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# A PROMETHEE-GAIA Method-based Appraisal of UNESCO World Heritage Sites in India

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**Abstract** *Evaluation of the UNESCO World Heritage Sites (WHSs) in India has become a challenging activity for the tourism planners, policy makers and managers to create effective management strategies for them. In this paper, a combined application of preference ranking organization method for enrichment evaluation (PROMETHEE) and geometrical analysis for interactive aid (GAIA) is presented to appraise the performance of 37 Indian UNESCO WHSs based on nine important criteria. It is observed that the Taj Mahal is the most attractive site for both domestic and foreign tourists, followed by the Historic City of Ahmadabad. On the other hand, Champaner-Pavagadh Archaeological Park is the least visited site. Number of citations for a specific site in https://www.google.com appears to be the most important evaluation criterion, followed by the number of good accommodations. The application of this combined methodology would help the decision-makers to visualize the strengths and weaknesses of each of the Indian UNESCO WHSs so as to formulate suitable recommendations and policies to increase their tourism attractiveness.*

***Keywords:*** *UNESCO, World Heritage Site, India, PROMETHEE, GAIA*

## INTRODUCTION

India, the second populous country in the world, has the present population of over 1.35 billion and it occupies 17.74% of the total global population. It has a total land area of 2,973,190 sq km, with 29 states and 7 union territories. It with its rich culture and history holds a symbolic place in the list of countries. The Indian civilization (also known as Indus Valley civilization) dates back to 3000 BCE. Its cultural heritage and monuments and sites erected by the past rulers symbolize its glorious past. Now, it has become the duty of the archaeologists, historians and art lovers to preserve those ancient heritage monuments from generations to generations as the signs of precious inheritance. Today, there are more than a thousand such historical sites in India, but only a few of them have universal importance. These historical sites are so exceptional that their protection and preservation have turned to be essential for every Indian. Thus, they have been declared *as the World Heritage Sites (WHSs) by the United Nations Educational, Scientific and Cultural Organization (UNESCO)* to secure them from decay over time. Apart from those historical monuments, some national parks and wildlife sanctuaries have also been included in the list of WHSs to preserve and boost the populations of the endangered flora and fauna (Karanth & DeFries, 2011).

A WHS can be defined as "a natural or man-made site, area or structure recognized as being of outstanding international importance and therefore of deserving special protection". A WHS thus indicates a site that belongs to a globally recognized top layer of heritage sites. It bears a unique and exceptional evidence of a cultural tradition or a civilization or an area of unparalleled natural beauty and creative importance. A WHS level would promote investment and tourism, thereby creating job opportunities to the local communities. The main policy of the UNESCO is to maintain both the cultural and natural heritages in good conditions for the coming generations while making them available to the public as much as possible. Cultural heritages include monuments, groups of buildings and sites. On the other hand, natural features (physical and biological

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formations), geological and physiographical formations, and natural sites are considered as natural heritages (Alzahrani, 2013; Gullino & Larcher, 2013; Lekaota, 2018). As on 2018, there are 1,073 UNESCO WHSs across the world and there is some more waiting to be included in this list. Italy has the most number of UNESCO WHSs of 54, closely followed by China (53), Spain (47), France (44), Germany (44) and India (37). In total, there are 13 countries with over 20 UNESCO WHSs. Among the 37 WHSs located in India, there are 29 cultural sites, seven natural parks and one mixed site. India thus has the sixth-largest number of WHSs in the world. Till 2017, India has 36 WHSs. But, in 2018, at the 42nd session of the World Heritage Committee of UNESCO at Manama in Bahrain, the Victorian and Art Deco Ensembles of Mumbai has been included as the new entry in the WHS list of India.

India, due to the presence of these WHSs with their dispersed locations, has already been a major attraction of the foreign tourists. During 2017-2018, there were approximately 10.04 millions of foreign tourist arrivals in India, with an annual growth rate of 14.0%. On the other hand, during that period, there were more than 1650 millions of domestic tourist visits to all its states and union territories with an overall growth rate of 2.3%. A total of 27.31 billion USD was the foreign exchange earnings from tourism itself, with an annual growth rate of 19.1%. There are some more interesting facts about tourism in India. During 2017-2018, its share in international tourist arrivals was 1.17%, it occupied 26th position in world tourist arrivals, its financial share to international tourist receipts was 2.05% and it was positioned at 13th rank in world tourist receipts. It is also worthwhile to mention here that Maharashtra, Tamil Nadu, Uttar Pradesh, Delhi and Rajasthan are the top five ranked Indian states with respect to foreign tourist visits (http://tourism.gov.in/sites/default/files/Other/ITS_Glance_2018_Eng_Version_for_Mail.pdf).

Thus, in order to promote tourism in India and attract more foreign as well as domestic tourists, it is the appropriate time to appraise the conditions and performance of those Indian WHSs. This appraisal problem can be treated as a multi-criteria decision making (MCDM) formulation where the best performing alternative needs to be identified in presence of a set of conflicting evaluation criteria (Liu et al., 2012).

## LITERATURE SURVEY

Dutta and Husain (2009) stressed on the applicability of MCDM method as a relevant tool for grading of the heritage sites and applied it for ranking of several heritage buildings in Calcutta, India. Landorf (2009) considered the relationship between heritage tourism and sustainable development with respect to six WHSs, and concluded that all those sites would properly develop suitable plans to alleviate tourism impacts and sustain site significance. Yau (2009) presented the application of analytic hierarchy process (AHP) as a scientific tool for urban built heritage conservation decision making. Mondéjar-Jiménez et al. (2010) proposed the application of an MCDM tool, in the form of preference ranking organization method for enrichment evaluation (PROMETHEE), to rank 11 Spanish cities declared WHSs by UNESCO. Using data envelopment analysis (DEA) technique, Siddiqui and Tripathi (2011) appraised the relative performance of various tourist centers in Uttar Pradesh (India) so that effective measures could be adopted for enhancing their operating efficiency. Iatu and Bulai (2011) proposed an approach to recognize the important role of tourism resources and infrastructures in attracting tourists in Moldavia (Romania). Mohamad and Jamil (2012) applied fuzzy hierarchical technique for order of preference by similarity to ideal solution (FHTOPSIS) to identify the most important factors affecting the choice of the local tourist destinations in Kedah, Malaysia and also determined the preferred determinations of the tourists. Kutut et al. (2013) adopted additive ratio assessment (ARAS) method to determine the priority order for reconstruction and preservation of some of buildings in Vilnius based on their archaeological, historical, architectural, economic and social importance. Horng et al. (2013) integrated fuzzy Delphi method, decision-making trial and evaluation laboratory method (DEMATEL), and analytic network process (ANP) methods for identifying the predominant tourism and gourmet attributes in Taiwan. Human resources and market development emerged out as the most and least significant attributes. While applying fuzzy AHP and TOPSIS methods, Göksu and Kaya (2014) assessed the relative performance of six tourist destinations in Bosnia and Herzegovina, and also identified those factors influencing tourists to visit those centres. Ranjan et al. (2016) presented the combined application of PROMETHEE and geometrical analysis for interactive aid (GAIA) methods for assessing and ranking all the Indian states with respect to their performance in tourism. Schägner et al. (2016) combined the primary data on annual visitor arrivals for 205 European National Parks, geographic information system and statistical regression technique to study the effects of the characteristics of those parks and their surroundings on the total annual recreational visitors. Cuccia et al. (2017) investigated the role of the UNESCO sites on the enhancement of tourism destinations performance in Italy over a period of 1995-2010. A two-stage DEA window analysis was subsequently applied to identify efficiency trends and resort to both pooled-truncated and panel data estimators to evaluate determinants of the efficiency changes in tourist destinations over the considered period. While considering international tourism expenditures, international tourism receipts, number of international tourist arrivals and number of international tourist departures as the four evaluation criteria, Ilban and Yıldırım (2017) appraised the tourism performance of 15 countries using TOPSIS method. Turskis et al. (2017) integrated AHP with evaluation based on distance from the average solution (EDAS) method for ranking of the heritage buildings in Lithuania for renovation purpose. While applying AHP and PROMETHEE methods, Butowski (2018) proposed an evaluation structure to assess the European coastal and offshore areas for sailing tourism, and concluded that the combined approach would be quite helpful in judging the strengths and weaknesses of those tourism areas. Çetinkaya et al. (2018) first applied AHP technique to estimate the weights of various evaluation criteria and then employed PROMETHEE method to identify the best ecotourism site from a set of nine cities in the Black Sea region of Turkey. Lopes et al. (2018) integrated PROMETHEE with GAIA method to study the competitiveness of eight tourist destinations located in the Northern Region of Portugal. The relative strengths and weaknesses of each of the destinations considered were also identified. Roy et al. (2018) employed an MCDM tool in the form of rough multi-attributive border approximation area comparison (MABAC) method for evaluating the performance of different medical tourism destinations in India. Quality of infrastructure of the healthcare institutions was identified as the most important criterion and Chennai was the best medical tourism site in India. Sharma et al. (2018) applied a hybrid MCDM tool while integrating rough AHP and MABAC methods for appraising the performance of the Indian railway stations. Based on PROMETHEE method and using some of the important criteria, Zuraidah (2019) developed a decision support system to help the tourists in selecting the most attractive destination site in Bali. Stević et al. (2019) assessed the tourism attractiveness of six cultural heritage sites in Porto, Portugal using two MCDM tools, i.e. simple additive weighting (SAW) and TOPSIS methods. Both the adopted methods provided almost identical results with respect to the ranking of the considered cultural heritage sites.

Based on the existing literature review, it can be clearly revealed that different MCDM tools have already been identified as the suitable methods for performance evaluation of various tourism destination sites. In this direction, AHP, TOPSIS, SAW, DEA, EDAS, MABAC etc. have found their successful applications. The PROMETHEE method has also been integrated with GAIA to study the effectiveness and competitiveness of various tourist destinations. In the context of India, its various states have already been compared with respect to their performance in tourism using PROMETHEE-GAIA method, and DEA technique has also been adopted to appraise the relative performance of various tourist centers in Uttar Pradesh (a state of India). Till date, no attempt has been put forward to analyze the positions of the UNESCO WHSs in India with respect to their tourist attractiveness. This paper thus endeavours to integrate PROMETHEE with GAIA method to measure the strengths and weaknesses of the considered sites based on nine evaluation criteria, while also identifying the best and worst performing sites. It would help the concerned decision-makers and policy planners to increase attractiveness of the underperforming Indian UNESCO WHSs through supportive tourism development planning and implementation of corrective strategies.

# PROMETHEE-GAIA METHOD

The PROMETHEE is a group of outranking methods, mainly consisting of PROMETHEE I for partial ranking of the alternatives and PROMETHEE II for complete ranking of the alternatives. Besides these two, there are also other variants of PROMETHEE, like PROMETHEE III for ranking based on interval, PROMETHEE IV for partial or complete ranking of the alternatives with continuous set of solutions, PROMETHEE V for problems having segmentation constraints, PROMETHEE VI for human brain representation, PROMETHEE GDSS for group decision making and visual interactive module GAIA (Brans & Vincke, 1985; Brans et al., 1986; Brans & Mareschal, 1984). The PROMETHEE I and II methods have already become quite popular among the decision making community because of their several advantages, likeability to take care of both qualitative and quantitative evaluation criteria, capability to deal with uncertain and fuzzy data, ability to arrive at the best course of action in group decision-making environment, easy calculation procedure, clear understandability etc. An excellent review of the applications of PROMETHEE method in diverse fields of engineering and managerial decision making is available in Behzadian et al. (2010) and Mardani et al. (2015).

The application of PROMETHEE method starts with the following decision (evaluation) matrix (Chakraborty et al., 2018):

$$A=\begin{bmatrix} g_1(a_1) & g_2(a_1) & \dots & g_j(a_1) & \dots & g_n(a_1) \\ g_1(a_2) & g_2(a_2) & \dots & g_j(a_2) & \dots & g_n(a_2) \\ \dots & \dots & \dots & \dots & \dots & \dots \\ g_1(a_i) & g_2(a_i) & \dots & g_j(a_i) & \dots & g_n(a_i) \\ \dots & \dots & \dots & \dots & \dots & \dots \\ g_1(a_m) & g_2(a_m) & \dots & g_j(a_m) & \dots & g_n(a_m) \end{bmatrix} \quad (1)$$

where $g_j(a_i)$ represents the performance of $i^{th}$ alternative with respect to $j^{th}$ criterion, $m$ is the number of alternatives and $n$ is the number of criteria.

The PROMETHEE method is based on development of a preference structure with pair-wise comparisons where the deviation between the performance evaluations of any two alternatives on a particular criterion is envisaged. If the deviation is less, small preference is allocated to the best alternative by the decision-maker. In some cases, no preference is allotted when the deviation is almost negligible. Higher preference is assigned to the best alternative when the deviation is large. These preferences are expressed in real numbers ranging between 0 and 1. Thus, for each criterion, the decision-maker determines the following preference function:

$$P_j(a,b) = F_j[d_j(a,b)] \quad \forall a,b \in A \tag{2}$$

where $d_j(a,b) = [g_j(a) - g_j(b)]$ and $0 \le P_j(a,b) \le 1$.

For beneficial criteria, this function assigns the preference of alternative '$a$' over alternative '$b$' for the perceived deviations between their evaluations with respect to criterion $g_j(.)$. When the deviations are negative, the preference is equated to 0. On the other hand, for non-beneficial (cost) criteria, the preference function can be rewritten as follows:

$$P_j(a,b) = F_j[-d_j(a,b)] \tag{3}$$

For each criterion, there is a generalized criterion, $\{g_j(.), P_j(a,b)\}$, associated to criterion $g_j(.)$. To facilitate choosing a specific preference function, there are six basic types of preference function available, i.e. usual criterion, U-shape criterion, V-shape criterion, level shape criterion, V-shape with indifference criterion and Gaussian criterion. In some of these preference functions, it is often required to fix certain threshold parameters ($p$, $q$ or $s$) which may increase the computational complexity of this method.

Based on the evaluation matrix, $g_j(.)$, relative priority (weight), $w_j$ and generalized criterion, $\{g_j(.), P_j(a,b)\}$, the aggregated preference indices can now be determined as follows:

$$\begin{cases} \pi(a,b) = \sum_{j=1}^{n} P_j(a,b)\, w_j \\ \pi(b,a) = \sum_{j=1}^{n} P_j(b,a)\, w_j \end{cases} \tag{4}$$

where $\pi(a,b)$ denotes the degree with which alternative '$a$' is preferred to alternative '$b$' over all the criteria and $\pi(b,a)$ signifies how alternative '$b$' is favoured over alternative '$a$'. In this method, each alternative '$a$' is compared with $(m-1)$ number of other alternatives of the decision matrix. Now, two outranking flows can be defined as follows:

Positive outranking flow, $\varphi^+(a) = \frac{1}{m-1}\sum_{x\in A}\pi(a,x)$ (5)

Negative outranking flow, $\varphi^-(a) = \frac{1}{m-1}\sum_{x\in A}\pi(x,a)$ (6)

The positive outranking flow signifies how an alternative '$a$' outranks all the other alternatives. Its higher value symbolizes a better alternative. Similarly, the negative outranking flow represents how an alternative '$a$' is being outranked by all the others. Worse alternatives have lower negative outranking flows (Komchornrit, 2017).

In PROMETHEE I method, based on the positive and negative outranking flows, a partial ranking of the alternatives is available. On the other hand, PROMETHEE II method provides a complete ranking order of the alternatives using a net flow, although there is a chance of losing valuable information about the preference relations. But, in this method, a balance is maintained between the positive and negative outranking flows. The net outranking flow for each alternative is computed using the following expression:

$$\varphi(a) = \varphi^+(a) - \varphi^-(a) \tag{7}$$

A higher net outranking flow indicates a better alternative. Now, based on the positive and negative outranking flow values, the net outranking flow can be estimated as:

$$\varphi(a) = \varphi^+(a) - \varphi^-(a) = \frac{1}{m-1}\sum_{j=1}^{n}\sum_{x\in A}[P_j(a,x) - P_j(x,a)]w_j \tag{8}$$

Thus,

$$\varphi(a) = \sum_{j=1}^{n}\varphi_j(a)\, w_j \tag{9}$$

if $$\varphi_j(a) = \frac{1}{m-1}\sum_{x\in A}[P_j(a,x) - P_j(x,a)] \tag{10}$$

where $\varphi_j(a)$ is the single criterion net flow for criterion $g_j(.)$ only. It acts as an indicator how an alternative '$a$' is outranking, i.e. $\varphi_j(a) > 0$ or outranked, i.e. $\varphi_j(a) < 0$ by the remaining alternatives with respect to criterion $g_j(.)$. It is observed from Eq. (9) that the scalar product of the vector of criteria weights and profile vector of an alternative provides the global net flow value for that alternative. This property helps in developing the corresponding GAIA plane. Now, using the single criterion net flow values of all alternatives, the matrix $M$ $(m\times n)$ can be defined (Kovačić, 2010).

$$M = \begin{bmatrix} \varphi_1(a_1) & \varphi_2(a_1) & \ldots & \varphi_j(a_1) & \ldots & \varphi_n(a_1) \\ \varphi_1(a_2) & \varphi_2(a_2) & \ldots & \varphi_j(a_2) & \ldots & \varphi_n(a_2) \\ \ldots & \ldots & \ldots & \ldots & \ldots & \ldots \\ \varphi_1(a_i) & \varphi_2(a_i) & \ldots & \varphi_j(a_i) & \ldots & \varphi_n(a_i) \\ \ldots & \ldots & \ldots & \ldots & \ldots & \ldots \\ \varphi_1(a_m) & \varphi_2(a_m) & \ldots & \varphi_j(a_m) & \ldots & \varphi_n(a_m) \end{bmatrix} \tag{11}$$

As the degrees of preference given by the generalized criteria are considered in $M$, the information included in it would be more extensive than the original decision matrix. Moreover, $\varphi_j(a_i)$ are dimensionless and do not depend on the criteria weights.

Now, the set of $m$ alternatives can be portrayed as a cluster of $m$ points in a $n$-dimensional space. When the number of criteria exceeds two, a clear view of the relative positions of those points with respect to the criteria becomes difficult to obtain. Thus, the GAIA plane is constructed by projecting this on a plane while losing minimum information. In a GAIA plane, alternatives $(a_1,a_2,\ldots,a_m)$ are denoted by points and criteria $(c_1,c_2,\ldots,c_n)$ are represented by axes. As the PROMETHEE net flow of $a_i$ is the projection of vector of its single criterion net flows on $w$, the relative positions of the projections of all the alternatives on *w* gives the PROMETHEE ranking of the considered alternatives. The vector *w* is represented in GAIA plane using the projection of the unit vector of the weights which is referred to as PROMETHEE decision axis (π). It exhibits the direction of the agreed solution resulting from the calculated criteria weights. When the weights are concentrated on a particular criterion, the π-axis would coincide with the axis of that criterion in the GAIA plane. For equally distributed weights among all the criteria, this axis would be a weighted resultant of all the criteria axes.

In the GAIA plane, a long π-axis has a strong decision power and the decision-maker is always advised to choose alternatives mostly on its direction. On the other hand, a short π-axis has less decision power, which indicates that the considered criteria are actively conflicting leading to non-availability of a well-accepted compromise solution. In this plane, all the criteria having similar preference based on the evaluation data are aligned in the same direction, whereas, the conflicting criteria are positioned in opposite directions. In this plane, the positions of the alternatives and criteria remain unchanged with the modifications of the criteria weights. The weight vector acts as a decision stick which can be moved by the decision-maker according to the preference in favour of a particular criterion.

## APPRAISAL OF UNESCO WHSs IN INDIA

It has already been mentioned that the main objective of this paper is focussed on the performance evaluation of 37 UNESCO WHSs in India with the help of an integrated PROMETHEE- GAIA approach. The application of PROMETHEE II method provides the complete ranking of all the WHSs while identifying the best and the worst-performing sites. On the other hand, GAIA-based analysis indicates the relative strengths and weaknesses of each of the considered sites. It also identifies the set of similar performing sites, set of criteria having similar preference for the given evaluation task and set of conflicting criteria. In Table 1, the list of all the UNESCO WHSs in India is provided along with the information with respect to the name of the state where it is located, its year of notification and its brief description. The locations of these UNESCO WHSs in the map of India are shown in Fig. 1. Now, in order to appraise the performance of the Indian UNESCO WHSs, a set of nine evaluation criteria is shortlisted, as exhibited in Table 2 (Dahiya & Batra, 2016). Amongst them, criteria $C^4$, $C^5$, $C^6$, $C^7$ and $C^8$ are of beneficial type, always requiring their higher values. On the other hand, $C^1$, $C^2$, $C^3$ and $C^9$ are non-beneficial (cost) criteria, where their lower values are always desired. The weights of those evaluation criteria, as also provided in Table 2, are determined using AHP technique. It can be observed from this table that criterion $C^4$ (number of citations in https://www.google.com) has the highest weight of 0.1658, followed by criterion $C^5$ (number of nearby hotels). On the other hand, $C^3$ (entry fee for domestic tourists) is the least important criterion with a priority weight of only 0.0262. Highest value of weight for criterion $C^4$ is well justified because both the foreign and domestic tourists interested in visiting those UNESCO WHSs in India usually acquire the detailed information about them through their citations available in the Internet. Similarly, they also want good, comfortable and secured stay during their visits to those sites. The entry fees to those sites for the domestic tourists are so cheap to make $C^3$ as the least important criterion. Practically, in some of the sites, there are at all no entry fees for the domestic tourists. Now, the decision matrix of Table 3 is developed showing the related information for all the evaluation criteria with respect to the considered Indian UNESCO WHSs. The necessary information is collected for the year 2017-2018 while consulting several websites, like https://www.wikipedia.org, https://whc.unesco.org/uploads/nominations/1056rev.pdf, https://whc.unesco.org/uploads/nominations/944bis.pdf, http://www.tourism.rajasthan.gov.in/annual-progress-report.html, https://whc.unesco.org/uploads/nominations/1338.pdf etc. The data of this decision matrix are now analyzed using PROMETHEE-GAIA software (http://www.promethee-gaia.net/vpb.html) while taking into account usual criterion as the most appropriate preference function.

**Table 1: List of the UNESCO WHSs in India**

| Sr. No. | Name of the UNESCO WHS | State | Year of Notification | Description |
|---|---|---|---|---|
| 1. | Kaziranga National Park ($A_1$) | Assam | 1985 | Located in Golaghat and Nagaon districts of Assam, it hosts two-thirds of the world's great one-horned rhinoceroses. It was also declared as a tiger reserve in 2006. |
| 2. | Keoladeo Ghana National Park ($A_2$) | Rajasthan | 1985 | Situated in Bharatpur, it is an artificial wetland and a famous avifauna sanctuary. Over 230 species of birds are known to be the residents here. |
| 3. | Manas Wildlife Sanctuary ($A_3$) | Assam | 1985 | Known for its rare and endangered species, it is situated in the foothills of the Himalayas. It is a Project Tiger reserve, a biosphere reserve and an elephant reserve. It is also famous for its population of water buffalos. |
| 4. | Nanda Devi National Park and Valley of Flowers ($A_4$) | Uttarakhand | 1982<br>2005 | Established in 1982, it is situated around the peak of Nanda Devi (7816 m) in Uttarakhand. The entire park lies at an elevation of 3500 m above sea level. Some 312 floral species including 17 rare ones are found here. |

| Sr. No. | Name of the UNESCO WHS | State | Year of Notification | Description |
|---|---|---|---|---|
| 5. | Sunderbans National Park ($A_5$) | West Bengal | 1984 | It is a part of the Sundarbans on the Ganges delta, densely covered by mangrove forests. It is famous for the Bengal tiger, and a variety of bird, reptile and invertebrate species. |
| 6. | Western Ghats ($A_6$) | Maharashtra, Goa, Karnataka, Tamil Nadu, Kerala | 2012 | Also known as Sahyadri (which translates to 'Benevolent Mountains'), it covers an area of 1,40,000 sq km in a stretch of 1600 km parallel to the Indian western coast. It is one of the eight 'hottest hot-spots' of biological diversity in the world. |
| 7. | Great Himalayan National Park ($A_7$) | Himachal Pradesh | 2014 | Located in the Kullu region in the Western Himalayas, it spreads across four valleys. It is a home to numerous flora and more than 375 fauna species. |
| 8. | Agra Fort ($A_8$) | Uttar Pradesh | 1983 | It was the main residence of the emperors of the Mughal dynasty till 1638. It received its present look during the reign of Akbar. It stands on an ancient site and was traditionally known as Badalgarh. |
| 9. | Ajanta Caves ($A_9$) | Maharashtra | 1983 | It has approximately 30 rock-cut Buddhist cave monuments which date from the 2$^{nd}$ century BCE to about 480 CE in Aurangabad district, built in two phases. The caves include some of the finest paintings and rock-cut sculptures depicting the life of Buddha. |
| 10. | Buddhist Monuments at Sanchi ($A_{10}$) | Madhya Pradesh | 1989 | It comprises a group of Buddhist monuments, pillars, palaces, monasteries and temples, all dating back to 2$^{nd}$ and 1$^{st}$ centuries BC. |
| 11. | Champaner-Pavagadh Archaeological Park ($A_{11}$) | Gujarat | 2004 | Located in Panchmahal district, it includes cultural heritage monuments and remains of the capital of 16$^{th}$ century Gujarat. Kalika Mata temple is an important shrine. Transition between the Hindu and Muslim culture and architecture is illustrated here. |
| 12. | Chhatrapati Shivaji Terminus ($A_{12}$) | Maharashtra | 2004 | Formerly known as Victoria Terminus, it serves as the headquarters of the Central Railways of India. It was designed by Frederick William Stevens and built in 1887 to commemorate the Golden Jubilee of Queen Victoria. |
| 13. | Churches and Convents of Goa ($A_{13}$) | Goa | 1986 | It consists of a set of religious monuments in old Goa. The influence of the monuments in Western art form dissemination and specific value of tomb of Francisco Xavier in the Basilica of Bom Jesus are highlighted here. |
| 14. | Elephanta Caves ($A1_4$) | Maharashtra | 1987 | Predominantly dedicated to the Hindu god Shiva, it is located on the Elephanta island in Mumbai Harbour. It contains rock cut stone sculptures and Mandala patterned temples. |
| 15. | Ellora Caves ($A_{15}$) | Maharashtra | 1983 | Located in Aurangabad district, these are one of the largest rock-cut monastery complexes in the world. It features the largest single monolithic rock excavation in the world, the chariot shaped Kailasha temple, dedicated to Lord Shiva. |
| 16. | Fatehpur Sikri ($A_{16}$) | Uttar Pradesh | 1986 | A town in Agra district, it was founded by Mughal emperor Akbar as his capital city in 1571. Buland Darwaza, the entrance to the town, is the most famous monument here. |
| 17. | Great Living Chola Temples ($A_{17}$) | Tamil Nadu | 1987 | Built by the Chola kings in South India, it includes three great 11$^{th}$ and 12$^{th}$ century temples, i.e. Brihadisvara temple at Thanjavur, Brihadisvara temple at Gangaikondacholisvaram and Airavatesvara temple at Darasuram. |
| 18. | Group of Monuments at Hampi ($A_{18}$) | Karnataka | 1986 | Hampi was the last capital of the great Hindu kingdom of Vijayanagar. The Dravidian temples and palaces won the admiration of the travellers in the 15$^{th}$ and 16$^{th}$ centuries before the city was pillaged and abandoned. |
| 19. | Group of Monuments at Mahabalipuram ($A_{19}$) | Tamil Nadu | 1984 | It is a collection of 7th and 8th century CE religious monuments on the Coromandel coast. The site has 400 ancient monuments and Hindu temples, including one of the oldest open-air rock reliefs in the world, i.e. the *Descent of the Ganges* or Arjuna's Penance. |
| 20. | Group of Monuments at Pattadakal ($A_{20}$) | Karnataka | 1987 | Built in the 7$^{th}$ and 8$^{th}$ centuries by the rulers of the Chalukya dynasty, the monuments represent a harmonious blend of North Indian and South Indian architectural forms. The monuments include a series of nine Hindu temples and a Jain monastery. The Temple of Virupaksha is the most famous monument. |
| 21. | Hill Forts of Rajasthan ($A_{21}$) | Rajasthan | 2013 | It includes six majestic forts in Chittorgarh, Kumbhalgarh, Sawai Madhopur, Jhalawar, Jaipur and Jaisalmer. These forts are a testimony to the power of the Rajput princely states from the 8$^{th}$ to 18$^{th}$ century. It also features extensive water harvesting structures, still in use. |

| Sr. No. | Name of the UNESCO WHS | State | Year of Notification | Description |
|---|---|---|---|---|
| 22. | Humayun's Tomb ($A_{22}$) | Delhi | 1993 | Built in 1570 with the patronage of Emperor Akbar, it is the first of grand dynastic mausoleums that highlighted Mughal architecture. It is also the first garden tomb of the Indian subcontinent. |
| 23. | Khajuraho Group of Monuments ($A_{23}$) | Madhya Pradesh | 1986 | Located in Chattarpur, it is famous for the Nagara-style architectural symbolism. It spreads over 6 sq km, and only 25 temples of the original 85 temples have survived. The temples are dedicated to two religions, i.e. Hinduism and Jainism. |
| 24. | Mahabodhi Temple Complex ($A_{24}$) | Bihar | 2002 | It is one of the four sites related to the life of Lord Buddha, particularly to the attainment of Enlightenment. It is also one of the earliest brick Buddhist temples, dates back to 5$^{th}$ or 6$^{th}$ centuries. |
| 25. | Mountain Railways of India ($A_{25}$) | Tamil Nadu, Himachal Pradesh, West Bengal | 1999, 2005, 2008 | It includes the Darjeeling Himalayan Railway, the Nilgiri Mountain Railway and the Kalka-Shimla Railway. They are all narrow-gauge railways. |
| 26. | Qutb Minar and its Monuments ($A_{26}$) | Delhi | 1993 | Built in the early 13$^{th}$ century, the Qutb Minar is a red sandstone tower. Funerary buildings, the magnificent Alai Darwaza gate, the masterpiece of Hindu-Muslim art and two mosques surrounding the Qutb Minar are included in the group of monuments. |
| 27. | Rani-Ki-Van (the Queen's Stepwell) at Patan ($A_{27}$) | Gujarat | 2014 | Located on the banks of Saraswati river, it was built as a memorial to a king in 11$^{th}$ century AD. It was designed as an inverted temple highlighting sanctity of water, while reflecting the mastery of the Maru-Gurjara architectural style. |
| 28. | Red Fort Complex ($A_{28}$) | Delhi | 2007 | It was built as the palace fort of Shahjahanabad, the new capital of Mughal Emperor Shah Jahan. It is named for its massive enclosing walls of red sandstone. Its architectural elements reflect a fusion of Persian, Timurid and Hindu traditions. |
| 29. | Rock Shelters of Bhimbetka ($A_{29}$) | Madhya Pradesh | 2003 | Located in the foothills of the Vindhyan mountains, it includes five clusters of natural rock shelters displaying paintings which appear to date from the Mesolithic period through to the historical period. |
| 30. | Sun Temple, Konarak ($A_{30}$) | Orissa | 1984 | It is a monumental representation of Sun God Surya's chariot. Its 24 wheels are studded with symbolic designs and the chariot is led by a team of 6 horses. It was built in the 13$^{th}$ century. |
| 31. | Taj Mahal ($A_{31}$) | Uttar Pradesh | 1983 | An immense mausoleum of white marble, it was built on orders of Shah Jahan in memory of his favourite wife, Mumtaz Mahal. It is also one of the seven wonders of the world. |
| 32. | The Jantar Mantar, Jaipur ($A_{32}$) | Rajasthan | 2010 | It is an astronomical observation site, built in the 18$^{th}$ century, by Maharaja Jai Singh II. It has a set of 20 main fixed instruments. |
| 33. | Archaeological Site of Nalanda Mahavihara ($A_{33}$) | Bihar | 2016 | It comprises the archaeological remains of a monastic and scholastic institution, dating from the 3$^{rd}$ century BCE to the 13$^{th}$ century BCE. It includes stupas, shrines, viharas and important artworks. |
| 34. | The Architectural Work of Le Corbusier ($A_{34}$) | Chandigarh | 2016 | Comprising 17 sites, including the Complexe du Capitole in Chandigarh, it demonstrates how Modernism was applied to construction, showing the global range of style of the architect. |
| 35. | Historic City of Ahmadabad ($A_{35}$) | Gujarat | 2017 | It consists of the walled city, founded by Sultan Ahmad Shah in the 15$^{th}$ century, on the eastern banks of River Sabarmati. It presents rich architectural heritage from the Sultanate period, primarily the Bhadra citadel, the walls and gates of the city as well as other important landmarks of the city. |
| 36. | Khangchendzonga National Park ($A_{36}$) | Sikkim | 2016 | It includes a unique diversity of plains, valleys, lakes, glaciers and mesmerising snow-capped mountains, including the world's third highest peak, Mount Khangchendzonga. There are mythological stories associated with the mountain, constituting the basis of Sikkimese identity. |
| 37. | The Victorian and Art Deco Ensemble of Mumbai ($A_{37}$) | Maharashtra | 2018 | It includes the ensemble of public buildings bordering the Oval Maidan open space and bears testimony to the phase of modernisation of Mumbai in the last two centuries. |

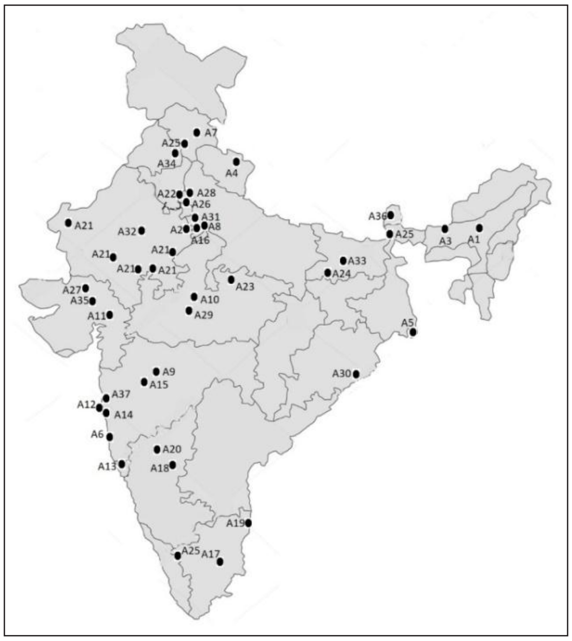


**Fig. 1: Locations of the UNESCO WHSs in the Map of India**

**Table 2: List of Evaluation Criteria**

| Sr. No. | Criteria | Description | Weight | Type |
|---|---|---|---|---|
| $C_1$ | $PM_{2.5}$ pollution index | $PM_{2.5}$ is a measure of air quality index which refers to measurement of atmospheric particulate matter (PM) having diameter less than 2.5 μm (in μg/m$^3$). | 0.0796 | Cost |
| $C_2$ | Entry fee for foreign tourists | It refers to the cost of ticket (in INR) for foreign tourists for entry to a specific WHS. | 0.0652 | Cost |
| $C_3$ | Entry fee for domestic tourists | It is the cost of ticket (in INR) for the Indian tourists for entry to a specific WHS. | 0.0262 | Cost |
| $C_4$ | Number of citations | It specifies the number of citations of the WHS's name (in English) based on a Google search (https://www.google.com). | 0.1658 | Benefit |
| $C_5$ | Number of nearby hotels | It provides information about the total number of 4 and 5 star hotels in the vicinity of a particular WHS. | 0.1462 | Benefit |
| $C_6$ | Revenue earned | It is a measure of the total revenue earned (in INR) from both foreign and domestic tourists for a particular WHS during 2017-2018. | 0.1447 | Benefit |
| $C_7$ | Number of foreign tourists | It counts the total number of foreign tourists visited a specific WHS during 2017-2018. | 0.1351 | Benefit |
| $C_8$ | Number of domestic tourists | It is the total number of domestic tourists visited a particular WHS during 2017-2018. | 0.1371 | Benefit |
| $C_9$ | Road distance from the state capital | It is the measure of road distance of a WHS from the capital of the state where it is located (in km). | 0.1002 | Cost |

**Table 3: Decision Matrix for Evaluation of UNESCO WHSs in India**

| Alternative | $C_1$ | $C_2$ | $C_3$ | $C_4$ | $C_5$ | $C_6$ | $C_7$ | $C_8$ | $C_9$ |
|---|---|---|---|---|---|---|---|---|---|
| $A_1$ | 25.25 | 1025 | 325 | 11,60,000 | 15 | **439,95,000** | **11,417** | 1,51,382 | 185 |
| $A_2$ | 39.22 | 500 | 75 | 1,20,000 | 37 | 2,14,31,124 | 25,417 | 1,20,641 | 186 |
| $A_3$ | 40 | 250 | 20 | 2.03,000 | 3 | **81,24,330** | **677** | **44,716** | 145 |
| $A_4$ | 24.5 | 650 | 150 | 3,15,000 | 35 | 16,76,335 | 486 | 7,053 | 310 |
| $A_5$ | 46 | 200 | 60 | 1,82,000 | 16 | 211,70,646 | 4,382 | 1,97,341 | 98 |
| $A_6$ | 13.2 | 0 | 0 | 59,90,000 | 350 | 112,45,600 | 6,784 | 6,29,402 | 291.2 |
| $A_7$ | 49.49 | 200 | 50 | 82,10,000 | 70 | 17,64,300 | 171 | 6,829 | 77 |
| $A_8$ | 155 | 550 | 40 | 176,00,000 | 223 | 1242,93,767 | 3,56,650 | 19,30,362 | 336 |
| $A_9$ | 123 | 250 | 10 | 25,30,000 | 4 | 120,76,066 | 23,592 | 4,19,846 | 426 |

| Alternative | $C_1$ | $C_2$ | $C_3$ | $C_4$ | $C_5$ | $C_6$ | $C_7$ | $C_8$ | $C_9$ |
|---|---|---|---|---|---|---|---|---|---|
| $A_{10}$ | 93 | 250 | 10 | 1,52,000 | 6 | 47,79,741 | 4,571 | 2,69,292 | 48 |
| $A_{11}$ | 55 | 500 | 30 | 50,700 | 5 | 20,87,163 | 2,140 | 1,55,030 | 168 |
| $A_{12}$ | 179 | 0 | 0 | 15,70,000 | 211 | 112,00,000 | 24,500 | 15,77,669 | 6 |
| $A_{13}$ | 36 | 0 | 0 | 58,100 | 2200 | 214,00,000 | 48,76,359 | 6,04,414 | 12 |
| $A1_4$ | 179 | 250 | 10 | 5,15,000 | 151 | 149,45,050 | 40,991 | 4,11,624 | 19 |
| $A_{15}$ | 123 | 250 | 30 | 17,50,000 | 67 | 251,27,941 | 27,493 | 15,42,815 | 329 |
| $A_{16}$ | 142 | 510 | 40 | 29,70,000 | 293 | 683,29,246 | 2,19,705 | 6,78,590 | 371 |
| $A_{17}$ | 22 | 0 | 0 | 4,05,000 | 34 | 69,00,000 | 1,021 | 4,012 | 347 |
| $A_{18}$ | 60 | 500 | 30 | 2,92,000 | 31 | 191,54,506 | 41,220 | 5,24,055 | 352 |
| $A_{19}$ | 109 | 250 | 10 | 1,85,000 | 52 | 355,82,097 | 67,483 | 10,39,021 | 56 |
| $A_{20}$ | 55 | 500 | 30 | 70,400 | 4 | 57,63,976 | 6,712 | 3,38,771 | 459 |
| $A_{21}$ | 89 | 153 | 17 | 12,00,000 | 444 | 20,77,090 | 16,10,000 | 19,15,695 | 286 |
| $A_{22}$ | 183 | 500 | 30 | 13,20,000 | 791 | 735,68,863 | 1,55,050 | 6,28,043 | 8 |
| $A_{23}$ | 65 | 500 | 10 | 3,16,000 | 64 | 272,84,505 | 58,486 | 2,46,467 | 376 |
| $A_{24}$ | 243 | 0 | 0 | 2,25,000 | 99 | 88,21,000 | 2,61,238 | 19,07,419 | 111 |
| $A_{25}$ | 32 | 205 | 205 | 73,00,000 | 1107 | 841,25,360 | 1,52,647 | 12,65,483 | 391 |
| $A_{26}$ | 183 | 500 | 30 | 13,50,000 | 1007 | 1235,02,594 | 3,51,156 | 23,28,852 | 15 |
| $A_{27}$ | 69 | 126 | 5 | 32,600 | 3 | 28,88,610 | 3,659 | 3,34,413 | 111 |
| $A_{28}$ | 183 | 500 | 35 | 863,00,000 | 376 | 748,62,726 | 79,560 | 22,93,843 | 5 |
| $A_{29}$ | 93 | 100 | 10 | 1,61,000 | 142 | 1,52,364 | 5,596 | 84,000 | 45 |
| $A_{30}$ | 43 | 250 | 10 | 9,99,000 | 12 | 296,00,081 | 77,991 | 16,30,365 | 65 |
| $A_{31}$ | 155 | 1000 | 40 | 993,00,000 | 257 | 26,55,74,684 | 4,15,548 | 43,02,791 | 336 |
| $A_{32}$ | 89 | 200 | 50 | 141,00,000 | 478 | 101,20,135 | 3,56,748 | 5,12,364 | 5 |
| $A_{33}$ | 151 | 200 | 15 | 33,800 | 14 | 61,07,241 | 29,198 | 6,44,391 | 95 |
| $A_{34}$ | 59 | 10 | 10 | 85,00,000 | 214 | 14,56,282 | 23,586 | 45,286 | 12 |
| $A_{35}$ | 100 | 0 | 0 | 58,50,000 | 329 | 4399,68,0000 | 1,38,000 | 74,59,000 | 27 |
| $A_{36}$ | 35 | 560 | 350 | 1,76,000 | 104 | 20,10,787 | 49,111 | 13,75,854 | 46 |
| $A_{37}$ | 179 | 0 | 0 | 3,14,000 | 840 | 91,42,500 | 26,600 | 14,60,600 | 1 |

In Fig. 2, the ranking positions of all the 37 UNESCO WHSs are provided based on the calculated values of net outranking flow. These sites are placed along a vertical scale which has two halves (upper half for positive net outranking flow and lower half for negative net outranking flow). Table 4 provides the values of positive, negative and net outranking flows for all the considered alternative sites. In this table, there are 19 UNESCO WHSs with positive net outranking flows, whereas, 18 UNESCO WHSs have negative net outranking flows. Fig. 2 reveals that alternative $A_{31}$ (Taj Mahal) having the maximum net outranking flow (0.5140) is the best performing UNESCO WHS in India, followed by site $A_{35}$ (Historic City of Ahmadabad) and site $A_{28}$ (Red Fort Complex). On the other hand, site $A_{11}$ (Champaner-Pavagadh Archaeological Park) and site $A_{20}$ (Group of Monuments at Pattadakal) are the least attractive Indian UNESCO WHSs. They lag behind their competitive sites with respect to several evaluation criteria.

**Table 4: Positive, Negative and net Outranking Flows for UNESCO WHSs in India**

| Alternative | $A_1$ | $A_2$ | $A_3$ | $A_4$ | $A_5$ | $A_6$ | $A_7$ | $A_8$ |
|---|---|---|---|---|---|---|---|---|
| $\varphi^+$ | 0.4145 | 0.3592 | 0.2632 | 0.2435 | 0.3711 | 0.6103 | 0.3861 | 0.6861 |
| $\varphi^-$ | 0.5855 | 0.6281 | 0.7218 | 0.7565 | 0.6235 | 0.3738 | 0.6076 | 0.3101 |
| $\varphi$ | -0.1709 | -0.2689 | -0.4586 | -0.5130 | -0.2523 | 0.2366 | -0.2215 | 0.3760 |
| Alternative | $A_9$ | $A_{10}$ | $A_{11}$ | $A_{12}$ | $A_{13}$ | $A_{14}$ | $A_{15}$ | $A_{16}$ |
| $\varphi^+$ | 0.3785 | 0.2924 | 0.2079 | 0.6017 | 0.6789 | 0.4967 | 0.5269 | 0.5932 |
| $\varphi^-$ | 0.5985 | 0.6887 | 0.7731 | 0.3780 | 0.3024 | 0.4822 | 0.4558 | 0.4052 |
| $\varphi$ | -0.2199 | -0.3963 | -0.5652 | 0.2237 | 0.3765 | 0.0145 | 0.0711 | 0.1882 |
| Alternative | $A_{17}$ | $A_{18}$ | $A_{19}$ | $A_{20}$ | $A_{21}$ | $A_{22}$ | $A_{23}$ | $A_{24}$ |
| $\varphi^+$ | 0.3507 | 0.4019 | 0.5223 | 0.2168 | 0.6172 | 0.6419 | 0.4360 | 0.5328 |
| $\varphi^-$ | 0.6334 | 0.5813 | 0.4610 | 0.7601 | 0.3806 | 0.3368 | 0.5454 | 0.4485 |
| $\varphi$ | -0.2826 | -0.1794 | 0.0612 | -0.5433 | 0.2367 | 0.3050 | -0.1094 | 0.0844 |
| Alternative | $A_{25}$ | $A_{26}$ | $A_{27}$ | $A_{28}$ | $A_{29}$ | $A_{30}$ | $A_{31}$ | $A_{32}$ |
| $\varphi^+$ | 0.7181 | 0.7264 | 0.2565 | 0.7363 | 0.3387 | 0.5777 | 0.7550 | 0.6967 |
| $\varphi^-$ | 0.2819 | 0.2523 | 0.7367 | 0.2438 | 0.6533 | 0.4055 | 0.2411 | 0.2920 |
| $\varphi$ | 0.4362 | 0.4741 | -0.4802 | 0.4924 | -0.3146 | 0.1722 | 0.5140 | 0.4047 |
| Alternative | $A_{33}$ | $A_{34}$ | $A_{35}$ | $A_{36}$ | $A_{37}$ | | | |
| $\varphi^+$ | 0.3562 | 0.4765 | 0.7485 | 0.4474 | 0.6008 | | | |
| $\varphi^-$ | 0.6384 | 0.5149 | 0.2356 | 0.5526 | 0.3789 | | | |
| $\varphi$ | -0.2822 | -0.0385 | 0.5129 | -0.1051 | 0.2219 | | | |

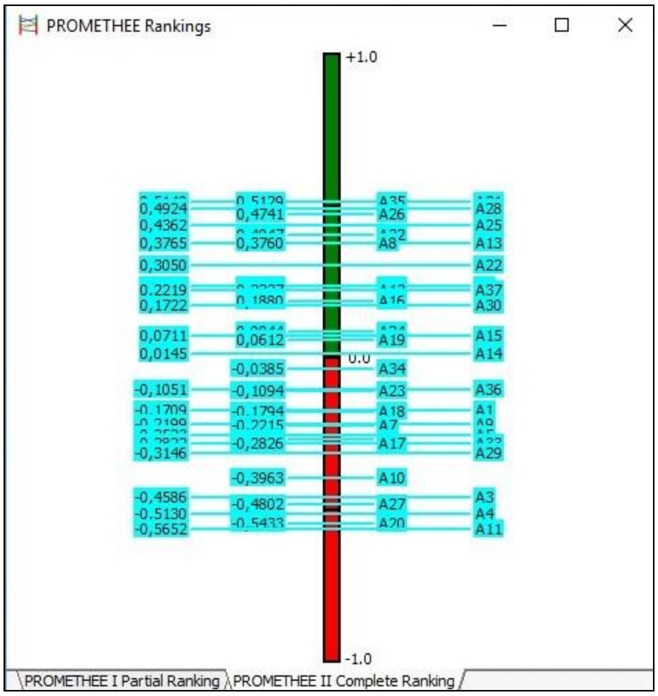


**Fig. 2: PROMETHEE II Ranking of 37 UNESCO WHSs in India**

In PROMETHEE rainbow diagram, as shown in Fig. 3, all the 37 UNESCO WHSs are positioned from left to right based on their rankings in this performance appraisal process. In this figure, for each UNESCO WHS, there is a vertical bar consisting of many slices. The thickness of any particular slice within the bar is proportional to the contribution of each criterion in the derived net flow for an UNESCO WHS. For a WHS, the slices for all the favourable criteria are positioned above the horizontal line and those for the weak criteria are below the line. Thus, this PROMETHEE rainbow diagram helps in visualizing the characteristic profiles of all the UNESCO WHSs with respect their performance in national and international tourist attractiveness. In this performance evaluation process, alternative $A_{31}$ occupies the top position in the ranking list, followed by alternative $A_{35}$. In Fig. 3, alternative $A_{31}$ is strong with respect to all the criteria except $C_1$, $C_2$, $C_3$ and $C_9$. On the other hand, the second-best alternative ($A_{35}$) has its weakness only on criterion $C_1$. From the PROMETHEE rainbow diagram, it can be observed that the top two most popular UNESCO WHSs, i.e. $A_{31}$ and $A_{35}$ have maximum strength with respect to criterion $C_4$ (number of citations) and $C_8$ (number of domestic tourists) respectively. Table 3 reveals that alternative $A_{31}$ has the maximum number of citations (993,00,000) among all the considered Indian UNESCO WHSs. Similarly, alternative $A_{35}$ has the maximum number of domestic tourists (74,59,000). This large number domestic tourists visiting site $A_{35}$ is quite justified as it is itself situated in the state capital of Gujarat. The last three ranked Indian UNESCO WHSs, i.e. $A_{11}$, $A_{20}$ and $A_4$ have only one criterion in their favour, i.e. criterion $C_1$ ($PM_{2.5}$ pollution index). A close analysis of the comparative performance of the top two Indian UNESCO WHSs, as shown in Fig. 4, indicates that site $A_{31}$ outperforms site $A_{35}$ with respect to five criteria, i.e. $C_1$, $C_4$, $C_5$ $C_6$, and $C_7$. On the other hand, the performance of alternative $A_{35}$ is better than alternative $A_{31}$ with respect to four criteria, i.e. $C_2$, $C_3$, $C_8$ and $C_9$. It is observed that as the sum of weights for all the favourable criteria (0.6714) for alternative $A_{31}$ is greater than that (0.3286) for alternative $A_{35}$, site $A_{31}$ emerges out as the best Indian UNESCO WHS having the maximum tourist attraction.

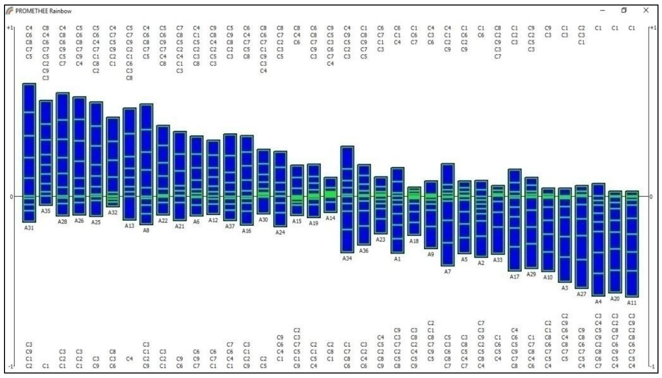

**Fig. 3: PROMETHEE Rainbow for Performance Evaluation of 37 UNESCO WHSs in India**

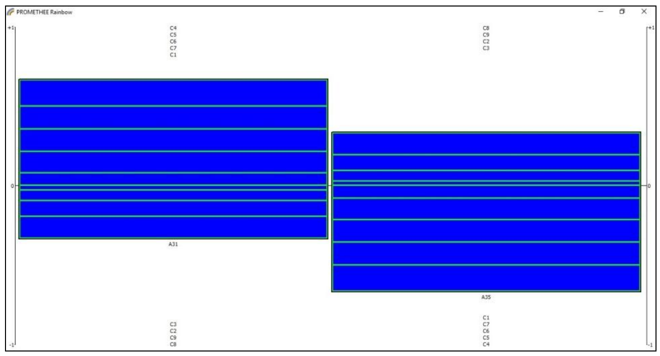

**Fig. 4: Criteria-Wise Comparison of the Top Two Indian UNESCO WHSs**

The GAIA plane depicting the relative positions of all the 37 UNESCO WHSs with respect to the considered evaluation criteria is provided in Fig. 5. In this figure, seven UNESCO WHS alternatives, i.e. $A_8$, $A_{16}$, $A_{22}$, $A_{25}$, $A_{28}$, $A_{31}$ and $A_{35}$ are practically oriented in the direction of $\pi$-axis having farthest distances from the origin of the GAIA plane. It indicates the superiority of these Indian UNESCO WHSs over the others with respect to the performance evaluation measures under consideration. Amongst these best-performing sites, alternative sites $A_{31}$ and $A_{35}$ have the maximum distances from the origin of the plane, while validating their excellent performance in both domestic and foreign tourist attractiveness. On the other hand, the positions of six Indian UNESCO WHSs, i.e. $A_1$, $A_2$, $A_3$, $A_4$, $A_{11}$ and $A_{20}$ are the farthest in the opposite direction of π-axis. Alternatives $A_{11}$ and $A_4$ which are positioned having the maximum distances in the opposite π-axis direction are the two worst-performing sites with respect to tourist attraction. In this plane, five criteria, i.e. $C_4$, $C_5$, $C_6$, $C_7$ and $C_8$ (number of citations, number of nearby hotels, revenues earned, and numbers of domestic and foreign tourists) belong to one cluster. Similarly, three evaluation criteria, i.e. $C_2$, $C_3$ and $C_9$ (entry fees for foreign and domestic tourists, and distance from the state capital) are in another cluster. These two clusters are oriented along the orthogonal axes in the GAIA plane and they are not related to each other with respect to their preferences. Criterion $C_1$ ($PM_{2.5}$ pollution index) is almost an outlier in the developed GAIA plane having no significant effect on this performance appraisal process. As expected, all the beneficial criteria ($C_4$, $C_5$, $C_6$, $C_7$ and $C_8$) and cost criteria ($C_2$, $C_3$ and $C_9$) are in two different groups, and have almost the same effect in this evaluation process. It can also be noticed from the GAIA plane that Indian UNESCO WHSs, $A_8$, $A_{16}$, $A_{22}$, $A_{25}$, $A_{28}$, $A_{31}$ and $A_{35}$ are extremely strong with respect to criteria $C_4$, $C_5$, $C_6$, $C_7$ and $C_8$; $A_{12}$, $A_{13}$, $A_{14}$, $A_{24}$, $A_{34}$, $A_{35}$ and $A_{37}$ have $C_2$, $C_3$ and $C_9$ criteria in their favour, and $C_1$ is the only favourable criterion for Indian UNESCO WHSs $A_1$, $A_2$, $A_4$, $A_9$ and $A_{20}$. As this performance appraisal problem for the UNESCO WHSs in India consists of 37 alternatives and nine evaluation criteria, it is hard to solve having solution quality of 63.3%.

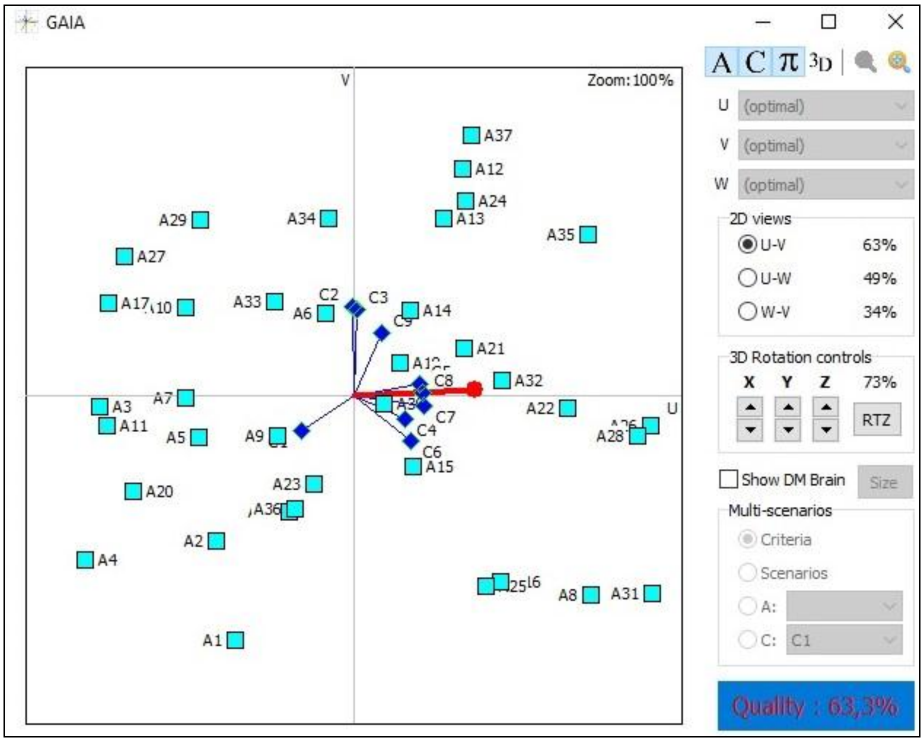


**Fig. 5: GAIA Plane for Performance Appraisal of the UNESCO WHSs in India**

Fig. 6 represents the best to worst ranking of the 37 Indian UNESCO WHSs and also the corresponding weights assigned to the nine evaluation criteria. In this figure, all the sites are clearly split into two separate clusters depending on their net outranking flow values. The UNESCO WHSs $A_{31}$, $A_{35}$, $A_{28}$, $A_{26}$, $A_{25}$, $A_{32}$, $A_{13}$, $A_8$, $A_{22}$, $A_{21}$, $A_6$, $A_{12}$, $A_{37}$, $A_{16}$, $A_{30}$, $A_{24}$, $A_{15}$, $A_{19}$ and $A_{14}$ belong to one cluster with positive flow values, whereas, the remaining sites, i.e. $A_{34}$, $A_{36}$, $A_{23}$, $A_1$, $A_{18}$, $A_9$, $A_7$, $A_5$, $A_2$, $A_{33}$, $A_{17}$, $A_{29}$, $A_{10}$, $A_3$, $A_{27}$, $A_4$, $A_{20}$ and $A_{11}$ are in another group with negative flow scores. Thus, amongst all the considered UNESCO WHSs in India, exactly 19 have satisfactory performance towards attracting domestic as well as foreign tourists. The other sites are underperformers having deficiencies with respect to some of their evaluation criteria. In this figure, by changing weights of different criteria (walking weights), the decision-maker can analyze the effects of those changing weights on the subsequent ranking of the Indian UNESCO WHSs. Here, the visual stability interval of criterion $C_1$ ($PM_{2.5}$ pollution index) is exhibited where the change of multi-criteria net flow with respect to weight of criterion $C_1$ is shown as a visual sensitivity analysis tool.

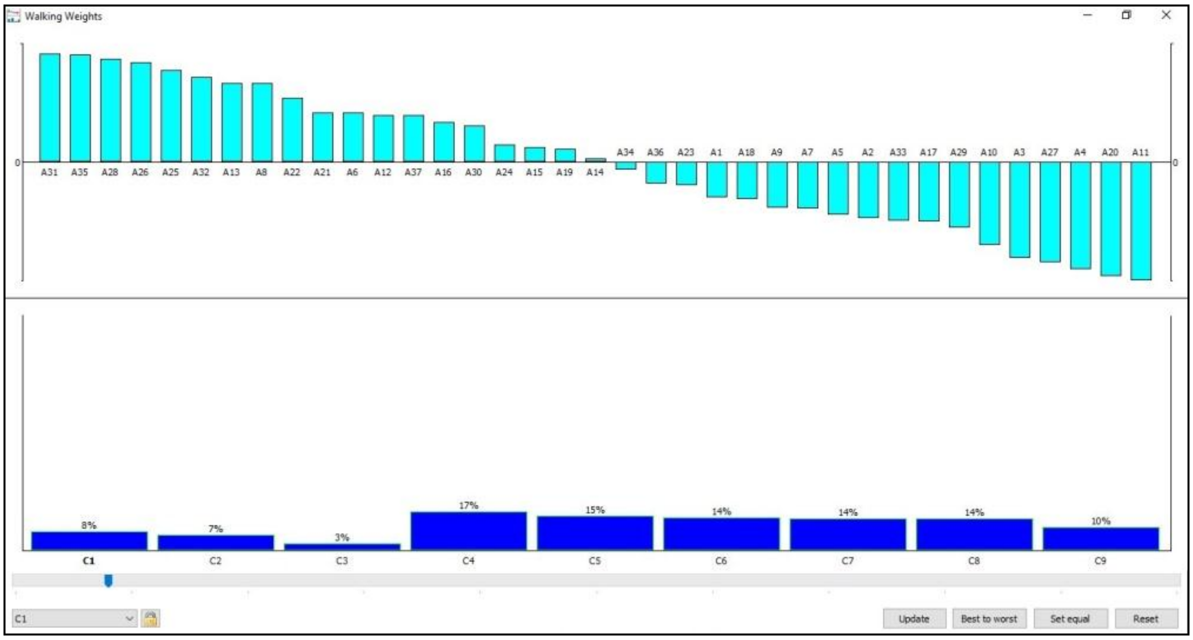


**Fig. 6: Walking Weights for Performance Evaluation of the Indian UNESCO WHSs**

The GAIA spider web as developed for this performance evaluation problem with respect to site $A_1$ (Kaziranga National Park) is exhibited in Fig. 7. In this figure, instead of showing different criteria at arbitrary angles, positions of the criteria axes in the GAIA plane are utilized as the reference. The strongly correlated criteria are close to each other on this web. Unicriterion net flows are represented on the web, i.e. −1 values are drawn at the centre of the web and +1 values are positioned on the outer circle. A rounded polygon is drawn connecting different criteria. For site $A_1$, criteria $C_2$ and $C_3$ (entry fees for the domestic and foreign tourists); $C_5$ and $C_8$ (number of nearby hotels and number of domestic tourists); and $C_4$ and $C_6$ (number of citations and revenue earned) are highly correlated, which are truly predictive in nature. In this figure, the decision axis is oriented towards criterion $C_8$, as already observed in the developed GAIA plane.

For this problem dealing with performance evaluation of UNESCO WHSs in India, the weight stability interval of criterion $C_1$ is shown in Fig. 8. Here, the criterion weight is exhibited in the horizontal dimension, whereas, the net outranking flow is positioned along the vertical dimension. The vertical axis is again divided into two portions for positive and negative net flow values. For each UNESCO WHS, a line is drawn representing the net flow as a function of the weight of criterion $C_1$. At the left edge of the horizontal axis, the weight of a particular criterion is 0%. On the other hand, the weight of that criterion is 100% at the right edge of this figure. A vertical green and red line is drawn at the current weight of criterion $C_1$ (7.96%). The intersections of the lines for different UNESCO WHSs with the vertical bar provide the present complete rankings of the considered sites. At the current weight of criterion $C_1$ as 7.96%, alternative sites $A_{31}$ and $A_{35}$ occupy the top two positions of the ranking list, whereas, alternative $A_{11}$ is the worst preferred UNESCO WHS in India. It can be interestingly noticed that the weight stability interval of $C_1$ criterion ranges between 7.93% and 7.98%, which denotes that within this interval, there would be no change in the positions of the top-ranked UNESCO WHSs. Even when criterion $C_1$ is not considered in this evaluation process (weight 0%), the positions of the top two sites would not alter. It can also be noted that when all the Indian UNESCO WHSs are solely ranked based on $C_1$ criterion (100% weight), alternative sites $A_6$ and $A_{17}$ would take the top two positions of the ranking list, whereas, $A_{24}$ would be the last ranked site. These variations in ranking can be well-validated based on the decision matrix of Table 3. Sites $A_6$ (Western Ghats) and $A_{17}$ (Great Living Chola Temples) have the minimum $P_{2.5}$ pollution indexes of 13.2 and 22 μg/m$^3$ respectively, whereas, site $A_{24}$ (Mahabodhi Temple Complex) has the highest $P_{2.5}$ pollution index of 243 μg/m$^3$. Similar types of weight stability intervals can also be performed with respect to other evaluation criteria to search out the possibility of rank reversals among the considered Indian UNESCO WHSs.

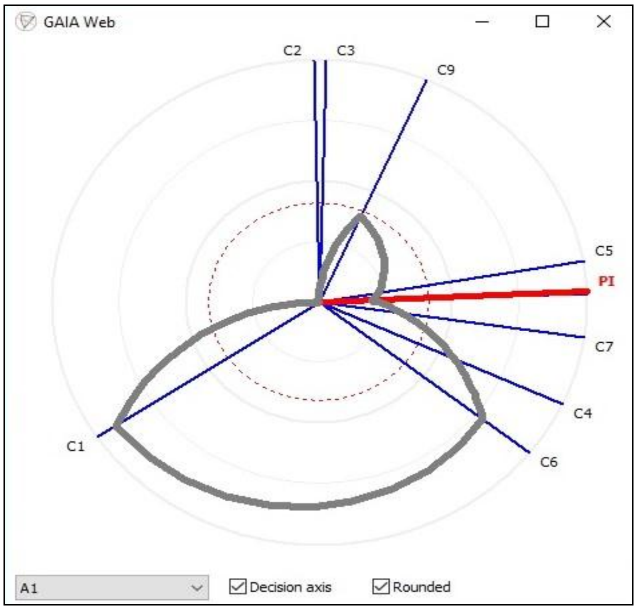


**Fig. 7: GAIA Spider Web for Alternative $A_1$**

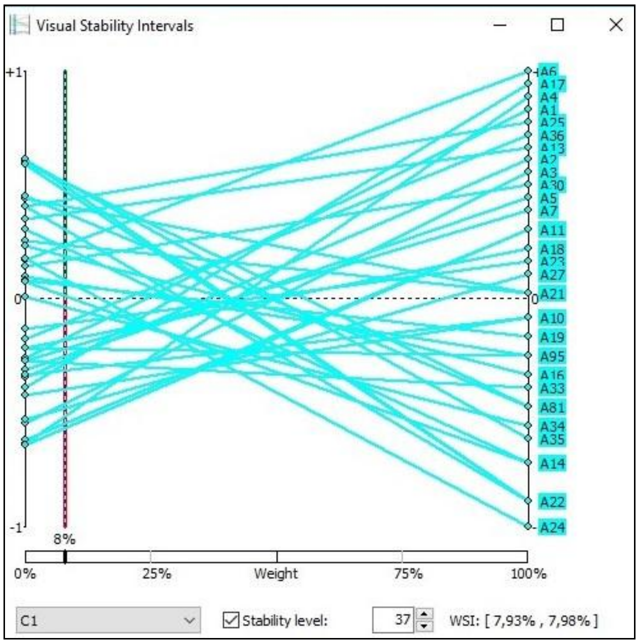


**Fig. 8: Weight Stability Interval of Criterion $C_1$**

## DISCUSSIONS AND CONCLUSIONS

Due to the presence of intrinsic complexities and involvement of large number of stakeholders and actors in the decision-making process, multi-criteria techniques and methodologies can be efficiently employed to identify efficient solutions, while fulfilling the requirements of both the participants and policymakers. Multi-criteria analysis is nowadays widely implemented in decision and evaluation processes, especially in tourism destination selection and performance appraisal. Evaluation of the tourism destination sites is a multidimensional concept, involving socio-economic, environmental, technical, financial and ethical perspectives, which are supposed to be strongly interrelated. Identification of the best performing tourism destination site would help in responding to the challenges, improving communication between the government or public administrations and stakeholders, allocating budgets based on a list of priorities, and favouring long-term investments. On the other hand, development of suitable strategic plans, understanding on prioritization of actions, involvement of the society and private sector are extremely important for promotion of the underperforming tourism destinations.

In this paper, an MCDM approach integrating PROMETHEE and GAIA methods is applied for appraising the performance of 37 UNESCO WHSs in India based on nine evaluation criteria. The phase of estimating and assigning weights to those criteria has indeed a key role in the analysis, which determines the final ranking of the considered UNESCO WHSs. The weights (relative importance) of those criteria are determined using AHP method and it is revealed that number of citations in www.google.com (a man-made criterion) has the maximum importance (0.1658) in evaluating those sites. The amount of information about a particular site in the related citations significantly influences the ranking of the Indian UNESCO WHSs, while increasing tourism attractiveness of that site. It focuses on the availability of tourism infrastructure for a particular place and encourages tourists to visit that attractive destination. It also helps in promoting increasing images of the UNESCO WHSs, while influencing successful tourism development for long-term sustainability of those sites. Number of nearby hotels for good accommodation and revenue earned during a specific financial year are the next two important criteria. On the other hand, entry fee for the domestic tourists for the considered Indian UNESCO WHSs is identified as the least significant criterion while evaluating the performance of those sites. It can be interestingly noted that in some of the Indian UNESCO WHSs, there are at all no entry fees for the Indian citizens. In some of the sites, entries for the foreign tourists are also totally free.

The application of PROMETHEE II method provides a complete ranking of all the 37 UNESCO WHSs in India with Taj Mahal, Historic City of Ahmadabad and Red Fort Complex respectively occupying the top three positions in the ranking list. The Taj Mahal, built on orders of Shah Jahan in memory of his favourite wife, Mumtaz Mahal, between 1631 and 1648, is approximately 204 kms from the south of New Delhi, the capital of India. It is well connected by air, rail and road. As it is also one of the seven wonders of the world, it attracts plethora of tourists, both domestic and foreign, every year. The Historic City of Ahmadabad, also known as the walled city of Ahmadabad, is a rich architectural heritage from the sultanate period, having numerous mosques and tombs as well as Hindu and Jain temples of later periods. It continued to flourish as the state capital of Gujarat for six centuries, up to the present. It remains always crowded with the domestic people. The Red Fort is considered to represent the zenith of Mughal creativity which, under the Shah Jahan, was brought to a new level of refinement. Being situated at the heart of the Indian capital, it attracts millions of tourists for its archaeological beauty. On the other hand, the Champaner-Pavagadh Archaeological Park and Monuments at Pattadakal are identified as the least attractive Indian UNESCO WHSs. These two places lag behind their competitors with respect to number of citations and number of good accommodations.

The developed GAIA plane and the related analyses help in identifying the 'bonus' and 'penal' criteria for each of the considered Indian UNESCO WHSs. It is observed that the top ranked sites have strengths with respect to number of citations, number of nearby hotels and revenue earned. The Taj Mahal (the best UNESCO WHS in India) has weaknesses with respect to PM2.5 pollution index, entry fees for both domestic and foreign tourists and distance from the state capital (although it is nearer to the Indian capital, New Delhi, it is 339 km distant from the capital of Uttar Pradesh, Lucknow). On the other, the Historic City of Ahmadabad is only weak with respect to PM2.5 pollution index. It can be interestingly noted that all the three worst-performing UNESCO WHSs are weak against all the evaluation criteria, except PM2.5 pollution index. When a critical analysis is performed between the two top-performing Indian UNESCO WHSs, it can be revealed that the Taj Mahal has five 'bonus' criteria and four 'penal' criteria. On the other hand, there are four 'bonus' criteria and five 'penal' criteria for the Historic City of Ahmadabad. The Taj Mahal outperforms the Historic City of Ahmadabad with respect to $C^1$, $C^4$, $C^5$, $C^6$, and $C^7$, whereas, the Historic City of Ahmadabad is better than the Taj Mahal with respect to $C^2$, $C^3$, $C^8$ and $C^9$. A recent report has also identified the Taj Mahal as the most beautiful UNESCO WHS (https://www.independent.co.uk/travel/news-and-advice/best-unesco-world-heritage-sites-beautiful-taj-mahal-great-barrier-reef-stonehenge-a8876666.html).

As expected, in the GAIA plane, all the criteria having similar preferences are segregated into separate groups, i.e. beneficial criteria are in one group and cost criteria form another group. Criteria, like number of citations, number of nearby hotels, numbers of domestic and foreign tourists and revenue earned, oriented in the direction of the decision axis, have strong influences in appraising the performance of the considered sites. In this plane, the position of $PM_{2.5}$ pollution index criterion is an outlier, having almost no significance in this evaluation process.

Thus, it can be concluded that the combined application of PROMETHEE-GAIA method seems to quite appropriate in appraising the considered Indian UNESCO WHSs with respect to a set of evaluation criteria. As the priority weights of all the criteria are included in this evaluation process, more accurate ranking results are expected to achieve. It also helps the decision maker to determine the weight stability intervals of all the criteria so as to search out the possibility of rank reversals among the Indian UNESCO WHSs. This method is also capable of effectively dealing with both quantitative and qualitative criteria. The GAIA plane, being a descriptive tool, provides a powerful graphical representation of the derived results, while presenting a detailed analysis based on the alternatives and criteria sets. The PROMETHE-GAIA method can thus be used to improve investment efficiency in changing tourism attractiveness of Indian UNESCO WHSs. The policymakers and investors can detect the weaknesses and strengths of those sites, and improve them to increase attractiveness of tourism destinations and supporting tourism development strategies and planning. Keeping in mind the possibilities of further promotion of Indian tourism, various Central Government projects, like computerization and information technology, domestic promotion and publicity including hospitality, infrastructure development for destination and circuits, assistance to central agencies for infrastructure development, National Mission for Pilgrimage Rejuvenation and Spiritual Augmentation Drive etc. have already started working. As a future scope of this paper, the effects of different preference functions on the rankings of the considered Indian UNESCO WHSs can be studied. The PROMETHE-GAIA approach can also be applied for performance evaluation of various national parks in India and setting priority ranking of the heritage buildings for renovation.

## REFERENCES

Alzahrani, D. A. (2013). The adoption of a standard definition of cultural heritage. *International Journal of Social Science and Humanity*, *3*(1), 9-12.

Behzadian, M., Kazemzadeh, R. B., Albadvi, A., & Aghdasi, M. (2010). PROMETHEE: A comprehensive literature review on methodologies and applications. *European Journal of Operational Research*, *200,* 198-215.

Brans, J. P., & Vincke, P. (1985). A preference ranking organisation method: The PROMETHEE method for MCDM. *Management Science*, *31,* 647-56.

Brans, J. P., Vincke, P., & Mareschal, B. (1986). How to select and how to rank projects: The PROMETHEE method. *European Journal of Operational Research*, *24,* 228-38.

Brans, J. P., & Mareschal, B. (1994). The Promcalc and Gaia decision-support system for multi-criteria decision aid. *Decision Support Systems*, *12,* 297-310.

Butowski, L. (2018). An integrated AHP and PROMETHEE approach to the evaluation of the attractiveness of European maritime areas for sailing tourism. *Moravian Geographical Reports*, *26*(2), 135-148.

Çetinkaya, C., Kabak, M., Erbaş, M., & Özceylan, E. (2018). Evaluation of ecotourism sites: A GIS-based multi-criteria decision analysis. *Kybernetes.* Retrieved from https://doi.org/10.1108/K-10-2017-0392

Chakraborty, S., Ranjan, R., & Mondal, P. (2018). A state-wise performance appraisal of Indian roads using PROMETHEE-GIS approach. *Benchmarking - An International Journal*, *25*(9), 3338-3356.

Cuccia, T., Guccio, C., & Rizzo, I. (2017). UNESCO sites and performance trend of Italian regional tourism destinations: A two-stage DEA window analysis with spatial interaction. *Tourism Economics*, *23*(2), 316-342.

Dahiya, K. S., & Batra, D. K. (2016). Tourist decision making: Exploring the destination choice criteria. *Asian Journal of Management Research*, *7*(2), 140-153.

Dutta, M., & Husain, Z. (2009). An application of multicriteria decision making to built heritage: The case of Calcutta. *Journal of Cultural Heritage*, *10*(2), 237-243.

Göksu, A., & Kaya, S. E. (2014). Ranking of tourist destinations with multi-criteria decision making methods in Bosnia and Herzegovina. *Journal of Economics and Business*, *12*(2), 91-103.

Gullino, P., & Larcher, F. (2013). Integrity in UNESCO world heritage sites. A comparative study for rural landscapes. *Journal of Cultural Heritage*, *14*, 389-395.

Horng, J. S., Liu, C. H., Chou, S. F., Yin, Y. S., & Tsai, C. Y. (2014). Developing a novel hybrid model for industrial environment analysis: A study of the gourmet and tourism industry in Taiwan. *Asia Pacific Journal of Tourism Research, 19*(9), 1044-1069.

Iatu, C., & Bulai, M., (2011). New approach in evaluating tourism attractiveness in the region of Moldavia (Romania). *International Journal of Energy and Environment*, *5*(2), 165-174.

Ilban, M. O., & Yıldırım, H. H. (2017). Determination of tourism activities of the world's best tourism destinations using the multi-criteria decision-making method. *Cogent Social Sciences*, 3, Article No. 1301763. Retrieved from http://dx.doi.org/10.1080/23311886.2017.1301763

Karanth, K. K., & DeFries, R. (2011). Nature-based tourism in Indian protected areas: New challenges for park management. *Conservation Letters*, *4,* 137-149.

Komchornrit, K., (2017). The selection of dry port location by a hybrid CFA-MACBETH-PROMETHEE method: A case study of Southern Thailand. *The Asian Journal of Shipping and Logistics*, *33*(3), 141-153.

Kovačić, M. (2010). Selecting the location of a nautical tourism port by applying Promethee and Gaia methods. *Traffic & Transportation*, *22*(5), 341-351.

Kutut, V., Zavadskas, E. K., & Lazauskas, M. (2013). Assessment of priority options for preservation of historic city centre buildings using MCDM (ARAS). *Procedia Engineering*, *57,* 657-661.

Landorf, C. (2009). Managing for sustainable tourism: A review of six cultural world heritage sites. *Journal of Sustainable Tourism*, *17*(1), 53-70.

Lekaota, L. (2018). Impacts of world heritage sites on local communities in the Indian ocean region. *African Journal of Hospitality, Tourism and Leisure*, *7*(3), 1-10.

Liu, C.-H., Tzeng, G.-H., & Lee, M.-H. (2012). Improving tourism policy implementation - The use of hybrid MCDM models. *Tourism Management*, *33*, 413-426.

Lopes, A. P. F., Muñoz, M. M., & Alarcón-Urbistondo, P. (2018). Regional tourism competitiveness using the PROMETHEE approach. *Annals of Tourism Research*, *73,* 1-13.

Mardani, A., Jusoh, A., Nor, K. M., Khalifah, Z., Zakwan, N., & Valipour, A. (2015). Multiple criteria decision-making techniques and their applications - A review of the literature from 2000 to 2014. *Economic Research-Ekonomska Istraživanja*, *28*(1), 516-571.

Mohamad, D., & Jamil, R. M. (2012). A preference analysis model for selecting tourist destinations based on motivational factors: A case study in Kedah, Malaysia. *Procedia-Social and Behavioral Sciences*, *65,* 20-25.

Mondéjar-Jiménez, J.-A., García-Centeno, M.-C., Mínguez-Salido, R., Mondéjar-Jiménez, J., & Cordente-Rodríguez, M. (2010). Cultural tourism, using a multicriteria analysis: Spanish world heritage cities. *International Journal of Management & Information Systems*, *14*(4), 35-43.

Ranjan, R., Chatterjee, P., & Chakraborty, S. (2016). Performance evaluation of Indian states in tourism using an integrated PROMETHEE-GAIA approach. *OPSEARCH*, *53*(1), 63-84.

Roy, J., Chatterjee, K., Bandyopadhyay, A., & Kar, S. (2018). Evaluation and selection of medical tourism sites: A rough analytic hierarchy process based multi-attributive border approximation area comparison approach. *Expert Systems*, 3. Retrieved from https://doi.org/10.1111/exsy.12232.

Schägner, J. P., Brander, L., Maes, J., Paracchini, M. L., & Hartje, V. (2016). Mapping recreational visits and values of European national parks by combining statistical modelling and unit value transfer. *Journal for Nature Conservation*, *31,* 71-84.

Sharma, H. K., Roy, J., Kar, S., & Prentkovskis, O., (2018). Multi criteria evaluation framework for prioritizing Indian railway stations using modified rough AHP-MABAC method. *Transport and Telecommunication*, *19*(2), 113-127.

Siddiqui, M. H., & Tripathi, S. N. (2011). Performance of tourist centres in Uttar Pradesh: An evaluation using data envelopment analysis. *ASCI Journal of Management*, *40*(1), 31-51.

Stević, I., Stević, S. R., & de Jesus Breda, Z. M. (2019). Application of MCDM methods to tourism evaluation of cultural sites. In M. O. Šćitaroci, B. O. Šćitaroci and A. Mrđa (Eds.) *Cultural Urban Heritage.* The Urban Book Series, Springer, 357-381.

Turskis, Z., Morkunaite, Z., & Kutut, V. (2017). A hybrid multiple criteria evaluation method of ranking of cultural heritage structures for renovation projects. *International Journal of Strategic Property Management*, *21*(3), 318-329.

Yau, Y. (2009). Multi-criteria decision making for urban built heritage conservation: Application of the analytic hierarchy process. *Journal of Building Appraisal*, *4*(3), 191-205.

Zuraidah, E. (2019). Decision support system for selecting Bali tourist attraction using the PROMETHEE method. *Journal Publications & Informatics Engineering Research*, *3*(2), 1-5.