Value assessment of existing architectural heritage for future generation using criteria importance through inter-criteria correlation and grey relational analysis method: a case of Odisha temple architecture in India

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This study aims to assess the value of architectural heritage (AH) for its management. Previously, evaluation of AH has been done based on the opinions of experts. In this study, weights of criteria and overall aggregation have been used based on the collected data, thus minimizing the bias in the opinions of experts and reducing the time of evaluation. To derive relative importance of the multi-dimensional values, criteria importance through inter-criteria correlation has been used, and for aggregation of the grey relationship values, the grey relational analysis method has been applied. In a hierarchy process, these two methods have been repetitively applied to obtain the index value of AH. For a case study, the Odisha temple architecture in India has been considered. The results have been compared with the existing state of protection, and the areas where there is a possibility of improvement of architectural heritage value for its management are discussed.

Keywords: Architectural heritage, evaluation and conservation, expert opinion, hierarchy process, value assessment.

THE phrase 'architectural heritage' (AH) is defined and interpreted in different ways. It is related to phrases like 'cultural built heritage'[1], 'historical buildings'[2], 'architectural built heritage'[3] and 'buildings associated with events and personality'[4]. AH has multiple dimensional values. Different international organizations such as ICOMOS and UNESCO, government agencies and individual researchers view AH differently. They value AH as the custodian for future generations. However, protecting the existing AH for future generations is not feasible due to limitations such as the political system, finance, environment, urbanization and rise in real estate demand in the core areas of the cities. Therefore, the future of AH is in danger. The type of AH that needs to be maintained with limited resources is the main factor to be considered during conservation efforts. Before going into the details of AH, one needs to consider the parameters (the directly measurable criteria) that must be evaluated for conservation.

International organizations such as ICOMOS, UNESCO and their charters mainly provide broader aspects of AH with a qualitative approach[5]. UNESCO has provided 10 aspects for selecting the World Heritage Sites (WHS), among which the first six are for man-made structures[6].

In different countries, various governmental organizations have provided specific dimensions (the broader aspects) and parameters (the measurable components under a dimension) for evaluating their AH. Organizations such as Heritage Council of Brampton Flower City used dimensions such as design, historical and contextual values in 2000, along with evaluation of the presence or absence of the parameters associated with AH[7]. In 2013, The Heritage Advisory Committee Ontario Heritage Act used the same dimensions with a five-point rating system for parameters that varied from excellent to low[8]. Kalman[9] used architectural, historical, environmental, usability and integrity of dimensions of AH for assessment. He used a verbal scale for data collection of parameters with a five-point scale ranging from excellent to poor. After collecting data on a verbal scale, he converted them into a numerical scale for value assessment of AH. Many organizations have used similar methods to rank AH[3]. All these methods rely on the opinion of experts and do not consider variation in the data input and their inter-relationships.

For AH in India, the selection criteria and grading system which is purely qualitative is provided by the Town and Country Planning Organization according to 'Modern Heritage Regulations'[10]. The process of evaluation and grading is based on the discretion of government officials and development authorities. The transparency of the evaluation system and robustness in the selection of AH are not clear and often questionable. Therefore, in the

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Indian context, a value assessment method for AH is required for sustainable management.

For the assessment of AH, the present study has identified the Odisha temple architecture (OTA) as a case study. OTA belongs to the period between 6th and 14th centuries[11]. OTA is known for its gigantic, aesthetically pleasing monuments[12]. Most of these are living temples where daily rituals are still being performed[13]. The performance of rituals shows the faith and belief in the deity consecrated inside the temple[14]. The whole temple structure, not just the deity, is worshipped[15]. Odisha has only one WHS – the Konark Temple, although the Jagannath Temple at Puri, and Lingaraj Temple at Bhubaneswar have equal importance in the history and architecture of Odisha[16]. The only reason for the inclusion of Konark Temple in the list of WHS is its non-living status (no rituals are performed in it), and access to all religions. Accessibility to all religions is a significant aspect for inclusion in the WHS list, which most of these temples fail to fulfill. Therefore, an appropriate assessment system of OTA is required for its management.

Before assessing OTA, it is necessary to identify the appropriate dimensions and parameters associated with it. For this, the three-step process described by Torre[17] was implemented. They are identification, evaluation and selection of AH[17]. Zavadskas *et al.*[18] have mentioned that the decision-making process is a complex and challenging task to perform with the involvement of various actors such as people, groups of people, government representatives, experts and other stakeholders who are directly or indirectly associated with AH.

The multi-criteria decision-making (MCDM) process must be transparent and straightforward[19]. It should include qualitative and quantitative parameters with a hierarchical structure, and the decision of the stakeholders and opinions of experts with multi-dimensional aspects require satisfactory consistency[20]. However, many a times, the opinions of experts are considered to be biased[21], time-consuming and predictable[22]. Therefore, this study aims to resolve the issues mentioned above without considering the opinions of the experts and utilizing a mathematical approach.

The objective of this study was to develop an unbiased selection of AH. It also focuses on the dimensional importance of AH and the level of importance of the parameters using the MCDM process. This study combines all the qualitative and quantitative parameters collected through the responses of various stakeholders, observational data and data from secondary sources. In this study, MCDM methods of analysis such as criteria importance through inter-criteria correlation (CRITIC) and grey relational analysis (GRA) are applied for the assessment of OTA.

Combination of CRITIC and GRA methods has been previously used in other areas of research, viz. in the banking sector of China[23], to solve the problems of the management and supervision systems. These methods have also been used for selection of highly technical and most innovative electrical vehicles[24], evaluation of landfill gas plant sitting problem[25] and population vulnerability assessment of geographical disasters in China[26].

Materials and methods

Odishan temple architecture

For the protection of OTA, the Archaeological Survey of India (ASI) has two divisions: (i) Central ASI (C-ASI) and (ii) State ASI (S-ASI). Most monuments under OTA are in the old town area of Bhubaneswar, the state capital of Odisha. This area is also known as Ekamrakshetra. Outside Bhubaneswar, the other two renowned temples, Jagannath Temple of Puri and Sun Temple of Konark (the only WHS), are included in this list for the assessment of OTA. For evaluation, 1 WHS, 18 Central ASI-protected, 14 state ASI-protected and 6 unlisted temples (total 39) were identified. The list of selected temples is presented in Table 1 along with the names of the organizations in charge of their protection, access conditions (ticketed or non-ticketed) and their ritual status (living or non-living). Figure 1 shows the images of these temples.

Dimensions and parameters for OTA

This study has identified broad dimensions and parameters from the literature published by ICOMOS, UNESCO, relevant books, governmental policies and manuals for the assessment of OTA. The variables which can be directly assessed are termed as 'parameters', and those which can be evaluated using the parameters are termed as 'sub-dimensions'. 'Dimensions' can be evaluated from the sub-dimension values. Table 2 lists the dimensions, sub-dimensions and parameters used in this study along with the relevant sources of data.

Data sources

For data collection, three schedules were prepared, namely 'Schedule for opinion of stakeholders', 'Schedule for primary observational data', and 'Schedule for secondary data'.

For the 'Schedule for opinion of stakeholders,' this study has identified five different types of stakeholders: G1 – temple authorities (the existing group of decision-makers), G2: residents near the temple premises or local visitors, G3: outside visitors (tourists), G4: local shopkeepers and G5: temple staff and workers (not included in the existing decision-making process).

After careful analysis, data were collected for different parameters under the three schedules. Table 2 shows the 'Schedule for opinion of stakeholders' on qualitative

Table 1. List of selected temples

Temple	Protected by	Ticketed (T)/ non-ticketed (NT)	Living (L)/ non-living (NL)
Ananta Basudeva Temple	C-ASI	NT	L
Baitala Temple	C-ASI	NT	NL
Bakreswar Temple	C-ASI	NT	NL
Bhaskareswar Temple	C-ASI	NT	L
Bhimeshwar Temple	UL	NT	L
Brahmeshwar Temple	C-ASI	NT	L
Champakeswar Temple	UL	NT	NL
Chausathi Jogini Temple	C-ASI	NT	L
Chintamaniswar Temple	UL	NT	L
Chitra Karini Temple	C-ASI	NT	NL
Dakara Bivisaneswara Temple	S-ASI	NT	L
Dhabaleswara Temple	S-ASI	NT	L
Ganga Jamuna Temple	S-ASI	NT	L
Gauri Shankar Ganesh Temple	S-ASI	NT	L
Jagannath Temple	C-ASI	NT	L
Kapileswar Temple	S-ASI	NT	L
Kartikeswar Temple	S-ASI	NT	NL
Kedar Gouri Temple	S-ASI	NT	L
Konark Sun Temple	C-ASI-WHS	T	NL
Kotitirtheswar Temple	S-ASI	NT	L
Lakhamaneswar Group Temple	S-ASI	NT	NL
Lakheswar Temple	S-ASI	NT	L
Lingaraj Temple	C-ASI	NT	L
Maitreswar Temple	C-ASI	NT	NL
Megheswar Temple	C-ASI	NT	L
Mukteswara Temple	C-ASI	NT	L
Nageswar Temple	S-ASI	NT	L
Parsurameswara Temple	C-ASI	NT	NL
Rajarani Temple	C-ASI	T	NL
Rameshwar Temple	C-ASI	NT	L
Subarna Jaleswar Temple	S-ASI	NT	L
Shukhameswar Temple	S-ASI	NT	L
Sidheswar Temple	C-ASI	NT	L
Sisireswar Temple	C-ASI	NT	NL
Suresvara Temple	S-ASI	NT	NL
Swarnajaleswara Temple	UL	NT	L
Tirtheswara Temple	UL	NT	L
Uttareswara Temple	UL	NT	L
Yameswar Temple	C-ASI	NT	L

parameters. For this, a minimum of 30 samples for every temple[27] or ten times the number of parameters[28] has been estimated, i.e. $10 \times 42 = 420$ responses. Ultimately, 1239 samples were collected. Finally, the median values of the parameters were considered for further analysis. The data for 'schedule for primary observational data' were collected through direct visits, obtaining photographs and discussing with experts on site. Data were also collected from the literature regarding OTA through the 'schedule for secondary data'.

Research methodology

The dimensions, sub-dimensions, and parameters were identified from the literature and expert opinions. Thirty-nine temples from Ekamrakshetra were selected under OTA. For evaluation of the parameters, data were collected through public opinion surveys, primary observation and secondary sources such as the literature. Then the weights of the parameters were obtained using the CRITIC method. Aggregation was performed using the GRA method for the sub-dimensional values. The CRITIC method was applied again to these sub-dimensional values to obtain the sub-dimensional weights. With the weights of sub-dimensions, aggregation of sub-dimensional values was performed using the GRA method to obtain the values of the dimensions. This process was repeated, where the CRITIC method provided the weights for the parameters, sub-dimension, and dimensions, and GRA method helped in the aggregation of the sub-dimensions and dimensions of OTA. Figure 2 shows the entire methodology.

Identifying weights based on the CRITIC method

Diakoulaki *et al.*[29] developed the CRITIC method in 1995. This is a type of objective weighting method which

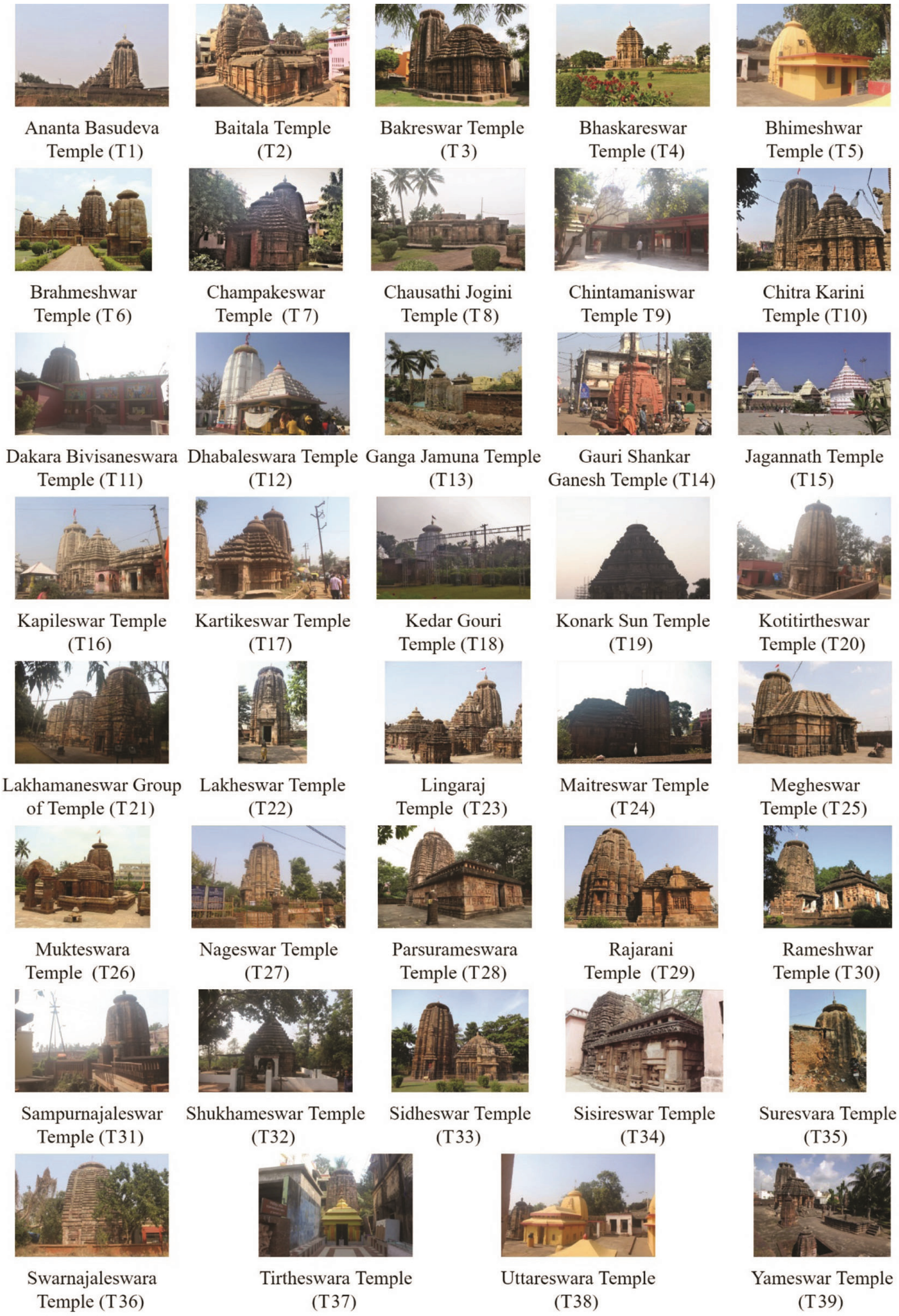

Figure 1. Selected temples T1 to T39.

converts correlation values into relative weights of parameters. It uses the conflict or relationship among the parameters, along with the standard deviation of the parameters. The higher the value of the standard deviation, higher is the difference between the parameters. This method is generally used when experts are unsure about the importance of a parameter. Else, it can be applied where expert opinion is not available. This method is less time-consuming, and

Table 2. Parameters of architectural heritage

Dimensions	Sub-dimensions	Parameters	Source of data collection
Architectural and aesthetic value (A)	Aesthetic value (A1)	Appeal (A11)	Stakeholders' perception
	Architectural and alteration value (A2)	Form and design (A12)	Secondary data
		Architectural intactness (A21)	Observational data
		Architectural integrity (A22)	
		Alteration of materials (A23)	
	Rarity value (A3)	Rarity in age/style (A31)	Secondary data
		Rarity in architectural details (A32)	
		Rarity in material and construction techniques (A33)	
		Scientific and technological value (A34)	
	Contextual value (A4)	Characteristics (A41)	Stakeholders' perception
		Landmark status (A42)	
		Landscape value (A43)	
Economic value (E)	Existence value (cost; E1)		Stakeholders' perception
	Option value (cost; E2)		
	Bequest value (cost; E3)		
	Direct use value (cost; E4)		
	Indirect use value (cost; E5)		
Environmental and ecological value (EE)	Ecological fragility/vulnerability (EE1)		Observational data
	Ecological threats (EE2)		
	Ecological potential (EE3)		
	Zoning compatibility (EE4)		
	Site alteration (EE5)		
	Site integrity (EE6)		
Historical value (H)	Age value (H1)	Phase (H11)	Secondary data
		Trends/patterns/themes (H12)	
		Archaeological value (H13)	
	Associative value (H2)	Activity (H21)	Secondary data
		Events associated with heritage site (H22)	
		Artistic value (H23)	
		Association with groups and communities (H24)	
		Historic grouping (H25)	
Socio-cultural value (SC)	Cultural and religious value (SC1)	Religious value (SC11)	Stakeholders' perception
		Spiritual value (SC12)	
		Community (SC13)	
	Functional value (SC2)	Social compatibility (SC21)	Stakeholders' perception
		Public use value (SC22)	
		Service value (SC23)	
	Social value (SC3)	Social accessibility (SC31)	Observational data
		Educational value (SC32)	Stakeholders' perception
		Political value (SC33)	
		Traditional value (SC34)	

there is no bias in selecting AH. The steps for the CRITIC method are given below.

Step 1 – Generating an evaluation matrix, with the insertion of m OTA and n parameters/sub-dimensions/dimensions as r_{ij}. Then we have a matrix as $(R_{ij})_{m \times n}$.

$$R_{m\times n} = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{12} & r_{22} & \cdots & r_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix}. \quad (1)$$

Step 2 – Forming the normalized decision matrix.

Evaluating the beneficial and non-beneficial criteria is done as follows

$$x_{ij} = \frac{(r_j)_{\max} - r_{ij}}{(r_j)_{\max} - (r_j)_{\min}} \quad (2)$$

where $i = 1, 2, 3, \ldots, m$ and $j = 1, 2, 3, \ldots, n$,

$$x_{ij} = \frac{r_{ij} - (r_j)_{\min}}{(r_j)_{\max} - (r_j)_{\min}}, \quad (3)$$

where $i = 1, 2, 3, \ldots, m$ and $j = 1, 2, 3, \ldots, n$,

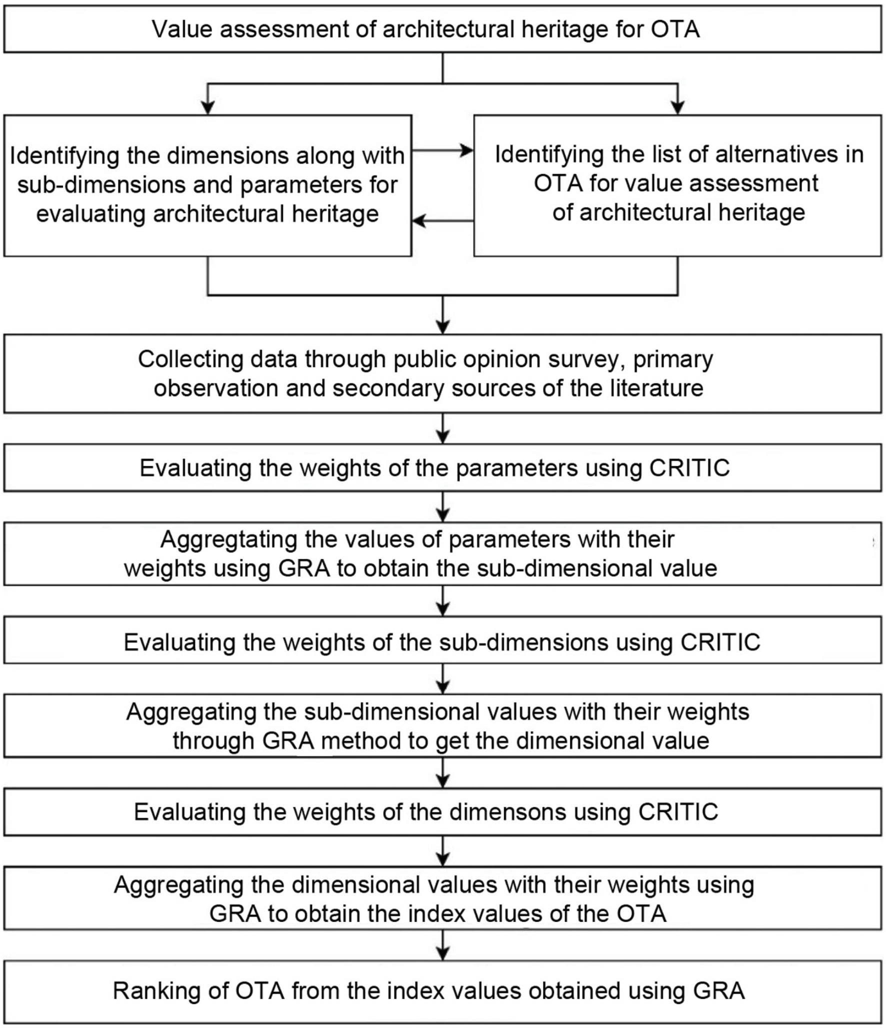

Figure 2. Methodology for ranking of the Odisha temple architecture.

where $X = (x_{ij})_{m\times n}$; the $(x_{ij})_{m\times n}$ matrix is normalized using the normalization method. $(r_{ij})_{\max} = \max(r_1, r_2, \ldots, r_m)$ and $(r_{ij})_{\min} = \min(r_1, r_2, \ldots, r_m)$.

Step 3 – Derivation of the correlation coefficient.

This is done using the following equation

$$\rho_{jk} = \frac{\sum_{i=1}^{m}(x_{ij}-\overline{x_j})(x_{ij}-\overline{x_k})}{\sqrt{\sum_{i=1}^{m}(x_{ij}-\overline{x_j})^2\sum_{i=1}^{m}(x_{ij}-\overline{x_k})^2}}, \quad (4)$$

where $\overline{x_j}$ and $\overline{x_k}$ represent the mean of the jth and kth parameters/sub-dimensions/dimensions. Both these values can be obtained as

$$\overline{x_j} = \frac{1}{n}\sum_{j=1}^{n} x_{ij} \text{ (where } j = 1, 2, 3, \ldots, n). \quad (5)$$

Step 4 – Estimating the Index (C).

First, we derive the standard deviation of each parameter/sub-dimension/dimension

$$\sigma_j = \sqrt{\frac{1}{n-1}\sum_{j=1}^{n}(x_{ij}-\overline{x_j})^2} \text{ (where } i = 1, 2, 3, \ldots, m). \quad (6)$$

Second, we derive the index value (C)

$$C_j = \sigma_j \sum_{k=1}^{n}(1-\rho_{jk}) \text{ (where } j = 1, 2, 3, \ldots, n). \quad (7)$$

Step 5 – Identifying weights of the parameters/sub-dimensions/dimensions.

$$w_j = \frac{C_j}{\sum_{j=1}^{n} C_j} \text{ (where } j = 1, 2, 3, \ldots, n). \quad (8)$$

Step 6 – Repeating the steps after aggregation using the GRA method.

The weights of the parameters/sub-dimensions/dimensions can be arranged in descending order to determine the most important criterion for evaluating AH.

Deriving degree of correlation based on GRA

GRA was developed by Deng[30], who stated that 'the goal of the Grey System and its application is to bridge the existing gap between the social science and natural science'. According to him, GRA can be applied in various fields such as agriculture, ecology, history, geography, industry, earthquake study, geology, hydrology, traffic management and the environment.

For the assessment of AH, this study has identified five broad dimensions, i.e. architectural and aesthetic value, economic value, environmental and ecological value, historical value and socio-cultural value, all of which are interdependent. Therefore, GRA was found to be the appropriate method. Based on the grey relational grade, the dimensions can be ranked to find the best and worst AH among the selected alternatives. The weights of the parameters can be borrowed from other methods (here, the CRITIC method was used for the weights). The steps for the GRA method are given below.

Step 1 – Generating an evaluation matrix, with the insertion of m OTA and n parameters/sub-dimensions/dimensions as r_{ij}. Then we have a matrix as $(R_{ij})_{m\times n}$.

$$R_{m\times n}=\begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{12} & r_{22} & \cdots & r_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix}. \tag{9}$$

Step 2 – Forming the normalized decision matrix.

Deriving the beneficial and non-beneficial criteria using the following formulae

$$x_{ij}=\frac{(r_j)_{\max}-r_{ij}}{(r_j)_{\max}-(r_j)_{\min}} \tag{10}$$

(where $i = 1, 2, 3, \ldots, m$ and $j = 1, 2, 3, \ldots, n$),

$$x_{ij}=\frac{r_{ij}-(r_j)_{\min}}{(r_j)_{\max}-(\mathrm{r}_j)_{\min}} \tag{11}$$

(where $i = 1, 2, 3, \ldots, m$ and $j = 1, 2, 3, \ldots, n$).

where $X = (x_{ij})_{m\times n}$; the $(x_{ij})_{m\times n}$ matrix is normalized using the normalization method. $(r_{ij})_{\max} = \max(r_1, r_2, \ldots, r_m)$ and $(r_{ij})_{\min} = \min(r_1, r_2, \ldots, r_m)$. Steps 1 and 2 are the same as those in the CRITIC method.

Step 3 – Calculating the grey relational coefficient

$$\xi_i(k)=\frac{\Delta_{\min}+\zeta\Delta_{\max}}{\Delta_{0,i}(k)+\zeta\delta_{\max}}, \tag{12}$$

where $\Delta_{0,i}$ is the deviation between the reference sequences and comparability sequence

$$\Delta_{(0,j)}=\| x_0^*(k)-x_i^*(k)\|,$$

$$\Delta_{\min}=\min_{\forall j\in i}\min_{\forall k}\| x_0^*(k)-x_i^*(k)\|,$$

$$\Delta_{\max}=\max_{\forall j\in i}\max_{\forall k}\| x_0^*(k)-x_i^*(k)\|,$$

$x_0^*(k)$ is the reference sequence and $x_i^*(k)$ is the comparative sequence.

ζ is known as the identification coefficient; $\zeta\in[0, 1]$. Typically, many researchers take $\zeta = 0.5$ as it offers a moderate distinguishing effect and stability. From the calculation, $\Delta_{\min}$ and $\Delta_{\max}$ were found to be 0 and 1 respectively. Therefore, the simplified grey relational coefficient equation is

$$\xi_i(k)=\frac{0.5}{\Delta_{0,i}(k)+0.5}. \tag{13}$$

Step 4 – Calculating the grey relational grade (GRG)

$$\gamma_i=\sum_{j=1}^{n}w_j\xi_i(k), \tag{14}$$

where w_j is the weight of the jth parameter/sub-dimension/dimension which can be obtained using the CRITIC method.

Step 5 – Repeating the steps after obtaining the weights from the CRITIC method.

After obtaining GRG for each of the temples, the ranking of OTA becomes possible. The higher the value of GRG, higher is the rank of OTA.

Analysis

The CRITIC and GRA methods have been used repetitively to obtain the weights of the parameters, sub-dimensions and dimensions. Table 3 lists the final weights of the parameters, sub-dimensions and dimensions obtained from the CRITIC method.

After a repetitive process for obtaining the values of parameters, sub-dimensions, and dimensions using the

Table 3. Weights of the parameters, sub-dimensions and dimensions of Odisha temple architecture (OTA)

Dimensions	Weights of dimensions	Sub-dimensions	Weights of sub-dimensions	Parameters	Weights of parameters
Architectural and aesthetic value (A)	0.163	Aesthetic value (A1)	0.265	Appeal (A11)	0.557
				Form and design (A12)	0.443
		Architectural and alteration value (A2)	0.252	Architectural intactness (A21)	0.266
				Architectural integrity (A22)	0.303
				Alteration of materials (A23)	0.431
		Rarity value (A3)	0.263	Rarity in age/style (A31)	0.282
				Rarity in architectural details (A32)	0.192
				Rarity in material and construction techniques (A33)	0.195
				Scientific and technological value (A34)	0.331
		Contextual value (A4)	0.221	Characteristics (A41)	0.254
				Landmark status (A42)	0.343
				Landscape value (A43)	0.402
Economic value (E)	0.266			Existence value (cost; E1)	0.192
				Option value (cost; E2)	0.231
				Bequest value (cost; E3)	0.219
				Direct use value (cost; E4)	0.155
				Indirect use value (cost; E5)	0.203
Environmental and ecological value (EE)	0.267			Ecological fragility/vulnerability (EE1)	0.196
				Ecological threats (EE2)	0.134
				Ecological potential (EE3)	0.123
				Zoning compatibility (EE4)	0.260
				Site alteration (EE5)	0.140
				Site integrity (EE6)	0.147
Historical value (H)	0.159	Age value (H1)	0.497	Phase (H11)	0.421
				Trends/patterns/themes (H12)	0.287
				Archaeological value (H13)	0.292
		Associative value (H2)	0.503	Activity (H21)	0.224
				Events associated with heritage site (H22)	0.228
				Artistic value (H23)	0.176
				Association with groups and communities (H24)	0.207
				Historic grouping (H25)	0.165
Socio-cultural value (SC)	0.145	Cultural and religious value (SC1)	0.397	Religious value (SC11)	0.265
				Spiritual value (SC12)	0.386
				Community (SC13)	0.349
		Functional value (SC2)	0.244	Social compatibility (SC21)	0.330
				Public use value (SC22)	0.348
				Service value (SC23)	0.322
		Social value (SC3)	0.359	Social accessibility (SC31)	0.423
				Educational value (SC32)	0.202
				Political value (SC33)	0.169
				Traditional value (SC34)	0.206

GRA method, Table 4 shows the final values of the dimensions, GRG and rank obtained from the GRG values. The current protected status of OTA is also mentioned in the table for comparison with the present methodology.

The results show the ranking of OTA from the GRG values (Table 4). The Lingaraj Temple, Bhubaneswar (T23); Sun Temple, Konark (T19) and Jagannath Temple, Puri (T15) occupied the first three ranks. From the results, it can be concluded that temples under the protection of C-ASI are the top rankers. The temples protected by S-ASI are the middle rankers, and those not protected are the bottom rankers. However, some contradictions are observed, which are discussed in the next section.

Results and discussion

This present study on OTA has identified 5 dimensions, 9 sub-dimensions and 41 parameters for value assessment of AH and its development. Using the correlation coefficient and standard deviation, the weights of the parameters, sub-dimensions and dimensions were obtained employing

Table 4. Grey relational grades of all the dimensions and index values of OTA with their ranks

Temple	A	E	EE	H	SC	GRG	Rank	Protected by
Ananta Basudeva Temple	0.076	0.105	0.108	0.065	0.061	0.415	15	C-ASI
Baitala Temple	0.061	0.092	0.097	0.057	0.053	0.360	35	C-ASI
Bakreswar Temple	0.063	0.151	0.111	0.057	0.050	0.432	11	C-ASI
Bhaskareswar Temple	0.063	0.105	0.182	0.057	0.052	0.459	10	C-ASI
Bhimeshwar Temple	0.055	0.104	0.097	0.055	0.053	0.364	33	UL
Brahmeshwar Temple	0.061	0.112	0.124	0.070	0.059	0.425	13	C-ASI
Champakeswar Temple	0.059	0.109	0.119	0.053	0.051	0.391	22	UL
Chausathi Jogini Temple	0.058	0.092	0.116	0.059	0.055	0.380	26	C-ASI
Chintamaniswar Temple	0.055	0.098	0.096	0.054	0.055	0.359	36	UL
Chitra Karini Temple	0.060	0.101	0.124	0.061	0.054	0.400	18	C-ASI
Dakara Bivisaneswara Temple	0.056	0.096	0.105	0.054	0.053	0.364	32	S-ASI
Dhabaleswara Temple	0.058	0.101	0.132	0.054	0.054	0.399	19	S-ASI
Ganga Jamuna Temple	0.060	0.112	0.096	0.060	0.053	0.382	25	S-ASI
Gauri Shankar Ganesh Temple	0.056	0.114	0.089	0.055	0.051	0.366	31	S-ASI
Jagannath Temple	0.142	0.124	0.267	0.159	0.109	0.801	3	C-ASI
Kapileswar Temple	0.059	0.109	0.107	0.062	0.054	0.391	21	S-ASI
Kartikeswar Temple	0.059	0.105	0.096	0.063	0.050	0.372	28	S-ASI
Kedar Gouri Temple	0.060	0.105	0.124	0.060	0.054	0.403	17	S-ASI
Konark Sun Temple	0.136	0.266	0.152	0.159	0.122	0.834	2	C-ASI
Kotitirtheswar Temple	0.059	0.115	0.124	0.065	0.066	0.428	12	S-ASI
Lakhamaneswar Group Temple	0.057	0.223	0.101	0.058	0.054	0.494	8	S-ASI
Lakheswar Temple	0.058	0.099	0.124	0.056	0.051	0.388	23	S-ASI
Lingaraj Temple	0.163	0.120	0.267	0.159	0.145	0.854	1	C-ASI
Maitreswar Temple	0.061	0.101	0.109	0.063	0.051	0.386	24	C-ASI
Megheswar Temple	0.063	0.127	0.188	0.062	0.083	0.524	6	C-ASI
Mukteswara Temple	0.095	0.120	0.211	0.095	0.064	0.585	5	C-ASI
Nageswar Temple	0.059	0.120	0.109	0.059	0.055	0.403	16	S-ASI
Parsurameswara Temple	0.072	0.100	0.106	0.062	0.054	0.394	20	C-ASI
Rajarani Temple	0.124	0.120	0.267	0.065	0.076	0.653	4	C-ASI
Rameshwar Temple	0.060	0.163	0.105	0.076	0.085	0.489	9	C-ASI
Subarna Jaleswar Temple	0.059	0.104	0.092	0.059	0.053	0.368	29	S-ASI
Shukhameswar Temple	0.057	0.120	0.095	0.054	0.052	0.377	27	S-ASI
Sidheswar Temple	0.069	0.098	0.211	0.058	0.060	0.496	7	C-ASI
Sisireswar Temple	0.056	0.089	0.092	0.057	0.048	0.343	39	C-ASI
Suresvara Temple	0.054	0.098	0.094	0.053	0.049	0.349	37	S-ASI
Swarnajaleswara Temple	0.058	0.112	0.094	0.054	0.049	0.367	30	UL
Tirtheswara Temple	0.055	0.092	0.089	0.054	0.052	0.343	38	UL
Uttareswara Temple	0.056	0.104	0.094	0.055	0.055	0.363	34	UL
Yameswar Temple	0.061	0.120	0.122	0.062	0.056	0.421	14	C-ASI

A, Architectural and aesthetic value; E, Economic value; EE, Environmental and ecological value; H, Historical value; SC, Socio-cultural value; GRG, Grey relational grade; C-ASI, Central Archaeological Survey of India; S-ASI, State Archaeological Survey of India and UL, Unlisted.

the CRITIC method. For aggregation of the data, the GRA method was used. The CRITIC and GRA methods adopted in this study are found to be suitable for an inter-disciplinary approach, where many grey relations are known.

Comparing the ranking obtained from the GRG values using the CRITIC and GRA methods and the protection of OTA in its existing state, it was observed that out of the top-10 ranked temples, 9 were centrally protected C-ASI temples along with the Lakhamaneswar Group of Temples (T21), which alone from the group is state-protected. The latter temple has a higher economic value than the other state-protected temples.

For the temples ranked 11 to 20, six are centrally protected and four are state-protected temples. Similarly, among the temples ranked 21 to 30, two are centrally protected, six are state-protected and two are unlisted. Among the temples ranked 31 to 39, two are centrally protected, three are state-protected, and four temples are unlisted. The primary concern is regarding the temples that are centrally protected, but have lower ranks in the list.

The most conflicting result pertains to the Baitala Temple (T2), located in the same boundary as the Sisireswar Temple (T34). Both these temples are protected by C-ASI for their higher quality of architectural, aesthetic and historical values. They do not perform well with respect to environmental, ecological, economic and socio-cultural values. The non-materialistic dimensions have significant impact on the current evaluation system. Cautious documentation of the problems and appropriate care by the C-ASI can make these temples enormously significant OTA.

Similarly, Chausathi Jogini Temple (T8), Parsurameswara Temple (T28) and Maitreswar Temple (T24) fall under C-ASI, but are ranked between 20 and 30. These temples have low economic value. None of the stakeholders is willing to pay for the use of the temples at present or in the future. Thus, these temples are becoming vulnerable and losing importance. Financial support from the government and non-government organizations and awareness generation for their protection are essential.

The Kedar Gouri Temple (T18), Kotitirtheswar Temple (T20), Lakhamaneswar Group of Temples (T21), and Nageswar Temple (T27) are under S-ASI protection and are ranked higher than many temples protected by C-ASI. These temples exhibit a substantial level of non-materialistic aspects along with moderate materialistic aspects. The Lakhamaneswar Group of Temples (T21) and Nageswar Temple (T27) have high economic value; therefore, these should be treated as ticketed temples for revenue generation and protection of OTA.

Comparing the derived ranks of OTA and the existing state of protection, this study has found that in 65% of the cases, the results are similar. It was observed that 14 out of 39 temples, in which ranking did not match with the existing level of protection, had greater values in a few dimensions but lacked in other dimensions. However, for an unbiased value assessment of the temples and their management, all dimensions must be considered.

Conclusion

In this study we used a method for prioritizing AH based on multi-dimensional values. Ranking and prioritizing would help in drawing the attention of policymakers while formulating regulatory policies and making byelaws for the management of AH. The research framework of this study draws the attention of stakeholders, their association in maintenance and management, fund-raising, and so on. The method of AH categorization proposed here can be helpful for ranking and grouping of AH, fulfiling the need for conservation. Considering the management of AH to contribute to all the five selected dimensions has proven to be a more thorough development, although further research on this aspect is needed. By considering interdisciplinary management and monitoring practices, this research framework is expected to broaden the understanding of heritage management and conservation practices. Identifying parameters and dimensions could help forecast challenges, develop priorities and deliver baseline research for a more sustainable management system.

During the assessment process, it has been found that the strength of the CRITIC method determines the objective weights in MCDM issues. The weights are derived from the correlations among the variables, which show positive and negative relationships. This process is fast, as there is no need for experts. However, it does not understand the predefined importance of the parameters, which is sometimes essential in qualitative research. GRA is a multi-objective optimization technique that aggregates multiple variables into a single one. The overall ranks of OTA depend on the GRG values. The higher the grade value, the higher is the rank of OTA. This process has a weakness as it does not understand the predefined levels of the parameters based on their qualitative aspects. Hence, the recommended methods are preferred when the opinions of experts for determining the level of importance or weights of the parameters for aggregation are not available.

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