serve as the lower, middle, and upper value of G respectively, while for $l = m = u$, TFN becomes a crisp number. Usual notation of the triangular fuzzy number will be $\tilde{G} = (l, m, u)$. Left and right side of the membership function $\mu_{TFN}(x)$ of TFN $\tilde{G} = (l, m, u)$, $\mu_{\tilde{G}}^{l}$ and $\mu_{\tilde{G}}^{r}$, as well as their matching inverse functions $(\mu_{\tilde{G}}^{l})^{-1}$ and $(\mu_{\tilde{G}}^{l})^{-1}$are respectively defined as $\mu_{\tilde{G}}^{l}$=$\frac{x-l}{m-l}$, $\mu_{\tilde{G}}^{r}$=$\frac{u-x}{u-m}$, $(\mu_{\tilde{G}}^{l})^{-1} = l + (m-l)y$, $(\mu_{\tilde{G}}^{r})^{-1} = u + (m-u)y, y \in [0,1]$. The total integral value, as a combination of left and right integral values is determined as follows (Kulak et all, 2005):

$$I_T^{\lambda}(\tilde{G}) = \lambda I_R(\tilde{G}) + (1-\lambda) I_L(\tilde{G})$$
$$= \lambda \int_0^1 (\mu_{\tilde{G}}^{r})^{-1} dy + (1-\lambda) \int_0^1 (\mu_{\tilde{G}}^{l})^{-1} dy =$$
$$= \frac{1}{2}\lambda(m+u) + \frac{1}{2}(1-\lambda)(m+l) = \frac{1}{2}(\lambda u + m + (1-\lambda) l),$$

where λ represents an optimism index, i.e. the attitude of an expert during decision-making process. The pessimistic point of view is presented taking the value λ=0, from where it is obtained that $I_T^0(\tilde{G}) = I_L(\tilde{G})$, for the value λ=1, the optimistic point of view is given, and $I_T^1(\tilde{G}) = I_R(\tilde{G})$. For λ=0.5, the balanced (moderate) attitude of the decision-maker is granted, and $I_T^{0.5}(\tilde{G}) = \frac{1}{2}\left(I_L(\tilde{G}) + I_G(\tilde{G})\right)$. There are also, recently introduced, semi-pessimistic, and semi-optimistic points of view, obtained for λ=0.25 and λ=0.75 respectively (Simjanović et al, 2022).

The main unary (scalar multiplication and inverse) and binary (addition, subtraction and multiplication) operations for TFNs $G_1 = (l_1, m_1, u_1)$ and $G_2 = (l_2, m_2, u_2)$ and scalar $k > 0$, $k \in \mathbb{R}$ are shown below (Wang et al, 2009):

$$\tilde{G}_1 \oplus \tilde{G}_2 = (l_1, m_1, u_1) \oplus (l_2, m_2, u_2) = (l_1 + l_2, m_1 + m_2, u_1 + u_2),$$
$$\tilde{G}_1 \ominus \tilde{G}_2 = (l_1, m_1, u_1) \ominus (l_2, m_2, u_2) = (l_1 - u_2, m_1 - m_2, u_1 - l_2),$$
$$\tilde{G}_1 \otimes \tilde{G}_2 = (l_1, m_1, u_1) \otimes (l_2, m_2, u_2) = (l_1 \cdot l_2, m_1 \cdot m_2, u_1 \cdot u_2),$$
$$k \cdot \tilde{G}_1 = k \cdot (l_1, m_1, u_1) = (k \cdot l_1, k \cdot m_1, k \cdot u_1),$$
$$\tilde{G}_1^{-1} = (l_1, m_1, u_1)^{-1} = \left(\frac{1}{u_1}, \frac{1}{m_1}, \frac{1}{l_1}\right).$$

In the sequel, the steps of the Fuzzy Analytic Hierarchy Process are summarized (Kahraman, 2004):

Step ONE: Establishing the main goal and hierarchical appearance of criteria.

The hierarchical structure, with the main goal as the most important component, at the top, has been organized vertically. The criteria and sub-criteria affecting the goal are at the intermediate levels, with alternatives at the lowest level.

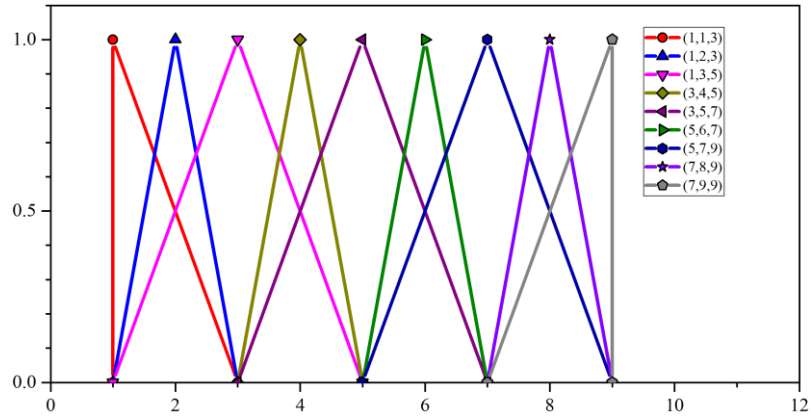
Step TWO: Setting the matrix $\tilde{H}$ in terms of triangular fuzzy numbers.

Criteria and sub-criteria are used during the pair-wise comparisons, enabling the creation of matrix $\tilde{H} = \left(\tilde{h}_{ij}\right)_{n\times n}$. The total of *n(n-1)/2* comparisons of elements from a higher level with elements from a lower level are made. Using triangular fuzzy numbers (TFNs), the hierarchy and comparison are given, where $\tilde{h}_{ij}$ is a fuzzy value representing the relative importance of one criterion to another. It holds that $\tilde{h}_{ii} = (1,1,1)$, when comparing criteria to itself, and $\tilde{h}_{ij} = 1/\tilde{h}_{ji}$ for $i \neq j$.

The fuzzy scale, TFNs, and their explanations used to enable pairwise comparisons are given:

TFN $\tilde{1}$: "Two criteria are equally important" $= (1, 1, 3)$
TFN $\tilde{3}$: "One criteria is slightly more important than another" $= (1, 3, 5)$
TFN $\tilde{5}$: "One criteria is strongly more important than another" $= (3, 5, 7)$
TFN $\tilde{7}$: "One criteria is very strongly more important than another" $= (5, 7, 9)$
TFN $\tilde{9}$: "One criteria is absolutely strongly more important than another" $= (7, 9, 9)$,
$\tilde{2} = (1, 2, 3), \tilde{4} = (3, 4, 5), \tilde{6} = (5, 6, 7)$, and $\tilde{8} = (7, 8, 9)$ are intermediate values used when compromise is needed (Dominguez, 2020). The graphic representation of the used FAHP scale with lower, median, and upper value is presented in Picture 4.

Picture 4: The Graphic representation of triangular fuzzy numbers



Step THREE: Matrix consistency calculation.

For matrix $H = (h_{ij})_{n\times n}$ we calculate the consistency index *CI* and consistency ratio *CR* using formulas

$$CI = \frac{\lambda_{max} - n}{n-1}, CR = \frac{CI}{RI},$$

where λ_{max} represents maximal eigenvalue of matrices H. The random index RI determined by the matrix size and corresponding value is shown as

$RI =$
$\{(3, 0.58), (4, 0.9), (5, 1.12), (6, 1.24), (7, 1.32), (8, 1.41), (9, 1.45), (10, 1.49)\}$.
The value $CR < 0.1$ verifies the matrix H consistency while differently, the reason for inconsistency should be determined, and all calculations redone.

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Step FOUR: The fuzzification process.
Applying formulas

$$D = \sum_{i=1}^{n}\sum_{j=1}^{n}\tilde{h}_{ij} = \sum_{i=1}^{n}\sum_{j=1}^{n}(l_{ij}, m_{ij}, u_{ij})$$

and

$$D^{-1} = \left(\sum_{i=1}^{n}\sum_{j=1}^{n}\tilde{h}_{ij}\right)^{-1} = \left(\frac{1}{\sum_{i=1}^{n}\sum_{j=1}^{n}u_{ij}}, \frac{1}{\sum_{i=1}^{n}\sum_{j=1}^{n}m_{ij}}, \frac{1}{\sum_{i=1}^{n}\sum_{j=1}^{n}l_{ij}}\right)$$

on triangular fuzzy numbers from the matrix $H = \left(h_{ij}\right)_{n\times n}$, the Chang synthetic fuzzy number $\tilde{S}_i = (l_i, m_i, u_i) = \sum_{j=1}^{n}\tilde{h}_{ij} \otimes D^{-1}$, $i = \overline{1,n}$ is obtained (Chang, 1996).

Step FIVE: The defuzzification process.
Applying the formula

$$w_i = I_T^{\lambda}(\tilde{S}_i) = 0.5(\lambda u_i + m_i + (1-\lambda)l_i)\,, i = \overline{1,n},\ \lambda \in [0,1],$$

on obtained TFNs $\tilde{S}_i$, $\overline{1,n}$, the total integral value is calculated.

Step SIX: Vector normalization and criteria weight calculation.
The weight vector $\boldsymbol{w} = (w_1, w_2, \dots, w_n)^T$ is normalized using formula

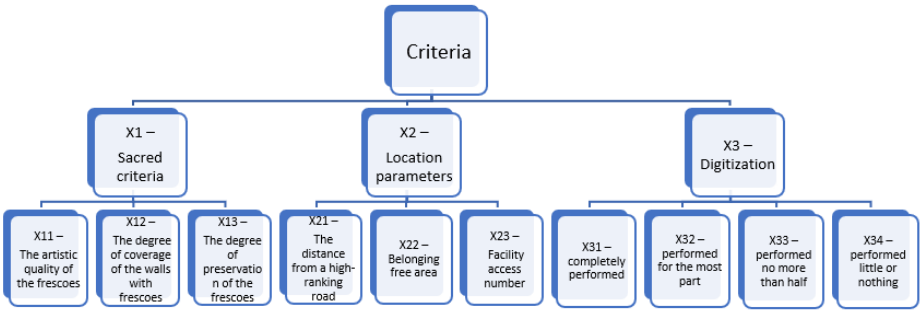
$$w_i^* = w_i\left(\sum_{i=1}^{n} w_i\right)^{-1}$$

After this, criteria ranking is performed.

4. Criteria and Sub-Criteria

Three major criteria groups, appreciating the experts' opinions are determined, with corresponding sub-criteria. The criteria and sub-criteria are presented in Picture 5. The corresponding sub-sub-criteria can be seen in (Simjanović et all, 2023).

Picture 5: The set of criteria and sub-criteria



5. Results and discussion

In this section we apply previously described method and present obtained results.

All matices were consistent, and in the sequel, Tables 1-4 and Picture 6 will explain the main criteria, and some sub-criteria ranking and sub-sub-criteria ranking.

Table 1. Comparison matrix for main criteria X (CI=0.005, CR=0.008)

X	X1	X2	X3
X1	1	2	3
X2	1/2	1	2
X3	1/3	1/2	1

Source: Authors (2024)

Table 2. Comparison matrix for sub-sub-criteria X11 (CI=0.01, CR=0.011)

X11	X111	X112	X113	X114
X111	1	2	3	4
X112	1/2	1	2	3
X113	1/3	1/2	1	2
X114	1/4	1/3	1/2	1

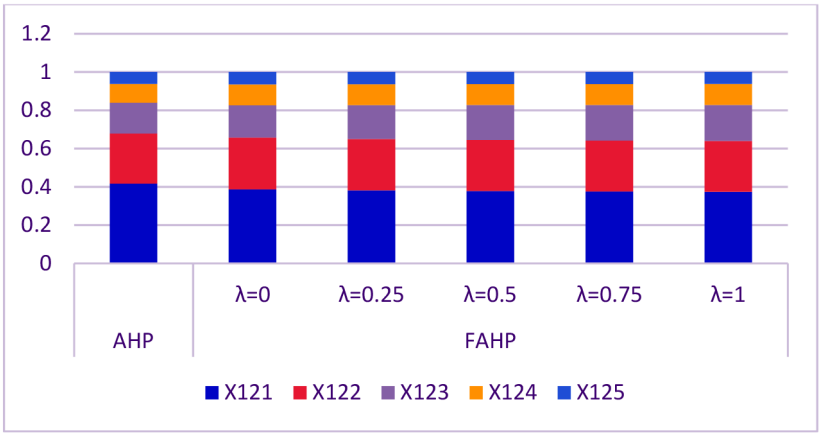
Source: Authors (2024)

Table 3. Weights for sub-sub-criteria X11 (CI=0.01, CR=0.011)

X12	AHP	FAHP				
		λ=0	λ=0.25	λ=0.5	λ=0.75	λ=1
X121	0.416212	0.386363	0.38084	0.377617	0.375506	0.374015
X122	0.261788	0.270868	0.268484	0.267093	0.266182	0.265538
X123	0.16105	0.168968	0.177569	0.182586	0.185874	0.188195
X124	0.098573	0.108697	0.109046	0.10925	0.109384	0.109478
X125	0.062376	0.065103	0.064061	0.063453	0.063055	0.062774

Source: Authors (2024)

Picture 6: Graphical representation of weights for sub-sub-criteria X11



Source: Authors (2024)

Table 4. Comparison matrix for sub-criteria X3 (CI=0.017, CR=0.019)

X3	X31	X32	X33	X34
X31	1	2	3	5
X32	1/2	1	2	4
X33	1/3	1/2	1	3
X34	1/5	1/4	1/3	1

Source: Authors (2024)

Among main criteria, the highest rank has the criteria X1 = Sacred criteria with weights 0.503 in the pessimistic, and 0.522 and 0.529 in the balanced and

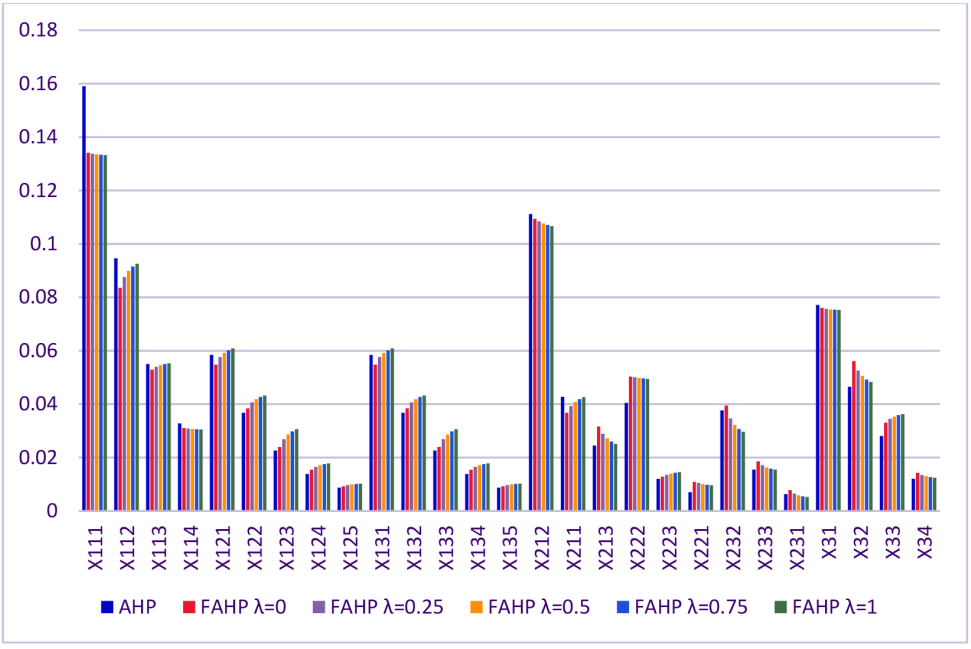
optimistic case of the FAHP. This criteria is followed by X2=Location parameters and X3=Digitization, whose weights in the balanced point of view are 0.304 and 0.174 respectively.

The leading sub-sub-criteria in groups of sub-criteria X11, X12, and X13 are X111=Exceptional quality of frescoes, X121 = 90%-100% of coverage of the walls with frescoes, and X131=90%-100% degree of preservation of the frescoes. Their weights for are 0.433, 0.378, and 0.378.

In the case of sub-criteria groups X21, X22, and X12, the highest rank have X212=200m-300m distance from a high-ranking road (weight is equal 0.613), X222=20%-50% of the belonging free area (weight is equal 0.675), and X232=Two accesses from the object (weight is equal 0.592).

The Completely performed digitization process named X31 with weights 0.471, 0.429, and 0.435 in the case of AHP, semi-pessimistic and semi-optimistic case of FAHP is the highest ranked sub-sub-criteria in the Digitization group of sub-criteria.

Picture 7: The final weights for all sub-sub-criteria



Source: Authors (2024)

The final ranking of sub-sub-criteria in presented in Picture 7. It can be observed that at the top of the ladder stands X111, followed by X212, X112, and

X31, same as those criteria were the leading ones in their corresponding groups. In the AHP case, X111 is approximately 1.43 times more important than X212, and 2.062 times more important than X31. In the FAHP case, for the pessimistic point of view, those quotions are equal 1.23, and 1.76, while in the optimistic point of view their values are 1.25 and 1.77. The importance of digitization and promotion of cultural heritage, its preservation, as well as national identity safeguarding is confirmed by the fourth place of the sub-sub-criteria X31. The highest degree of preservation of frescoes, X131, is also among important criteria, taking the fifth place.

At the end of the ladder, as iz could be expected, lie criteria conserning the lowest degree of coverage of the wall with fresco and fresco preservation, and long distance from a high-ranking road and small number of access roads. The highest ranked sub-sub-criteria is approximately 25.195 times more important than the lowest ranked one in the AHP case, while corresponding quotients in the pessimistic, balanced, and optimistic case of the FAHP are respectively equal 17.245, 22.736, and 25.392.

Conclusion

Cultural heritage provides a sense of identity and continuity for communities and individuals. It connects people with their past, shaping their present and future. Preserving traditions, languages, and historical sites helps maintain a community's unique character and promotes a sense of belonging. It also serves as a rich resource for education, providing tangible examples for teaching history, art, architecture, and social sciences. On the other side, many communities benefit economically from cultural tourism. Historic sites and cultural festivals can attract visitors, generate revenue, and create jobs. This economic incentive also reinforces the importance of preserving heritage. There is an important ethical obligation to preserve cultural heritage for future generations. This respect for the past ensures that future generations can experience and learn from the same cultural touchstones that we do today.

In this paper authors deal with many criteria, determining the important ones participating in the cultural heritage preservation. One orthodox church from the sixteenth century in the vicinity of Prizren was the theme of this article. Among all criteria, the importance of the quality of the frescoes, distance from the road, and high degree of digitization process stand out.

Our further research could be in determining the new set of criteria and expanding the number of churches in the same region.

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