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Evaluating the Strategies for Accessible Tourism in Cultural Heritage Sites: A Fuzzy SIWEC-RAWEC Methodology

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ABSTRACT

Ensuring inclusive access for people with disabilities is essential to achieving true equality and equity, key principles of sustainable tourism development. However, cultural tourism sites often encounter significant challenges in realizing this goal. Focusing on the Village Museum in Africa, this study proposes an integrated framework that comprises simple weight calculation and ranking alternatives with weights of criterion methods within a fuzzy (F-SIWEC-RAWEC) environment. First, data collection is conducted with four experts regarding six challenges and five strategies for accessible tourism in cultural heritage. While the SIWEC method assesses the weights of criteria, the RAWEC method ranks the strategies. The findings of the study indicate that insufficient funding and balancing site preservation with accessibility needs are the most critical challenges. Meanwhile, focused funding and resource development are the most appropriate strategy to overcome these challenges. Managers should implement adequate decision-support systems to direct dynamic and comprehensive planning and resource allocation for accessible tourism.

1. Introduction

Cultural tourism has gained popularity as a key strategy for promoting sustainable tourism, aligning with global democratic developments that emphasize equity and equality [1]. These changes have also improved accessibility in tourism, particularly for people with disabilities. The global commitment to disability rights, highlighted by the 2006 Convention on the Rights of Persons with Disabilities, marked a significant milestone in protecting the rights of over 600 million disabled people worldwide. Additionally, various initiatives and agreements aim to enhance accessibility and ensure the inclusion of disabled individuals in tourism, emphasizing the importance of fair and inclusive development.

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Due to increasing international attention and the effect of disability rights movements, policies have been implemented in advanced countries to foster the incorporation of disabled people in all angles of social life, besides tourism. These attempts have generated an environment where people with visual and physical impairments can comprehensively participate in frequent tourist places. Inversely, approachability is restricted in many less advanced countries, with limited facilities serving to wheelchair usage or giving appropriate information for those with loss of sensation [1]. However, various countries have started to adopt disability related laws to improve the inclusivity. In North American and European nations, the accessibility has been significantly improved in the tourism sector through travel experiences, services, and infrastructure upgrade for disabled people [2]. These efforts have led to the accessible tourism appearance-a concept focusing on eliminating barriers to movement of disabled people [2]. Being aware of the increasing necessity within this demographic, considerable steps have been taken in Australia to assist and create this niche market [3].

In response to growing international attention and the disability rights movement, many developed countries have implemented policies to promote the inclusion of disabled people in all aspects of social life, including tourism. These efforts have made popular tourist destinations more accessible to individuals with visual or physical impairments. However, in less developed countries, accessibility remains limited, with few facilities for wheelchair users or individuals with sensory impairments. In recent years, several countries have begun adopting disability-related laws to improve inclusivity. In North America and Europe, accessibility in tourism has been significantly enhanced through upgrades to services, infrastructure, and travel experiences [2]. This has led to the rise of accessible tourism, which focuses on removing barriers for disabled people. Recognizing the growing demand within this demographic, Australia has also taken significant steps to support and develop this niche market [3].

In many African countries, policies have been introduced to support the inclusion of disabled people in social services and employment, in line with global disability rights agreements. However, tourism policies often overlook the needs of disabled individuals, focusing more on the elderly, which limits their participation in cultural tourism [4]. Research on disability tourism in sub-Saharan Africa (SSA) is limited, and most studies focus on tourist motivations rather than the challenges disabled tourists face [5]. While countries in North America and Europe have explored barriers for disabled tourists [6], African countries with underdeveloped infrastructure have not widely applied similar frameworks. Furthermore, research tends to prioritize tourists' views over addressing accessibility issues at cultural heritage sites. Lwoga and Mapunda [7] examined the challenges encountered in cultural tourist sites in their attempts to provide for disabled people. However, they did not identify the most critical ones, nor did they propose appropriate strategies to overcome them. For that, a powerful managerial framework is required for accessible tourism in cultural heritage sites using a multi-criteria decision making (MCDM) approach. The application of MCDM approaches has proven to be successful in various studies [8, 9]. In this study, the challenges faced by cultural tourism sites in accommodating disabled visitors are assessed and effective solutions to overcome them are proposed. An integrated framework is adopted and comprises of the simple weight calculation (SIWEC) and ranking alternatives with weights of criterion (RAWEC) methods within a fuzzy environment.

The motivations of the study are as follows:

i. In contrast to other subjective criteria weighting approaches, the advantages of the SIWEC approach is to make easier the procedure of criteria significance determination for decision makers (DMs), where they will assess each criteria and will not compare them with each other nor prioritize them; to conduct the criteria weight computation procedure closer to DM and all needed parties in an easier manner, and adopt easier steps and processes for the criteria weight calculations [10].

ii. As for the RAWEC method, it offers a more streamlined and efficient ranking process by evaluating alternatives through deviation-based assessment, rather than relying solely on weighted scores as in SAW. In contrast to MARCOS and CRADIS approaches, RAWEC avoids the separate computation of ideal and anti-ideal reference points, reducing computational complexity and procedural steps. Moreover, unlike WASPAS, which blends outcomes from different techniques, RAWEC derives its compromise directly from deviation analysis, ensuring methodological consistency and simplicity.
iii. The contributions of the study are as follows:
iv. The integrated SIWEC-RAWEC approach, applied for the first time in this context, aims to promote accessible tourism at cultural heritage sites.
v. The most critical challenges are identified.
vi. The most appropriate strategies to overcome them are provided.

The remaining of the study is comprised of six sections: Section 2 Literature Review, Section 3 Problem definition, Section 4 Methodology, Section 5 Application, Section 6 Managerial implications, and Section 7 Conclusions and future recommendations.

2. Literature Review

2.1 Studies Related to Accessible Tourism in Cultural Heritage Sites

Various studies have been conducted on this topic. For instance, Spencer and Sargeant [11] examined how the sustainability of tourism should be measured at the sites related to cultural heritage and highlighted the necessity to enhance the collection of data, accurate parameters, good weighting approaches, and current long-term monitoring. Ismail *et al.,* [12] presents how cultural heritage tourism looks like in Malaysia, emphasizing its current challenges and state. Muštra *et al.,* [13] indicated the effect of cultural world heritage sites in the regional economic resilience in European countries. Their results indicated the considerable contribution of these sites to durable economic stability at regional level. Zhuang *et al.,* [14] compared cultural and social variations lead by tourism at world heritage locations. They found that a crucial role is played by tourism in modeling resident views and variations in moral values. Liu et *al.,* [15] examined how cultural heritage conservation, often reflective of Western values, impacts local sustainable livelihoods (SL) in a living cultural heritage site. Their findings show that changes related to tourism development and heritage conservation can reduce the sustainability of livelihoods in living heritage sites. Panzera *et al.,* [16] indicated the effect of cultural heritage in the European tourism sector via the assessment of cultural landscape, museums, and world heritage sites. García-Hernández *et al.,* [17] indicated how is the effect of tourism by pinpointing and assessing the different aspects of tourist pressure in a case study. Salehipour *et al.,* [18] centered on the Isfahan department to assess the ability related to Persian caravanserais for development as tourist attractions. Dong *et al.,* [19] studied the interaction approach among spatial patterns of conventional rural areas and tourism accessibility and accessibility in China. Moreno *et al.,* [20] explored the accessibility of cultural heritage sites in Seoul.

2.2 Applications and Extensions of SIWEC Approach

Since the introduction of SIWEC approach by Puška *et al.,* [21], various studies have used in different extensions. Badi *et al.,* [22] adopted it in a fuzzy environment to assess potential alternatives for strategic railway infrastructure planning in Libya. Their results indicated the strategy related to the development of coastal corridors as the most appropriate one. Katrancı *et al.,* [23] applied it for the choice of durable disposal technology and revealed how composting is considered the most appropriate technology. Şimşek *et al.,* [24] proposed an approach to pinpointing the most influential parameters to the procurement performance in the investment of solar energy projects. Their findings indicated how important strategy definition is during this process. Štilić *et al.,* [25] evaluated the ability to valorize tourist in botanical gardens and found that how these gardens playing an important role in varying tourist offerings. Yalçın *et al.,* [26] adopted a new integrated framework for choosing a transport policy in Northern Russia. Cao *et al.,* [27] implemented new technology for green digital twins. Çizmecioğlu *et al.,* [28] adopted an integrated framework to evaluate the most appropriate investment strategies for enhancing the technologies related to digital twins. Puška *et al.,* [29] adopted a fuzzy rough technique for the choice of electric vehicles for small farming. Eti *et al.,* [30] assessed the main strategies for the adoption of renewable energy in localized supply chain networks. The application and extensions of SIWEC approach are indicated in Table 1.

Table 1
Application and extensions of SIWEC method

Authors	Objective	Methodology	Location
Puška *et al.,* [21]	Choice in the sale channels of agricultural things	SIWEC, F-SIWEC	Bosnia and Herzegovina
Badi *et al.,* [22]	Strategic railway planning development	F-SIWEC, RAWEC	Libya
Katrancı *et al.,* [23]	Choice of sustainable waste disposal	F-SIWEC, F-RAWEC	Turkish
Şimşek *et al.,* [24]	Assessment of purchasing procedure in solar energy project investment	SIWEC	-
Štilić *et al.,* [25]	Valorizing tourism in botanical gardens	F-SIWEC, TOPSIS	Croatia
Yalçın *et al.,* [26]	Choice of transportation policy	IF-SIWEC-ARLON	Northern Russia
Cao *et al.,* [27]	Implementing new techniques to green digital twins	SF-SIWEC-SAW	-
Çizmecioğlu *et al.,* [28]	Strategic choice of competitive intelligence platforms	p, q-QOFN, SIWEC-MABAC	-
Puška *et al.,* [29]	Choice of electric cars	FR-SIWEC-RAWEC	-
Eti *et al.,* [30]	Strategy building for the adoption of renewable energy in localized supply chain networks	FF-SIWEC-EDAS	-

Note: ARLON- Alternative Ranking using two-step Logarithmic Normalization; two-step LOgarithmic Normalization; EDAS- Evaluation Based on Distance from Average Solution ; FF-Fermatean Fuzzy; FR-Fuzzy Rough; MABAC- Multi-Attributive Border Approximation area Comparison ; p, q-QOFN- p , q-quasirung Orthopair fuzzy number; RAWEC- Ranking of Alternatives with Weights of Criterion; SAW - Simple Additive Weighting; TOPSIS- Technique for Order of Preference by Similarity to Ideal Solution.

2.3 Applications and Extensions of the RAWEC Approach

Since the introduction of RAWEC technique by Puška *et al.,* [31], it has been applied in various fields. For instance, Nedeljković *et al.,* [32] adopted an integrated approach to determine the channel for selling cabbage for customers. Their study showed that good results are obtained with online sales. Puška *et al.,* [33] examined the implementation of renewable energy alternatives in the agriculture sector. Their findings revealed that solar energy is the most prioritized. Petrović *et al.,*

[34] adopted a multi-criteria approach for sustainability assessment of distinct transportations modes in Europe. Demir and Ulusoy [35] implement a hybrid approach to explore which of the communications technologies are the most sustainable. Dündar and Karadağ [36] determined which of the 45 African countries is appropriate for a top cosmetic enterprise functioning in Turkey location. Mukhametzyanov and Pamucar [37] compared various MCDM approaches to find the most appropriate. Tešić *et al.,* [38] extends the RAWEC method under Fermatean fuzzy approach. Badi *et al.,* [39] presented an integrated technique to evaluate pharmacies through some service measures. The application and extensions of SIWEC approach is indicated in Table 2.

Table 2
Application and extensions of RAWEC method

Authors	Objective	Methodology	Location
Nedeljković *et al.,* [32]	Choice related to agricultural products sales	F-MEREC-RAWEC	Bosnia and Herzegovina
Puška *et al.,* [33]	Enhancing agricultural sustainability	DIWEC, F-RAWEC	Bosnia and Herzegovina
Petrović *et al.,* [34]	Sustainable transport mode evaluation	RAWEC	European Union
Demir and Ulusoy [35]	Sustainable communication technology assessment	F-WENSLO-RAWEC	-
Dündar and Karadağ [36]	Facility location choice for cosmetic enterprise	F-LBWA, I-RAWEC	Africa
Mukhametzyanov and Pamucar [37]	Comparative analysis of MCDM approaches	WSM, RS, MABAC, TOPSIS, MAIRCA, RAWEC	-
Tešić *et al.,* [38]	Improvement of MCDM approach for alternative ranking	FF-RAWEC	-
Badi *et al.,* [39]	Performance assessment of pharmacy service measures	DES, RAWEC	Libya

Note: DIWEC- Direct Weight Calculation; F-Fermatean; LBWA- Level Based Weight Assessment; MAIRCA- Multi Atributive Ideal-Real Comparative Analysis; MEREC- MEthod based on the Removal Effects of Criteria; RS- Ratio System approach; WENSLO- Weight by Envelope and Slope; WSM- Weighted Sum Model.

3. Problem Definition

Table 3 outlines the key barriers to accessible tourism at cultural heritage sites in African countries [7, 40-42], each paired with targeted approaches designed to address and overcome these issues.

Table 3
Criteria and alternatives definition

Criteria	References
Poor accessibility in interpretation for disabled visitors (C1) Lack of designated parking spaces (C2) Insufficient funding (C3) Lack of skilled interpreters for effective communication (C4) No resting or seating areas available (C5) Challenge of balancing site preservation with accessibility needs (C6)	[7, 40-42]

Table 3
Continued

Alternatives	References
Equitable planning for preservation and accessibility (S1)	[40]
Focused funding and resource development (S2)	Expert opinion
Creation of accessible interpretive materials (S3)	Expert opinion
Enhancing infrastructure with universal design principles (S4)	[41]
Training interpreters and building capacity (S5)	Expert opinion

4. Methodology

An Integrated fuzzy SIWEC-RAWEC methodology is adopted to assess the challenges as well as the strategies to overcome them for accessible tourism in cultural heritage sites. The first stage is the fuzzy SIWEC application through following steps. Figure 1 shows the flowchart of our methodology.

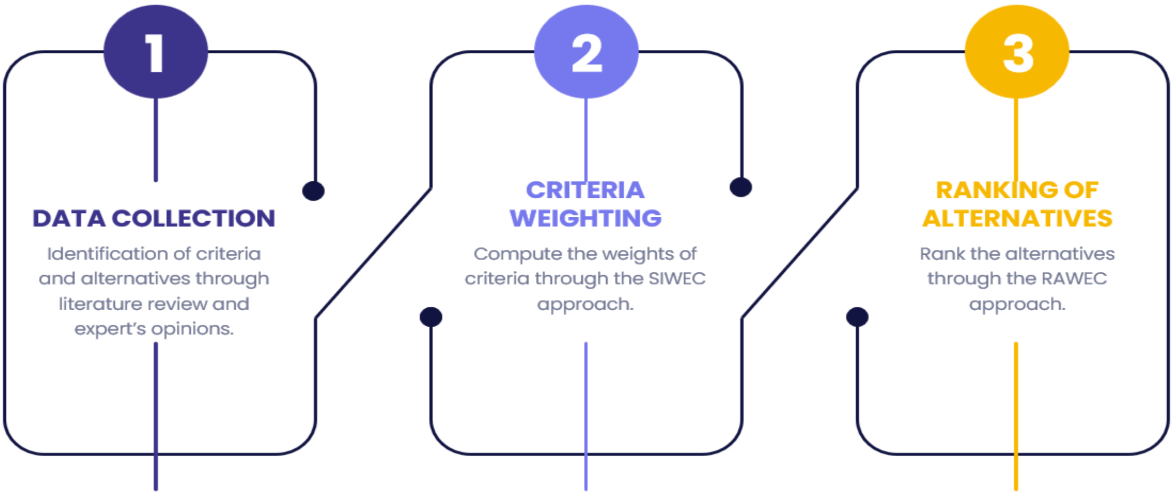

Fig. 1. The flowchart of our methodology

Step 1. The relative significance of each criterion is assessed by experts by attributing linguistic variables from Table 4 to represent the opinion of experts.

Table 4
Fuzzy linguistic evaluation scale

Linguistic terms	Membership function
Absolutely bad (AB)	(1,1,1)
Very bad (VB)	(1,2,3)
Bad (B)	(2,3,4)
Medium-bad (MB)	(3,4,5)
Equal (E)	(4,56)
Medium-good (MG)	(5,6,7)
Good (G)	(6,7,8)
Extremely good (EG)	(7,8,9)
Absolutely good (AG)	(8,9,10)
Perfect (P)	(9,10,10)

Step 2. Experts offered linguistic evaluations which are transferred to triangular fuzzy numbers, which are defined as lower, middle, and upper bounds, thereby apprehending the subjectivity in experts' opinions.

$$\tilde{x}_{ij} = \left(x_{ij}^{l}, x_{ij}^{m}, x_{ij}^{u}\right) \tag{1}$$

Step 3. The original fuzzy decision matrix is established according to fuzzy numbers obtained from the assessment of the experts. Each parameter represents the observed significance of a defined criterion, including the ambiguity apprehended through the evaluation of linguistics. This matrix represents the foundation for criteria weights computation using the F-SIWEC technique.

$$\begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{12} & \dots & \tilde{x}_{1n} \\ \tilde{x}_{21} & \tilde{x}_{22} & \dots & \tilde{x}_{2n} \\ . & . & \dots & . \\ . & . & \dots & . \\ . & . & \dots & . \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \dots & \tilde{x}_{mn} \end{bmatrix} \tag{2}$$

Step 4. In this stage, there is a normalization of fuzzy values from the decision matrix by dividing them by the greater upper bound ($\max x_{ij}^{u}$) seen through all criteria and experts.

$$\tilde{n}_{ij} = \frac{x_{ij}^{l}}{\max x_{ij}^{u}}, \frac{x_{ij}^{m}}{\max x_{ij}^{u}}, \frac{x_{ij}^{u}}{\max x_{ij}^{u}} \tag{3}$$

Step 5. There is a calculation of standard deviation (std.dev_j) according to fuzzy numbers obtained from experts. This calculation represents consistency or variation in the criteria assessment, permitting the approach to highlight criteria where the judgments of experts indicate higher differentiation, an important characteristic of the F-SIWEC technique for apprehending the associated importance under ambiguity.

Step 6. A multiplication of normalized fuzzy rating by related values of standard deviation is made to reflect the normalized fuzzy rating.

$$\tilde{v}_{ij} = \tilde{n}_{ij} \times st.dev_j \tag{4}$$

Step 7. An aggregation of fuzzy weighted values for each parameter is made through the summation of weighted fuzzy assessment offered by all experts. This produced a general representation of each parameter's significance, allowing both independent expert opinions and the ambiguity captured in antecedent steps. The results are an integrated fuzzy weight for each parameter, which becomes a foundation for finding the final significance rankings.

$$\tilde{S}_{ij} = \sum_{j=1}^{n} \tilde{v}_j \tag{5}$$

Step 8. There is a division of each independent fuzzy value by total sum of all fuzzy values to acquire the normalized fuzzy weight for each parameter. During this procedure, it is important to guarantee that the lower bound is less or equal to the middle value. This is possible only if the logical order of the fuzzy numbers is maintained.

$$\widetilde{w}_{ij} = \frac{S_{ij}^{l}}{\sum_{j=1}^{n} S_{ij}^{u}}, \frac{S_{ij}^{m}}{\sum_{j=1}^{n} S_{ij}^{m}}, \frac{S_{ij}^{u}}{\sum_{j=1}^{n} S_{ij}^{l}} \tag{6}$$

Step 9. There is a retention in the final fuzzy weights of each criterion through their fuzzy form or de-fuzzified into crisp values, based on the analytical necessities. In this study, there is a de-fuzzified of fuzzy weights employing a suitable defuzzification approach to transfer each fuzzy number into a unique representative value.

$$w_{jdef} = \frac{w_{ij}^{l} + 4 \times w_{ij}^{m} + w_{ij}^{l}}{6} \tag{7}$$

The second stage is related to the application of the fuzzy RAWEC approach through the following steps:

Step 1. The decision-makers evaluate the alternative strategies using the linguistic variables in Table 4, which are later transformed into the associated fuzzy numbers to create individual fuzzy evaluation matrices. The numbers in the matrices are averaged to produce the averaged fuzzy decision matrix.

Step 2. Normalization calculated for both maximum and minimum normalization using the average fuzzy decision matrix. The benefit and cost criteria are normalized using Eq. s (8) and (9) respectively for the maximum normalization process. Minimum normalization is performed by normalizing the benefit and cost criteria using Eq. (10) and Eq. (11).

For maximum normalization

$$n_{ij} = \frac{x_{ij}^{l}}{\max x_j^u}, \frac{x_{ij}^{m}}{\max x_j^u}, \frac{x_{ij}^{u}}{\max x_j^u} \text{ }, for\ benefit\ criteria \tag{8}$$

$$n_{ij} = \frac{\min x_j^l}{x_{ij}^{u}}, \frac{\min x_j^l}{x_{ij}^{m}}, \frac{\min x_j^l}{x_{ij}^{l}}, for\ cost\ criteria \tag{9}$$

For maximum normalization

$$n'_{ij} = \frac{\min x_j^l}{x_{ij}^{u}}, \frac{\min x_j^l}{x_{ij}^{m}}, \frac{\min x_j^l}{x_{ij}^{l}} \text{ }, for\ benefit\ criteria \tag{10}$$

$$n'_{ij} = \frac{x_{ij}^{l}}{\max x_j^u}, \frac{x_{ij}^{m}}{\max x_j^u}, \frac{x_{ij}^{u}}{\max x_j^u} \text{ }, for\ cost\ criteria \tag{11}$$

While x_j^{min} and x_j^{max} denotes the minimum and maximum value of a given criterion respectively.

Step 3. The criteria derived from the F-SEWIC method are applied to compute the weighted deviation values. Subsequently, the aggregate deviation for all alternatives is determined using Eq. s (12) and (13), respectively.

$$\tilde{v}_{ij} = \sum_{i=1}^{n} \widetilde{w}_j . (1 - \tilde{n}_{ij}) \tag{12}$$

$$\widetilde{v'}_{ij} = \sum_{i=1}^{n} \widetilde{w}_j . (1 - \widetilde{n'}_{ij}) \tag{13}$$

While $\widetilde{w}_j$ refers to the weight of the criterion j.

Step 4. The fuzzy numbers are converted into crisp values through a defuzzification process, using Eq. s (14) and (15) respectively.

$$v_{ij} = \frac{v_i^l + 4v_i^m + v_i^u}{6} \tag{14}$$

$$v'_{ij} = \frac{v\prime_i^l + 4v\prime_i^m + v\prime_i^u}{6} \tag{15}$$

Step 5. The ranking of the alternatives is measured using Eq. (16).

$$Q_i = \frac{v\prime_{ij} - v_{ij}}{v\prime_{ij} + v_{ij}} \tag{16}$$

5. Application

In this study, an integrated SIWEC-RAWEC approach is adopted for evaluation of strategies for accessible tourism in cultural heritage. To collect data, four experts from both academia and industry have participated. The expert panel consisted of two women and two men, each holding at least a master's degree and possessing a minimum of five years of professional experience in the relevant field. The foundation of the fuzzy weight calculation is the linguistic decision-making matrix, obtained through the expert assessments for each criterion. This matrix, detailed in Table 5, captures the initial judgments of the four experts.

Table 5
Linguistic decision-making matrix

	C1	C2	C3	C4	C5	C6
E1	G	E	AG	B	MB	G
E2	MG	E	EG	AB	E	G
E3	G	E	EG	AB	MB	EG
E4	E	MB	EG	AB	B	EG

To create the initial fuzzy decision matrix based on expert judgments, it was essential to first normalize the data to allow for meaningful comparisons across all criteria. Following the F-SEWIC methodology, this normalization process involved dividing each triangular fuzzy number by the highest upper-bound value from all expert assessments for each criterion. This approach transformed the entire data range into a normalized scale of [0, 1]. It is crucial to note that this step preserved the relative importance of the expert assessments, ensuring that the proportional relationships between the values remained intact without introducing any distortions. The resulting initial fuzzy decision matrix and its normalized counterpart are presented in Table 6. This normalization step addressed any potential biases tied to the scale of the numbers, establishing a consistent and unbiased baseline for the next stage, deriving the weights for each criterion which forms the basis for Stage 2 of the process.

Table 6
Normalized fuzzy decision-making matrix

	C1	C2	C3	C4	C5	C6
E1	(0.6,0.7,0.8)	(0.4,0.5,0.6)	(0.8,0.9,1.0)	(0.2,0.3,0.4)	(0.3,0.4,0.5)	(0.6,0.7,0.8)
E2	(0.5,0.6,0.7)	(0.4,0.5,0.6)	(0.7,0.8,0.9)	(0.1,0.1,0.2)	(0.4,0.5,0.6)	(0.6,0.7,0.8)
E3	(0.6,0.7,0.8)	(0.4,0.5,0.6)	(0.7,0.8,0.9)	(0.1,0.1,0.2)	(0.3,0.4,0.5)	(0.7,0.8,0.9)
E4	(0.4,0.5,0.6)	(0.3,0.4,0.5)	(0.7,0.8,0.9)	(0.1,0.1,0.2)	(0.2,0.3,0.4)	(0.7,0.8,0.9)

After normalization, the F-SEWIC method proceeds by factoring in the degree of consensus among the experts. This is done by multiplying the normalized fuzzy values by the standard deviation for each criterion, which reflects the variability in the experts' opinions. By doing so, criteria with greater disagreement among experts are given more weight, signaling that these criteria are either particularly relevant to an ongoing debate or exhibit variability within the context. The next step involves calculating the summed values, as shown in Table 7, which includes both the normalized fuzzy weights and the variability in expert opinions. The sum of these weighted values results in the initial fuzzy weights for each criterion, as determined by the expert team, while also capturing the inherent uncertainty. Throughout this calculation, care was taken to maintain the three-step fuzzy number sequence, ensuring that the condition (lower bound ≤ mode ≥ upper bound) holds true for each resulting fuzzy weight.

Table 7
Obtaining final values of the criteria by using fuzzy SIWEC method

Criterion	$\tilde{s}_{ij}$	$\tilde{w}_{ij}$
C1	(0.51,0.61,0.71)	(0.14,0.19,0.27)
C2	(0.37,0.46,0.56)	(0.10,0.15,0.21)
C3	(0.71,0.81,0.91)	(0.19,0.26,0.34)
C4	(0.12,0.14,0.24)	(0.03,0.05,0.10)
C5	(0.29,0.39,0.49)	(0.08,0.12,0.18)
C6	(0.64,0.74,0.84)	(0.17,0.23,0.32)

The results showed Figure 2 establish a clear hierarchy of concerns, reflecting the expert consensus that insufficient funding (C3) is the most critical challenge, dominating all others with the highest weight of 0.2594. This underscores the fact that financial constraint is the primary barrier to implementing accessibility and conservation improvements across African heritage sites. The second most important factor is the challenge of balancing site preservation with accessibility needs (C6) at 0.2377, highlighting the delicate policy balancing act required for sustainable tourism. In contrast, challenges related to the absence of skilled interpreters for effective communication (C4) (0.0509) and the non-resting or seating areas available (C5) (0.1259), received the lowest weights.

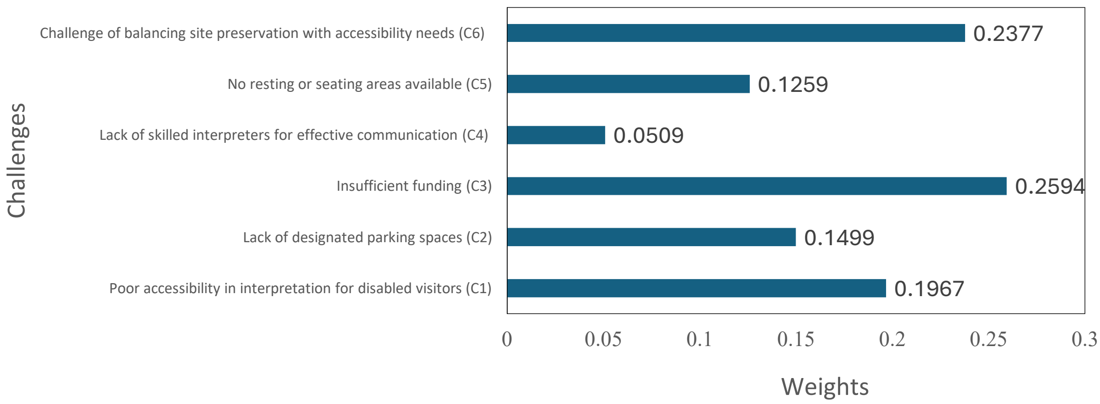

Fig. 2. Defuzzied value of the weights of achievements

Following the determination of criterion weights using the F-SIWEC methodology, the F-RAWEC approach was employed to evaluate the most suitable strategies to overcome these challenges. In the initial phase of the F-RAWEC process, decision makers assessed alternatives using linguistic variables varying from extremely low (EL) to extremely high (EH). These individual evaluations are compiled in Table 8.

Table 8
Initial Decision Matrix for Alternatives

Strategy 1	C1	C2	C3	C4	C5	C6
E1	L	H	H	VL	M	M
E2	L	H	M	VL	M	H
E3	M	VH	H	L	H	M
E4	M	VH	VH	L	H	H
Strategy 2	C1	C2	C3	C4	C5	C6
E1	VL	VL	L	H	L	L
E2	L	VL	VL	VH	M	VL
E3	VL	L	VL	H	L	VL
E4	L	L	VL	VH	L	VL
Strategy 3	C1	C2	C3	C4	C5	C6
E1	M	H	L	M	L	H
E2	L	M	H	VL	M	M
E3	H	VH	VH	M	H	VH
E4	M	VH	VH	M	H	H

Table 8
Continued

Strategy 4	C1	C2	C3	C4	C5	C6
E1	L	M	L	VL	L	M
E2	M	M	M	L	M	H
E3	L	L	M	VL	L	M
E4	M	M	M	L	L	M
Strategy 5	C1	C2	C3	C4	C5	C6
E1	L	H	H	VL	H	H
E2	M	H	VH	VL	H	H
E3	L	VH	H	L	VH	VH
E4	L	VH	H	VL	VH	H

An average fuzzy decision matrix was subsequently constructed by aggregating the decision makers' ratings, with the results presented in Table 9. The fuzzy decision matrix $\tilde{X}$, derived by aggregating the raw linguistic ratings from the experts, establishes the performance data for the F-RAWEC ranking process. Each element $\tilde{x}_{ij}$ is a Triangular Fuzzy Number (TFN) that quantitatively represents the effectiveness of strategy S_i in mitigating criteria C_j. As all criteria are designated as Cost type, a strategy with a lower TFN in this matrix is considered more effective. This matrix is subsequently normalized and combined with the F-SIWEC weights to determine the final strategy rank.

Table 9
Average fuzzy decision matrix

Strategy	C1	C2	C3	C4	C5	C6
S1	(2.0,4.25,8.0)	(6.0,7.75,9.0)	(4.0,7.75,9.0)	(1.0,3.50,4.0)	(4.0,6.00,8.0)	(4.0,6.50,8.0)
S2	(1.0,2.75,4.0)	(1.0,2.75,8.0)	(1.0,2.50,4.0)	(6.0,7.75,9.0)	(2.0,3.50,6.0)	(1.0,2.50,4.0)
S3	(2.0,5.75,8.0)	(6.0,8.25,9.0)	(2.0,7.75,9.0)	(1.0,4.75,6.0)	(2.0,6.50,8.0)	(6.0,7.75,9.0)
S4	(2.0,3.75,6.0)	(4.0,5.00,8.0)	(2.0,4.00,6.0)	(1.0,3.25,4.0)	(2.0,4.00,6.0)	(4.0,5.00,8.0)
S5	(2.0,3.75,6.0)	(6.0,7.75,9.0)	(6.0,7.75,9.0)	(1.0,3.50,4.0)	(6.0,8.25,9.0)	(6.0,7.75,9.0)

Table 10 showed the normalized matrices, which serve the critical function of rescaling the fuzzy decision matrix (X) into two directly comparable measures, revealing each strategy's relative proximity to the optimal and worst-case fuzzy solutions. Since all criteria are designated as cost type (representing challenges to be minimized), the performance goal is to achieve the lowest possible TFN rating. The $\tilde{n}_{ij}$ matrix measures the closeness of a strategy to the fuzzy anti-ideal solution (FAIS) (the worst possible performance), where a lower TFN is desired. Conversely, the $\widetilde{n'}_{ij}$ matrix measures the closeness to the fuzzy ideal solution (FIS) (the best possible performance), where a higher TFN is favorable. Analysis of these matrices immediately highlights performance differences: strategies S1 (focused funding and resource development) and S2 (equitable planning) consistently exhibit lower $\tilde{n}_{ij}$ values and higher $\widetilde{n'}_{ij}$ values against crucial criteria like C3 (insufficient funding) and C6 (challenge of balancing site preservation), indicating a superior efficiency in mitigating these specific operational challenges compared to S3 (accessible interpretative materials) and S5 (training interpretative and building capacity). These normalized TFNs are then multiplied by the F-SIWEC weights to quantify the final weighted deviations, which ultimately determine the relative ranking of the strategies.

Table 10
Normalized matrices

S#	C1	C2	C3	C4	C5	C6
$S1\ \tilde{n}_{ij}$	(0.22, 0.74, 4.00)	(0.67, 0.94, 1.50)	(0.44, 1.00, 2.25)	(0.11, 0.45, 0.67)	(0.44, 0.73, 1.33)	(0.44, 0.84, 1.33)
$S2\ \tilde{n}_{ij}$	(0.11, 0.48, 2.00)	(0.11, 0.33, 1.33)	(0.11, 0.32, 0.67)	(0.67, 1.00, 1.50)	(0.22, 0.42, 1.00)	(0.11, 0.32, 0.67)
$S3\ \tilde{n}_{ij}$	(0.22, 1.00, 4.50)	(0.67, 1.00, 1.50)	(0.22, 1.00, 1.50)	(0.11, 0.61, 1.00)	(0.22, 0.79, 1.33)	(0.67, 1.00, 1.50)
$S4\ \tilde{n}_{ij}$	(0.22, 0.65, 3.00)	(0.44, 0.61, 1.33)	(0.22, 0.52, 1.00)	(0.11, 0.42, 0.67)	(0.22, 0.48, 1.00)	(0.44, 0.65, 1.33)
$S5\ \tilde{n}_{ij}$	(0.22, 0.65, 3.00)	(0.67, 0.94, 1.50)	(0.67, 1.00, 1.50)	(0.11, 0.45, 0.67)	(0.67, 1.00, 1.50)	(0.67, 1.00, 1.50)
$S1\ \widetilde{n'}_{ij}$	(0.50, 0.79, 2.00)	(0.11, 0.35, 1.33)	(0.11, 0.32, 1.00)	(0.25, 0.93, 4.00)	(0.25, 0.58, 3.00)	(0.25, 0.38, 4.00)
$S2\ \widetilde{n'}_{ij}$	(1.00, 1.00, 4.00)	(1.00, 1.00, 8.00)	(1.00, 1.00, 4.00)	(0.11, 0.42, 0.67)	(0.33, 0.86, 3.00)	(1.00, 1.00, 4.00)
$S3\ \widetilde{n'}_{ij}$	(0.22, 0.48, 2.00)	(0.11, 0.33, 1.33)	(0.11, 0.32, 0.80)	(0.17, 0.68, 4.00)	(0.25, 0.54, 3.00)	(0.11, 0.32, 1.00)
$S4\ \widetilde{n'}_{ij}$	(0.33, 0.73, 2.00)	(0.13, 0.55, 2.00)	(0.17, 0.63, 2.00)	(0.25, 1.00, 4.00)	(0.33, 0.88, 3.00)	(0.13, 0.50, 4.00)
$S5\ \widetilde{n'}_{ij}$	(0.33, 0.73, 2.00)	(0.11, 0.35, 1.33)	(0.11, 0.32, 0.67)	(0.25, 0.93, 4.00)	(0.22, 0.42, 1.00)	(0.11, 0.32, 1.00)

The final ranking phase of the F-RAWEC method, shown in Table 11, synthesized the complex fuzzy weighted deviations into a single, crisp $Q_i\ score$, establishing the definitive hierarchy among the five intervention strategies aimed at enhancing accessibility in African heritage sites. Since all criteria were defined as Cost type (challenges), the ranking rule dictates that the alternative with the lowest Q_i score is the most preferred, as it achieves the optimal balance between minimizing the distance from the Fuzzy Ideal Solution V_i' and maximizing the distance from the Fuzzy Anti-Ideal Solution Vi. Strategy S2 (Focused funding and resource development) emerged as the optimal solution, securing Rank 1 with the lowest $Q_i\ score$ of 0.619, driven by its favorable V_i' (0.325), which indicates the smallest weighted distance from the ideal (best) outcome across all criteria. This result established a clear strategic hierarchy of S2>S1>S4>S3>S5. Conversely, S5 (Training interpreters and building capacity) was the least suitable option, reflecting the highest Qi score of 0.706.

Table 11
Defuzzification of Deviation from the Criterion Weight

Strategy	V_i	V'_i	Q_i	Rank
S1	0.292	0.499	0.634	2
S2	0.2	0.325	0.619	1
S3	0.176	0.408	0.698	4
S4	0.275	0.522	0.655	3
S5	0.173	0.416	0.706	5

6. Managerial Implications

From a managerial perspective, the findings highlight the necessity for site managers to treat accessibility funding as a core strategic priority rather than an optional or peripheral cost, while systematically integrating accessibility requirements into heritage conservation and preservation plans. Managers and policymakers should pursue holistic management frameworks that harmonize inclusive design principles with the safeguarding of cultural values, ensuring that improvements in accessibility respect and preserve site authenticity. The results further emphasize the importance of data-driven and evidence-based decision-making to optimize resource allocation and select the most effective strategies within financial limitations. In addition, tourism authorities and cultural site administrators are advised to reinforce institutional collaboration and organizational capacity, through targeted staff training, cross-stakeholder coordination, and inclusive governance mechanisms, to support the successful implementation of accessibility initiatives. Overall, these actions can foster greater social equity, enhance the quality of visitor experiences, and strengthen the long-term sustainability and competitive positioning of cultural tourism destinations.

7. Conclusions

In this study, an integrated fuzzy SIWEC-RAWEC methodology is proposed to evaluate the strategies for accessible tourism in cultural heritage sites. For that six challenges as well as four strategies are identified. To collect the data, four experts are involved. The results indicated that insufficient funding and balancing site preservation with accessibility needs are the most critical challenges. The findings also indicated that focused funding and resource development strategy is the most appropriate to overcome these challenges. While the study has made some contributions, it has some limitations. First, a small number of experts participated. Second, since Africa is comprised of 54 countries, the findings cannot be generalized because every country may have specific characteristics. Future studies should consider increasing the number of experts, conducting the study at national or regional levels. In addition, it will important to adopt our methodology in other sectors such agriculture, healthcare [43], education [44] and so on [45]. Further new methodology can be adopted using an integration of data envelopment analysis (DEA) and fuzzy logic. Moreover, we should consider the clustering approach as a future research direction given the number of African countries with various characteristics.

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Conflicts of Interest

The authors declare no conflicts of interest.

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