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**Meriem Younes[1]* , Abdelhak Acidi* , Kaddour Boukhemis* , Mohammed Hamzaoui**, Miloud Sallaye****

**Laboratory of Natural Resources and Planning, Badji Mokhtar - Annaba University 12, P.O.Box , 23000 Annaba, Algeria*
***Department of Geography and territory planning, University Farhat Abbas setif 1, Algeria*

# EVALUATION OF THE TOURIST ATTRACTIVENESS OF ANNABA'S BEACHES BETWEEN POTENTIAL, EXPECTATIONS, AND ENHANCEMENT PROSPECTS

**Abstract:** In a global context where territories compete with each other, the notion of attractiveness remains an essential lever for coastal development. The objective of this research is to measure, compare, and evaluate the potential for tourist attractiveness of the beaches in the inter-municipalities of Annaba, agglomeration which the latter being considered a major hub on the eastern Algerian coasts, mobilizing the ELECTRE III (Elimination and Choice Translating Reality method) multi-criteria method, which conceived not as an end in itself but as a decision-making tool capable of ranking seaside performance and guiding development choices. Eleven beaches were analyzed according to their degree of attractiveness through a family of six weighted criteria. The results obtained highlight a clear hierarchy of beaches across five levels. Rizi Amor beach occupies an ideal position at the top of the ranking with very strong attractiveness, the two beaches La Caroube and Refes Zahouene 2 occupy second position with strong attractiveness, while, Belvedere II, Annasr, and Rezgui Rachid I beaches are in the last class with weak attractiveness. Beyond the ranking, the observed differences reflect variations in management, governance, and enhancement. ELECTRE III thus asserts itself as an analytical and prospective instrument, capable of supporting integrated Annabi coastal planning and even a balanced requalification of the Algerian coastline.

**Keywords:** tourist attractiveness, Annaba, coastal planning, multi-criteria grid, ELECTRE III

[1] meriem.younes@univ-annaba.dz (corresponding author)
Meriem Younes (https://orcid.org/0009-0006-3828-0724)
Abdelhak Acidi (https://orcid.org/0009-0002-7780-7884)
Kaddour Boukhemis (https://orcid.org/0009-0009-7925-1489)
Mohammed Hamzaoui (https://orcid.org/0009-0008-5231-5430)
Miloud Sallaye (https://orcid.org/0000-0002-2104-6484)

## Introduction

In the era of globalization, tourist destinations face increasing competition to attract visitors and stimulate local economic development (Bofill, 1989). In this context, tourist attractiveness is defined as its ability to optimally mobilize territorial potential to meet the needs and expectations of tourists (Mayo & Jarvis, 1981; Vengesayi, 2003; El-Manhaly, 2024). Coastal areas, and more specifically beaches, are distinguished by their specific capacities linked to their biodiversity and the landscape value they offer (Özdemir Işık & Demir, 2017). However, seaside attractiveness is not limited to natural attributes alone: it also depends on anthropogenic factors such as cleanliness, comfort, safety, and the quality of infrastructure, which directly influence the tourist experience and visitors' propensity to return ( Dzitse et al., 2024). In this regard, the evaluation of beach attractiveness is based on multidimensional indicators, given its complexity, integrating both the intrinsic characteristics of the destination, the quality of infrastructure, and visitor perceptions (Reitsamer et al., 2016). In this framework, multi-criteria methods such as AHP and ELECTRE III have proven particularly effective for evaluating, comparing, prioritizing, and classifying coastal areas according to their tourism potential, by simultaneously considering a diversity of quantitative and qualitative indicators (Özdemir Işık & Demir, 2017; Roy, 1978; Maystre et al., 1994; Wang, 2024). This method, ELECTRE III, offers public decision-makers robust analytical support for guiding the planning and enhancement of tourism resources, in order to increase the attractiveness of territories and stimulate visitor flows (Formica & Uysal, 2006; Laifa & Benhassine, 2023). Despite their importance, empirical studies on beach attractiveness remain limited, especially those using the ElectreIII method in evaluation, particularly in the Mediterranean basin.

In the Algerian context, seaside attractiveness is understood as a strategic lever for enhancing natural and cultural heritage, in accordance with the guidelines of the Master Plan for Tourist Development 2025 (SDAT 2025), which places tourism development within a logic of sustainability, territorial competitiveness, and regional balance (Zermane et al, 2021). In this national context, the city of Annaba occupies a strategic position. As the country's fourth-largest metropolis and a major hub on the northeastern Mediterranean coast (SDAT, 2025), it benefits from a temperate climate, a privileged opening to the Mediterranean, and remarkable natural and historical heritage. These assets give it strong potential for seaside tourism attractiveness, with beaches authorized for swimming distributed among the municipalities of Annaba, El Bouni, Seraïdi, and Chetaïbi (Annaba Province Tourism Directorate, 2025). During the 2023 summer season, it recorded an influx exceeding two million visitors (DTA, 2025), a significant proportion of whom came from neighboring wilayas such as Tébessa, Souk Ahras, Guelma, or Oum El Bouaghi, etc. Despite the potential and the large number of tourists, Annaba's tourism structure remains only partially developed. The observed shortcomings particularly concern integrated coastal management, service quality, equipment provision, and the diversification of tourism products. This contrasts with the bioclimatic richness of the territory (beaches bordered by rocky coves, wetlands of ecological importance, and a mountainous hinterland suitable for tourism).This disparity highlights the need for a systematic evaluation of the tourist attractiveness of its beaches. To this end, the present study focuses on eleven beaches located in the municipalities of Annaba and El-Bouni, given their central role in the regional coastal system and their high tourist frequentation. These territories are characterized by a marked diversity of beaches in terms of accessibility, natural landscape, equipment, services, cleanliness, as well as management and protection methods, which makes them a relevant framework for analyzing and comparing levels of seaside attractiveness. However, this attractiveness remains highly differentiated, which leads to the following question:

*What are the decisive indicators of the tourist attractiveness of Annaba and El-Bouni beaches, and how can they be rigorously and objectively prioritized?*

The aim of this study is to measure, evaluate, and compare the attractiveness potential of the eleven beaches located in the municipalities of Annaba and El-Bouni, in order to produce an operational ranking and guide priorities in terms of development, management, services, and enhancement. The ELECTRE III multi-criteria method is used to simultaneously integrate a diversity of quantitative and qualitative indicators and provide a robust decision-making tool for coastal managers. The scientific novelty of this research lies in the proposal of a rigorous, explicit, and reproducible methodological framework, allowing for the establishment of a transparent prioritization of beaches and the translation of analytical results operational recommendations. This contribution addresses a major scientific gap: the absence of robust and reproducible tools to evaluate the tourist attractiveness of Algerian coastal areas, and more broadly, in comparable Mediterranean contexts. It thus strengthens methodological support for strategic decision-making and supports the planned and sustainable development of seaside destinations.

## Materials and methods

### *Study area*

The province of Annaba is located in the far northeastern part of Algeria, approximately 700 kilometers from Algiers the national capital. It is recognized as the oldest coastal province in the country. The province covers a total area of 1,393.20 Km². The sources of the data is (Official Yearbook of the province of Annaba, 2025) and is bordered to the north by the Mediterranean Sea, to the east by the province of El Tarf, to the west by Skikda, and to the south by Guelma. Administratively, it comprises municipalities in number of 12 (Fig. 1).

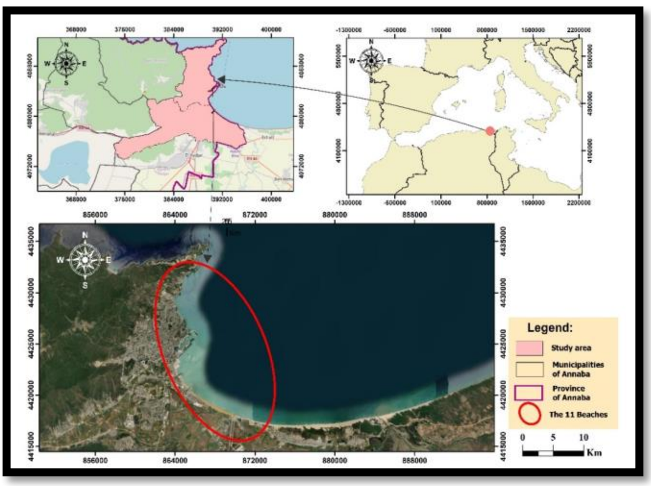


*Fig. 1. Location of the study area*
*(Source: Authors, Google Earth Pro, 2025)*

According to recent estimates, the total population of the province is approximately 675,000 inhabitants, while that of the urban agglomeration of Annaba will reach 379,000 inhabitants in 2025, with an average annual growth rate of 1.49%. The average density is estimated at 444 inhabitants/km² (Official Yearbook of the province of Annaba, 2025). Annaba is one of the main Algerian coastal metropolises, is distinguished by marked urban dynamics, and sustained spatial growth. Its coastal location, combined with a diverse natural environment, makes it a strategic urban and seaside area. This geographical setting provides a privileged study ground for the application of a multi-criteria evaluation method aimed at measuring and prioritizing the seaside tourist attractiveness of the eleven beaches distributed between the communes of Annaba and El Bouni, according to their natural, functional, and accessibility character is tics.

### *Methodology of evaluation and approach adopted*

This research aims to evaluate the seaside tourist destinations on the coast of Annaba and El-Bouni according to their degree of attractiveness, with a view to establishing a hierarchical ranking of beaches using the ELECTRE III method (Elimination and Choice Translating Reality method). Its use is justified by its constructive and non-compensatory approach (Roy et al., 1993; Maystre et al., 1994). It allows for comparing, outranking, and ranking alternatives (beaches) according to multiple and heterogeneous criteria, based on a fuzzy partial aggregation of performances and taking into account the uncertainty of judgments (Bernard, 2004). The ELECTRE III method thus constitutes a relevant multi-criterion decision-making tool (Battisti, 2022) applied to tourism evaluation.

Initially, a thorough bibliographic analysis was conducted at various international, national, and local (Annaba) scales to identify the determining factors of seaside attractiveness. This allowed for a better understanding of the specific challenges of coastal tourism and to contextualize the issue of attractiveness within the Bônois region. On this basis a multi-criteria evaluation grid was developed, adapted to local specificities and inspired by reference works on the subject which can serve as a methodological reference model for other Algerian coastal territories .The ELECTRE III method (Roy et al., 1993; Maystre et al., 1994; Bernard, 2004; Battisti, 2022) was chosen for its ability to provide a robust ranking, integrate evaluation uncertainty, and avoid full compensation between criteria, thus producing an adequate decision-support tool to evaluate beaches that have high tourism stakes and pronounced spatial variability. The application of this research method to the beaches of the inter-municipalities of the Annaba region is justified by the lack of objective and comparative assessments of beach attractiveness at this territorial scale, even though the Annaba region exhibits a high degree of heterogeneity among beaches in terms of environmental quality, accessibility, and facilities, thereby requiring an appropriate decision-support tool which aiming to strengthen competitiveness and attractiveness and to guide public and private investments, to identify levers for improving attractiveness, and to guide balanced and sustainable planning of the beaches of the two municipalities Annaba and El-Bouni. This evaluation serves to guide the strategies of local decision-makers and tourism investors based on the actual potential of the beaches.

Secondly, the empirical analysis focused on eleven beaches distributed between the municipalities of Annaba and El-Bouni, frequented during the summer period (July-August 2025). Data was collected through detailed field surveys, a survey of visitors, and semi-structured interviews with experts from the tourism, environment, and coastal planning sectors. The collected data allowed for the construction of an initial multi-criteria table grouping 80 indicators related to the tourist performance of the eleven beaches. After a rigorous selection process based on relevance, observed frequency, and the weight attributed by experts, 28 key indicators were retained to structure the multi-criteria set that serves to compare the attractiveness of the beaches in a coherent and rigorous manner, these indicators were grouped into six main categories of criteria, representing the essential criteria of seaside . tourist attractiveness (Fig.2).

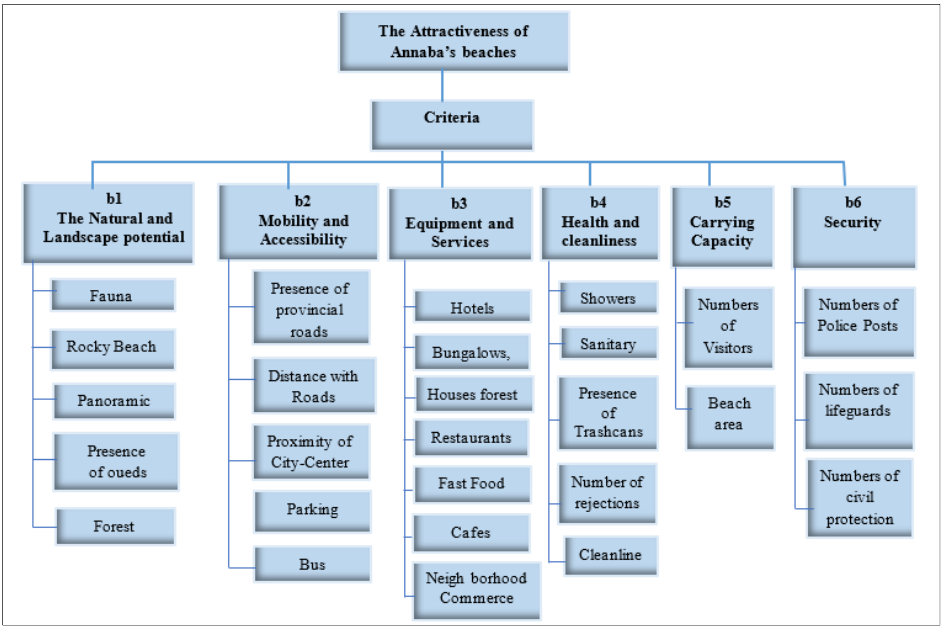


*Fig. 2. Structure of the multi-criteria grid (criterion family)*

Figure 2 illustrates the hierarchical composition of the multi-criteria framework for the beaches of Annaba and El-Bouni, allowing evaluation in families of six criteria (b1 to b6) and then as a set of indicators used to construct the performance matrix. Criterion b1 encompasses natural and landscape potential (fauna, rocky beach, panorama, presence of wadis, forest); b2 considers accessibility and mobility (presence of provincial roads, distance to roads, proximity to the city center, parking, bus transport); b3 groups facilities and services (hotels, bungalows, rental houses, restaurants, fast-food outlets, cafés, local shops); b4 refers to hygiene and cleanliness (showers, restrooms, trash bins, waste, cleanliness); b5 reflects carrying capacity (number of visitors, beach area); while b6 includes safety, evaluated by the number of police posts, lifeguards, and civil protection units.

Each indicator was evaluated on a five-level scale (from 1 to 5), in order to distinguish the different degrees of attractiveness of the beaches. This scale is broken down as follows: very low performance, low performance, moderate performance (average), strong performance, very strong performance. The experts surveyed actively participated in assigning weights to the indicators within the criteria grid, ensuring a balanced assessment that accurately reflects field realities. Within this framework, a performance matrix was established, and the indifference (q), preference (p), and veto (v) thresholds specific to the ELECTRE III method were defined (Roy et al., 1993; Maystre et al., 1994; Bernard, 2004; Battisti,

2022) to account for the imprecision and uncertainty inherent in evaluating tourism-related criteria. Concordance and discordance matrices were calculated for each pair of alternatives (beaches). The concordance matrix measures the weighted degree of agreement among the criteria in favor of one beach outranking another, while the discordance matrix identifies strong oppositions that could challenge this outranking. These two matrices were then combined to calculate the credibility index of outranking, which forms the basis for the final ranking and hierarchical classification of the beaches.

Finally, the distillation process allowed the establishment of a final non-compensatory ranking of the beaches of Annaba and El-Bouni, based on the analysis of outgoing, incoming, and net flows, providing a robust hierarchy that can be directly used as a decision-support tool for coastal planning and management. All calculations were performed using Microsoft Excel (version 2016) as a tool for descriptive and multi-criteria statistical processing, ensuring transparent, reproducible, and easily verifiable matrix calculations consistent with the ELECTRE III framework, as well as a concise presentation of results in tables and graphs. Additionally, the geographic information system ArcGIS (version 10.8) was employed, given the importance of GIS for spatial localization, visualization, and the spatial presentation of beaches according to their comparison and hierarchical classes from most to least attractive, providing decision support This combination of tools ensured a comprehensive, reliable, and operational analysis of the beaches of Annaba and El-Bouni within the ELECTRE III method framework.

It should be noted that criteria related to image and tourism reputation, including indicators such as visitor numbers, overall atmosphere, tranquility, notoriety, reputation, and TIC (Technologies Information and Communication), were not considered in the final evaluation due to the lack of reliable and homogeneous data allowing a rigorous assessment of these aspects.

### *The ELECTRE III Method*

The ELECTRE III multi-criteria analysis method used in this research is an outranking method, as previously mentioned, based on the concept of fuzziness. It allows for taking into account the uncertainty inherent in evaluating the performance of alternatives through pseudo-criteria to assess not the absolute acceptance or rejection of an alternative, but to measure the degree of credibility of this relationship, varying between 0 and 1. The weak preference zone, located between indifference and preference, reflects the decision-maker's uncertainty thanks to two thresholds: indifference (q) and preference (p). A third threshold, the veto (v), allows for modeling discordance, i.e., the refusal of an outranking deemed excessive (Roy et al., 1993; Maystre et al., 1994; Bernard, 2004; Battisti, 2022).

The method is divided into two main phases the aggregation phase, which constructs the outranking relations, and exploitation, which establishes the final hierarchy of alternatives. The first step involves introducing subjective parameters specific to each criterion (weights and thresholds q, p, v) as well as the performance matrix, by identifying the alternatives (a, b, c beaches along the Annaba coastline) and selecting relevant criteria (J1, J2, J3) according to the ranking objective based on attractiveness, where $g_1(a)$, $g_2(a)$... represent the performance values of each alternative with respect to the criteria. These values can be expressed on a numerical or qualitative scale according to the ELECTRE III method. This structure follows the multi-criteria decision performance matrix. These criteria must form a coherent set, respecting the principles of exhaustiveness, consistency, and non-redundancy, forming the basis for ELECTRE III processing (Table 1) (Roy & Bouyssou, 1993; Bernard, 2004; Albert & Bernard, 2011; Battisti, 2022).

*Table 1. Performance matrix structure*

| | | *criteria* | | | |
|---|---|---|---|---|---|
| *The alternatives* | | *J1* | *J2* | *J3* | ....... |
| | *a* | $g_1(a)$ | $g_2(a)$ | ..... | ..... |
| | *b* | $g_1(b)$ | $g_2(b)$ | ..... | ..... |
| | *c* | $g_3(c)$ | $g_3(c)$ | .... | ...... |

(Source: Bernard, 2004; Albert & Bernard, 2011; Battisti, 2022).
g1(a), g2(a)... représentent les valeurs de performance J1, J2,J3)... représentent les critères
a,b,c......... représentent les alternatives

The performance matrix, constructed according to the weighted average of criteria for each alternative. The indifference threshold ($q_j$) expresses the minimum difference below which two alternatives are considered equivalent. The preference threshold ($p_j$) corresponds to the difference from which one alternative is judged clearly superior to another. Finally, the veto threshold ($v_j$) represents the maximum difference beyond which an alternative can no longer be outranked, even if it performs better on other criteria. Establishing these thresholds therefore makes it possible to model the outranking relationships between two alternatives a and b, by gradually translating the degrees of indifference, preference, and rejection, which are essential to the functioning of the ELECTRE III model.

In the next step of the process, the concordance matrix is calculated, which allows determining the overall concordance index C (a, b). This calculation is based on the principle that the majority of criteria, weighted according to their relative importance, must agree with the outranking relation a S b. For each pair of alternatives (a,b) and for each criterion J, using the threshold (p) preference and (q) indifference which the partial concordance degree Cj (a,b) is thus defined using the following formula (01) (Roy & Bouyssou, 1993; Bernard, 2004; Albert & Bernard, 2011; Battisti, 2022).

$$c_j(a,b) = \begin{cases} 0 & \text{If } g_j(a) \geq g_j(b) - q_j \\ 1 & \text{If } g_j(a) \leq g_j(b) - p_j \\ \text{If no} & \dfrac{p_j - [g_j(b) - g_j(a)]}{p_j - q_j} \end{cases} \tag{1}$$

This degree expresses how much criterion gj supports the claim "a is at least as good as b".
Cj (a,b): a, b: Two actions. (The alternatives)
pj: The relative weight for criterion j.
$g_j(a)$: The evaluation of criterion j for action a.
j: The index of the criterion.
p, q: The preferences and indifference. Thresholds.

The values of the concordance index Cj (a, b) belong to the interval [0, 1]. After creating concordance matrices for each criterion including the concordance indices Cj (a, b), an overall concordance matrix is then created (including the overall concordance indices C (a, b). The overall concordance is aggregated. according to the weights using the following formula (02). (Albert et Bernard, 2011; Bakhsh, 2019)

$$C(a,b) = \frac{\sum_{j=1}^{n} p_j C_j(a,b)}{\sum_{j=1}^{n} p_j} \quad (2)$$

After it, consist to calculate discordance indices. It involves checking that the minority of criteria conflicting with the outranking relation a S b does not strongly oppose it: The outranking relation should not be significantly worse relative to the minority criteria. The degree of discordance dj (a, b) for each criterion gj measures the extent to which gj opposes the outranking according to formula (03); from which a discordance matrix is established for each criterion. Using the veto threshold (v) veto (Battisti, 2022; Chabane et al., 2025).

$$d_j(a,b) = \begin{cases} 0 & \text{If } g_j(a) \geq g_j(b) - p_j \\ 1 & \text{If } g_j(a) \geq g_j(b) - p_j \\ \quad \text{If} & \frac{[g_j(b) - g_j(a)] - p_j}{v_j - p_j} \end{cases} \quad (3)$$

Is the calculation of the credibility degree (or outranking index): The credibility index S (a, b) combines the concordance and discordance indices according to formula (4) (Bernard, 2004; Battisti, 2022)

$$S(a,b) = C(a,b) \times \prod_{JeJ(a,b)} \frac{1 - d_j(a,b)}{1 - d_j(a,b)} \quad (4)$$
$$J(a,b) = \{j \mid d\_j\ (a,b) > C(a,b)\}$$

In the exploitation phase the ELECTRE III method establishes a hierarchical ranking of actions based on binary (Albert et Bernard, 2011; Bakhsh, 2019; Battisti, 2022) The ranking algorithm is based on the significance level of the credibility degree. This level indicates the value at which the difference between two credibility degrees becomes significant.

This exploitation phase relies on a dual distillation process by cross-referencing two complementary pre-orders: that of ascending distillation, which orders alternatives from best performing to least performing based on their best relative evaluations and descending distillation, which ranks them in reverse, from least-performing to best-performing, according to their lowest scores. The confrontation of these two distillations leads to the construction of an outranking graph (synthetic matrix), allowing for a final ranking of alternatives, integrating both situations of equality and incomparability between actions (Fig. 3).

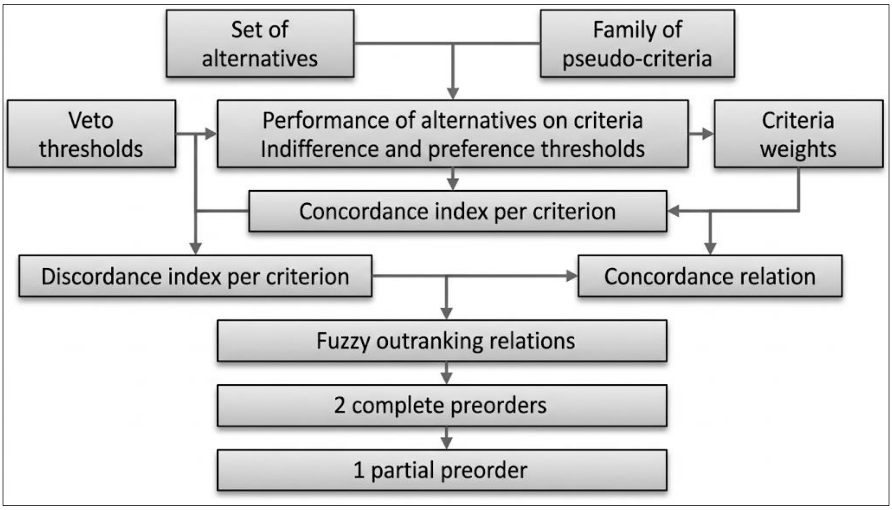


*Fig. 3. ELECTRE III method algorithm*
*(Source: Maystre et al., 1994)*

## Result and discussion

The application of the ELECTRE III method to the study area, comprising eleven beaches in Annaba, is structured around two main phases. It begins with an aggregation phase that includes several sequential steps, the first of which involves constructing the performance matrix of alternatives with respect to the selected criteria. It consists of defining a weighting system that reflects the relative importance of each criterion in evaluating the attractiveness of the eleven Annabi seaside beaches that are the subject of this research. The assigned weights are as follows: (b1) natural and landscape potential (0.05), (b2) mobility and accessibility (0.25), (b3) equipment and services (0.10), (b4) cleanliness and health (0.25), (b5) reception capacity (0.10), and (b6) security (0.25). Criteria b2, b4, and b6, which are successively mobility and accessibility, health and cleanliness, and security, are the most decisive (each weighing 25%), while b1, b3, and b5, which are successively natural potential, equipment and services, and reception capacity, have a lower weight (5%, 10%; 10% successively). This evaluation was assigned after analyzing the results of a satisfaction survey among vacationers as well as interviews with experts on each criterion. After data normalization, a weighted performance matrix (Table 2) was developed, serving as the basis for multi-criteria processing and the construction of concordance, discordance, and credibility matrices leading to the final ranking of beaches according to their degree of attractiveness.

*Table 2. Performance matrices for coastal tourism attractiveness in Annaba*

| The criterion / The beaches | $b_1$ The naturel lands cape potential | $b_2$ Mobility and accessibility | b3 Equipment and services | b4 Health and property | b5 Capacity | b6 Safety |
|---|---|---|---|---|---|---|
| Sidi Salem beach (P1) | 2,6 | 3,166 | 1,71 | 2 | 4 | 5 |
| Annasr beach (P2) | 3 | 3 | 1 | 2 | 2,5 | 1 |
| Rezgui Rachid I beach (P3) | 3 | 3 | 1,14 | 2 | 3 | 1 |
| Rezgui Rachid II beach (P4) | 2,2 | 3 | 1,714 | 3 | 3 | 4,33 |
| Rizi Amor beach (P5) | 1,8 | 4 | 3,42 | 3,25 | 4,5 | 4,33 |
| La Caroube beach (P6) | 2 | 3,3333 | 2,57 | 3,5 | 1,5 | 4 |
| Refes Zahouene I beach (P7) | 2,8 | 2,8333 | 2,14 | 3,75 | 1,5 | 1 |
| Refes Zahouene II beach (P8) | 2,6 | 3,3333 | 2,28 | 3 | 2 | 3,66 |
| Belvédère I beach (P9) | 3,2 | 3 | 2,714 | 3,25 | 1,5 | 3,33 |
| Belvédère II beach (P10) | 3 | 2,6666 | 2 | 2,5 | 1 | 4 |
| Ain Achir beach (P11) | 4,2 | 3,6666 | 1,42 | 2 | 1,5 | 4 |
| Le poids | 0,05 | 0,25 | 0,1 | 0,25 | 0,1 | 0,25 |

The examination of the performance matrix reveals significant discrepancies between the different beaches studied. Rizi Amor beach (P5) shows very strong performance, with high scores on the main criteria: security (b6 = 4.33), mobility and accessibility (b2 = 4), equipment and services (b3 = 3.42), reception capacity (b5 = 3.42), and cleanliness and health (b4 = 3.25). Located in the city center of Annaba, this beach benefits from optimal accessibility, well-maintained infrastructure, and a clean and organized environment, justifying its position among the most attractive sites on the Annabi coast. Ain Achir beach (P11) stands out with generally high values on several criteria as well, particularly natural potential (b1 = 4.2), security (b6 = 4), and mobility and accessibility (b2 = 3.67). These results reflect remarkable attractiveness, supported by the quality of its landscape environment, a good level of site security, and good accessibility given its location at the extreme end of the city, thus strong performance. La Caroube (P6) and Rezgui Rachid II (P4) beaches show intermediate average performances. The former achieves good results on cleanliness (b4 = 3.5) and security (b6 = 4), while the latter stands out for security (b6 = 4.33) and balanced values on mobility and accessibility (b2 = 3), cleanliness (b4= 3), and reception capacity (b5= 3). These scores reflect controlled attendance, average quality of development, and an effective surveillance system provided by civil protection and security services.

Sidi Salem beach (P1) shows an overall average performance. However, it stands out with an excellent level for criterion Safety (b6= 5), reflecting strong security coverage ensured by the presence of Civil Protection and police services. Regarding criterion Capacity (b5 = 4), the beach benefits from its vast area, approximately 4000 m long by 50 m wide, which promotes good accessibility and fluid circulation for vacationers. Criterion Mobility and accessibility (b2=3.16), indicates generally satisfactory accessibility. In contrast, criterion Equipment and services (b3 = 1.71) reveals a clear lack of infrastructure and services, constituting a notable weakness for this beach. Belvedere II (P10) beach for criterion Safety (b6= 4) but low scores for Equipment and services (b3=2) and Capacity (b5 =1), therefore good safety but insufficient infrastructure; average attractiveness and performance despite its potential. Belvedere I (p9) beach contains scores between 3 and 3.3 for all indicators except Capacity (b5 = 1.5), it is a balanced beach but limited by its capacity; low attractiveness and performance. Whereas Annasr (P2) and Rezgui Rachid I (P3) beaches obtain very low performance results on several major criteria, notably safety (b6 = 1), due to the lack of suitable equipment and services. It should be noted that the equipment available on Rezgui Rachid II (P4) beach indirectly benefits Rezgui Rachid I (P3) due to their geographical proximity, which partially explains this disparity and the weakness of the latter is potential. Finally, Refes Zahouene 1 (P7) beach records very low performance, particularly on criteria capacity (b5 = 1.5) and safety (b6=1), which penalizes its overall position. This weakness can be explained by the immediate proximity of Refes Zahouene 2 (P8), which represents an average performance, better equipped, and having all the necessary potential to accommodate vacationers.

The indifference ($q$), preference ($p$), and veto ($v$) thresholds were established based on the weights assigned to each criterion. These thresholds were used to compute the concordance matrices for each pair of actions (the beaches). The weighting procedure was carried out by assigning scores to each threshold according to the judgments of the surveyed experts, in order to integrate them into the ELECTRE III multicriteria analysis (Table 3).

Assigned scores are $q = 0.20$, $p = 0.75$ et $v = 0.90$.

*Table 3. Indifference, preference, and veto thresholds*

| Thresholds / The criteria | q | p | V |
|---|---|---|---|
| b1 | 0,48 | 1,8 | 2,16 |
| b2 | 0,26666667 | 1 | 1,2 |
| b3 | 0,48571429 | 1,82142857 | 2,18571429 |
| b4 | 0,35 | 1,3125 | 1,575 |
| b5 | 0,7 | 2,625 | 3,15 |
| b6 | 0,8 | 3 | 3,6 |

q: The indifference threshold, P: The preference threshold, v: the veto threshold, b: The measured criteria

The objective is to measure the level of agreement between the criteria regarding the outranking relationship a S b. In other words, it allows verifying whether the majority of criteria, weighted according to their importance, support the idea that alternative a is at least as good as b. For each pair of alternatives (a,b) and each criterion gi, a partial concordance index Cj(a,b) is calculated according to formula( 1) above, using indifference, preference, and veto thresholds, adjusted by coefficients calculated for each criterion (table 3). These six partial concordance indices are then aggregated to obtain the global concordance C (a,b) formula (2).The global concordance matrix (Table 4) represents the degree of agreement of the criteria in favor of the proposition that beach a is at least as attractive as another beach b. The coefficients C (a, b), ranging from **0 to 1**, express the strength of agreement among the weighted criteria to support this outranking **[0-1]**

- A value close to **1** indicates strong agreement among the majority of criteria (beach a clearly outranks b).
- A value close to **0** indicates overall disagreement or inverse dominance (beach a is considered less attractive than b).

The analysis of the concordance matrix highlights a hierarchical structure of seaside performance based on the degree of inter-criteria agreement. The distribution of coefficients, mostly above 0.70, certifies the good consistency of the weighting system, the reliability of multi-criteria evaluations, and the quality of the data collected.

*Table 4. Global Concordance Matrix*

| | P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 | P9 | P10 | P11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| P1 | 1,00 | 1,00 | 1,00 | 0,92 | 0,92 | 0,68 | 0,75 | 0,83 | 0,88 | 0,79 | 0,82 |
| P2 | 0,61 | 1,00 | 1,00 | 0,59 | 0,35 | 0,25 | 0,70 | 0,61 | 0,90 | 0,48 | 0,61 |
| P3 | 0,57 | 1,00 | 1,00 | 0,58 | 0,33 | 0,24 | 0,69 | 0,60 | 0,89 | 0,47 | 0,61 |
| P4 | 0,92 | 0,96 | 0,96 | 1,00 | 0,68 | 0,49 | 0,81 | 0,68 | 0,91 | 0,96 | 0,84 |
| P5 | 1,00 | 0,98 | 0,98 | 1,00 | 1,00 | 1,00 | 0,76 | 0,96 | 0,98 | 0,98 | 0,95 |
| P6 | 0,77 | 0,89 | 0,91 | 0,94 | 0,71 | 1,00 | 0,96 | 0,95 | 0,98 | 0,97 | 0,72 |
| P7 | 0,52 | 0,92 | 0,94 | 0,69 | 0,36 | 0,58 | 1,00 | 0,79 | 0,83 | 0,75 | 0,68 |
| P8 | 0,78 | 1,00 | 0,92 | 0,92 | 0,83 | 0,79 | 0,85 | 1,00 | 0,95 | 1,00 | 0,77 |
| P9 | 0,80 | 0,92 | 0,94 | 0,71 | 0,34 | 0,77 | 0,79 | 0,77 | 1,00 | 1,00 | 0,86 |
| P10 | 0,50 | 0,71 | 0,74 | 0,53 | 0,47 | 0,71 | 0,98 | 0,59 | 0,54 | 1,00 | 0,73 |
| P11 | 0,76 | 0,92 | 0,94 | 0,86 | 0,56 | 0,70 | 0,67 | 0,85 | 0,94 | 0,70 | 1,00 |

The matrix represents five classes of concordance such as following the development of the performance matrices describing the coastal tourism attractiveness of Annaba, the evaluation phase is carried out by constructing the concordance matrix using Microsoft Excel (2016). This software, widely employed in MCDA applications, enables the systematic calculation of concordance, discordance, and credibility matrices. The procedure starts with the computation of the concordance matrix, forming the basis for subsequent outranking and credibility analyses.

The results of the concordance analysis reveal a marked differentiation among the beaches along the Annaba coastline. Rizi Amor (P5) stands out with a very high concordance index (0.962), reflecting an almost total strength of the criteria related to accessibility, environmental and sanitary quality, facilities, and safety, making it a benchmark beach for tourism development. Caroube (P6) and Refès Zahouene II (P8) display high concordance values (≈0.89), indicating strong attractiveness, although improvements are still needed in terms of facilities and service provision. A medium to high level of concordance is observed for Rezgui Rachid II (P4), Sidi Salem (P1), and Aïn Achir (P11) (0.80–0.84), reflecting moderate agreement across the structuring criteria, with more heterogeneous performance regarding facilities and cleanliness.

Conversely, Belvedere I (P7) and Refès Zahouene I (P9) show medium to low concordance (0.70–0.79), revealing natural potential that remains insufficiently valorized. Finally, Belvedere II (P10), Anasr (P2), and Rezgui Rachid I (P3) record the lowest concordance levels (≤0.60), highlighting strong inter-criteria inconsistencies and structural deficiencies that require priority upgrading and rehabilitation interventions.

From the concordance matrix, the discordance matrices must be calculate related to the six criteria, out these matrices allow for evaluating, for each criterion, the degree of disagreement between the alternatives (the beaches).

The credibility matrix was developed by applying formula (4). The credibility matrix, developed from the concordance and discordance matrices according to formula (4), synthesizes the strength of outranking between the beaches. Each value S (Pi, Pj), between 0 and 1, expresses the degree to which beach Pi is at least as good as Pj. Values close to 1 indicate total outranking, those close to 0 indicate an absence of domination, while intermediate values indicate partial outranking. The main diagonal equal to 1 and the off-diagonal asymmetry confirm the non-reciprocal nature of preference relations between beaches. The credibility matrix (Table 5) presents a globally homogeneous structure, with a majority of values greater than (0.70), which indicates strong internal stability of the ELECTRE III method This consistency confirms the relevance of the thresholds and weights assigned to each criterion and attests to the quality of expert judgments and data collected in the field.

*Table 5. Credibility Matrix*

| | P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 | P9 | P10 | P11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| P1 | 1,00 | 1,00 | 1,00 | 0,92 | 0,92 | 0,68 | 0,75 | 0,83 | 0,88 | 0,79 | 0,82 |
| P2 | 1,56 | 1,00 | 1,00 | 0,59 | 0,00 | 0,25 | 0,70 | 0,61 | 0,90 | 0,48 | 0,61 |
| P3 | 1,34 | 1,00 | 1,00 | 0,58 | 0,00 | 0,24 | 0,69 | 0,60 | 0,89 | 0,47 | 0,61 |
| P4 | 0,92 | 0,96 | 0,96 | 1,00 | 0,68 | 0,49 | 0,81 | 0,68 | 0,91 | 0,96 | 0,84 |
| P5 | 1,00 | 0,98 | 0,98 | 1,00 | 1,00 | 1,00 | 0,76 | 0,96 | 0,98 | 0,98 | 0,95 |
| P6 | 0,77 | 0,89 | 0,91 | 0,94 | 0,71 | 1,00 | 0,96 | 0,95 | 0,98 | 0,97 | 0,72 |
| P7 | 1,07 | 0,92 | 0,94 | 0,69 | 0,00 | 0,58 | 1,00 | 0,79 | 0,83 | 0,75 | 0,68 |
| P8 | 0,78 | 1,00 | 0,92 | 0,92 | 0,83 | 0,79 | 0,85 | 1,00 | 0,95 | 1,00 | 0,77 |
| P9 | 0,80 | 0,92 | 0,94 | 0,71 | 0,34 | 0,77 | 0,79 | 0,77 | 1,00 | 1,00 | 0,86 |
| P10 | 0,50 | 0,71 | 0,74 | 0,53 | 0,47 | 0,71 | 0,98 | 0,59 | 0,54 | 1,00 | 0,73 |
| P11 | 0,76 | 0,92 | 0,94 | 0,86 | 0,56 | 0,70 | 0,67 | 0,85 | 0,94 | 0,70 | 1,00 |

The results of the credibility analysis reveal a clear and structured hierarchy of the beaches along the Annaba coast. Rizi Amor (P5) stands out as the dominant site, exhibiting almost perfect credibility, with indices exceeding (0.98) in most pairwise comparisons, reflecting comprehensive superiority across all evaluated criteria, including optimal accessibility, high cleanliness standards, and maximum safety; its balanced infrastructure, controlled attendance, and well-preserved landscape position it as a strategic reference beach and a pivotal seaside hub. A second tier is formed by La Caroube (P6) and Refes Zahouène II (P8), which display high credibility levels (0.90 - 0.97), indicating strong and consistent agreement among criteria; their attractiveness is driven by smooth accessibility, good environmental quality, well-organized safety systems, and diversified recreational functions, making them particularly suitable for family, youth, and sports-oriented tourism. Sidi Salem (P1) and Rezgui Rachid II (P4) occupy an intermediate position with medium to high credibility (0.75-0.89), characterized by good overall coherence between criteria, strong reception capacity, and effective security, although uneven equipment quality and cleanliness constrain their advancement within the coastal hierarchy. A lower tier, comprising Refes Zahouène I (P7), Belvedere I (P9), Belvedere II (P10), and Aïn Achir (P11), shows medium credibility (0.60–0.74), where significant natural and landscape assets are offer by deficiencies in accessibility, cleanliness, and spatial management, resulting in largely seasonal use. Finally, Anasr (P2) and Rezgui Rachid I (P3) register low credibility levels (<0.60), reflecting substantial structural shortcomings across most criteria particularly in facilities, hygiene, and access which severely limit their integration into the seaside system and call for urgent requalification measures.

On some, the analysis of the credibility of Annaba's coastal beaches reveals that Annaba's coastline presents contrasting attractiveness, between sites of excellence and areas in transition, calling for strengthened coastal planning and management.

### *Distillation and Final Ranking of Annaba's Beaches*

Despite the high global tourist visitation to beaches, empirical studies assessing their attractiveness remain limited due to the complexity of coastal systems and the often-conflicting nature of evaluation criteria. Traditional compensatory methods are insufficient to address these challenges. The ELECTRE III method is therefore particularly suitable, as it accounts for uncertainty, mitigates compensation effects between criteria, and produces robust rankings of the eleven beaches based on an outranking logic accordingly, the second phase of the ELECTRE III method, namely the exploitation phase based on the distillation procedure, makes it possible to establish the final ranking of the beaches along the Annaba and El-Bouni coastline through the combined analysis of (out-sum) (in-sum), and net flows (Table 6).

*Table 6. Distillations and final ranking*

| Ranking beaches | out sum | in sum | Netfolw |
|---|---|---|---|
| Rizi Amor beach (P5) | 10,5874459 | 5,51652024 | 5,07092564 |
| Caroube beach (P6) | 9,80486376 | 7,21667303 | 2,58819073 |
| Refes Zahouene 2 beach (P8) | 9,80092946 | 8,63945124 | 1,16147823 |
| Rezgui Rachid II beach (P4) | 9,20713012 | 8,73262032 | 0,4745098 |
| Ain Achir beach (P11) | 8,88467023 | 8,58484848 | 0,29982175 |
| Refes Zahouene 1 beach (P7) | 8,24571735 | 8,96065699 | -0,7149396 |
| Sidi Salem beach (P1) | 9,5785587 | 10,4763881 | -0,8978295 |
| Belvedere I beach (P9) | 8,89828113 | 9,80901451 | -0,9107334 |
| Belvedere II beach (P10) | 7,51781895 | 9,08766234 | -1,5698434 |
| Annasr beach (P2) | 7,69920494 | 10,2857143 | -2,5865093 |
| Rezgui Rachid I beach (P3) | 7,41609789 | 10,3311688 | -2,9150709 |

The net flow, defined as the difference between (out-sum) (in-sum), flows, reflects the relative performance of a beach in terms of its capacity to outrank competing alternatives (positive values) or to be dominated by them (negative values). Unlike the majority of previous studies, which generally rely on single composite indicators, this research adopts a non-compensatory outranking framework, thereby providing a finer and more reliable discrimination of the levels of tourism attractiveness of heterogeneous beaches. This approach goes beyond the mere establishment of a hierarchical order and constitutes a decision-support tool that is transparent, reproducible, and directly applicable to the planning and management of coastal areas. The distillation and final ranking analysis reveals a structured five-level hierarchy of beach attractiveness along the Annaba coastline. Rizi Amor Beach (P5), at the top level with a net flow of +5.07, demonstrates exceptional performance due to optimal accessibility, high cleanliness, and maximum safety, supported by balanced infrastructure with very high attractiveness. Its consistent dominance (credibility >0.95) positions it as a regional benchmark for integrated coastal tourism. Caroube Beach (P6) and Refes Zahouène II Beach (P8) occupy the second level (net flows +2.59 and +1.16)), which show high attractiveness, reflecting a strong balance of accessibility, environmental quality, and safety. Rezgui Rachid II (P4) and Aïn Achir (P11) form the third level of moderate attractiveness (net flows +0.47 and +0.30), performing adequately in location, capacity, and landscapes but limited by occasional shortcomings in cleanliness, facilities, and accessibility (Figure 4).

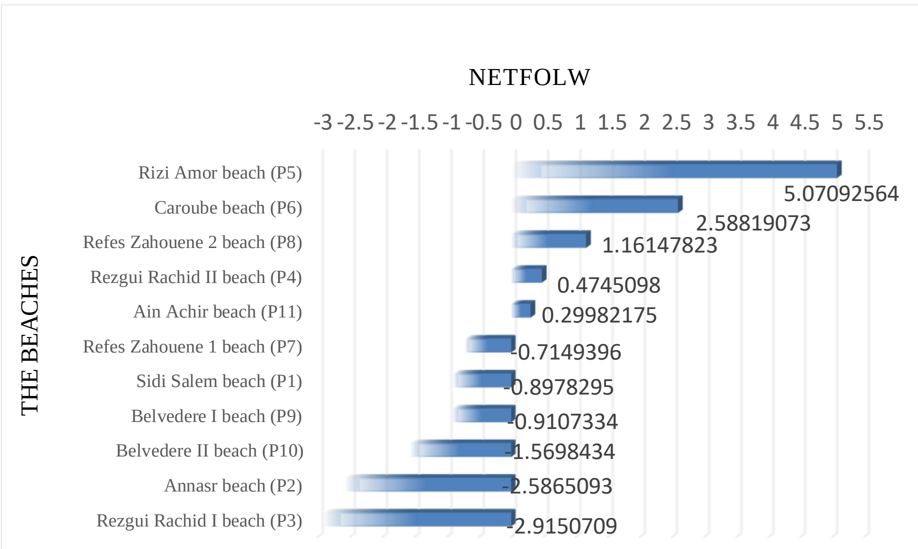


*Fig. 4. Ranking Annaba and El-Bouni's beaches based on ELECTRE III Method*

This ranking underscores the effectiveness of the non-compensatory ELECTRE III approach in discriminating heterogeneous coastal tourism sites and provides a robust framework for sustainable planning and management. Refès Zahouène I (P7), Sidi Salem (P1), and Belvedere I (P9) are in the fourth level of moderate to low attractiveness, with slightly negative net flows (-0.71 to -0.91), indicating fragile appeal due to limited infrastructure and hygiene, despite natural potential and good accessibility. Belvedere II (P10), Plage Anasr (P2), and Rezgui Rachid I (P3) form the fifth and lowest level, with strongly negative net flows (-1.57 to -2.91), reflecting structurally weak tourist attractiveness caused by poor accessibility, insufficient facilities, and irregular cleanliness. Belvedere II's private status and Rezgui Rachid I's proximity to a stronger beach (Rezgui Rachid II) further reduce their appeal. The final ELECTRE III results (Fig.5) establish a clear hierarchy of beaches.

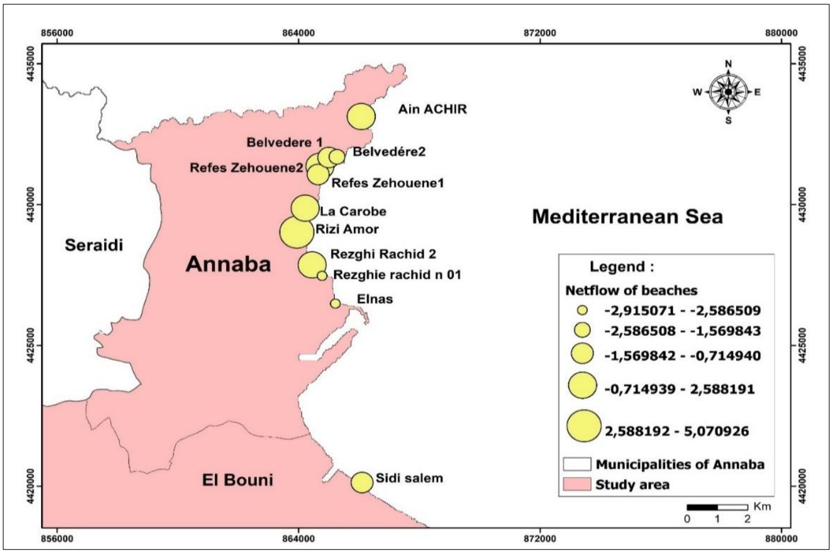


*Fig. 5. Hierarchy of the beaches of Annaba et El-Bouni according to ELECTREIII method (Source: Authors, 2025)*

This gradation highlights a highly contrasted coastline, combining areas of excellence with vulnerable sites, and underscores the need for targeted requalification strategies to achieve a more balanced and sustainable coastal tourism development. The rigorous application of the ELECTRE III method confirms its relevance as an effective decision-support tool, capable of translating the multi-criteria complexity of seaside attractiveness into a coherent, operational hierarchy, providing a robust foundation for strategic planning and sustainable management of coastal tourism in Annaba.

## Conclusion

This study rigorously measured, evaluated, and ranked the tourist attractiveness of the beaches along the coast of Annaba and El-Bouni using the ELECTRE III multi-criteria method. The analysis of outgoing, incoming, and net flows from the distillation process allowed for a clear ranking of the eleven beaches, taking into account their respective potentials and constraints. This ranking reveals a strong spatial differentiation of seaside attractiveness along the coast, thus providing managers and decision-makers with a precise tool to identify actions likely to improve the tourist performance of each site. The results show that Rizi Amor beach (P5) stands out as a pole of excellence, with a very positive net flow (+5.07) reflecting an optimal convergence of key criteria (accessibility, cleanliness, safety, and facilities). Caroube (P6) and Refès Zahouène II (P8) beaches exhibit high attractiveness, balanced between environmental quality and tourist amenities, while Rezgui Rachid II (P4) and Aïn Achir (P11) beaches occupy an intermediate level, with real potential limited by targeted deficiencies. Conversely, Belvedere II (P10), Anasr (P2), and Rezgui Rachid I (P3) beaches are at the bottom of the hierarchy, indicating structurally low attractiveness due to cumulative deficits in infrastructure, services, and environmental quality. The ELECTRE III method proved particularly relevant for understanding the complexity and subjectivity inherent in evaluating tourist attractiveness by overcoming the limitations of classic compensatory approaches, producing a robust and operational ranking. These results provide a practical decision-making tool to prioritize interventions based on each beach's level of attractiveness. They highlight the need to strengthen high-potential sites, support moderately attractive beaches, and urgently address the weakest ones. Overall, they promote differentiated coastal management to optimize resources and ensure sustainable development. Future prospects for this research include extending this approach and these evaluation methods to other segments of the Algerian coast, incorporating dynamic spatio-temporal factors, as well as enriching the research with socio-economic indicators and user preferences. This aims to strengthen the predictive and operational capacity of the evaluation and to support more sustainable, balanced, and competitive seaside tourism development strategies at the national or Mediterranean level.

Conflicts of Interest: The authors declare no conflict of interest.



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