

STRATEGIC PRIORITIES FOR SUSTAINABLE GEOTOURISM IN THE LANG SON UNESCO GLOBAL GEOPARK: INTEGRATING DELPHI WITH SWOT-AHP-TOWS

Trinh Thi PHAN¹ , Vu Dinh HOA^{2*} , Nguyen Cam CHI² 

¹Hong Duc University, Thanh Hoa, Vietnam; trinththiphan@hdu.edu.vn (T.T.P.)

²Vietnam National University, VNU School of Interdisciplinary Sciences and Arts, Hanoi, Vietnam; hoa.vudinh@vnu.edu.vn (V.D.H.); nguyencamchi@vnu.edu.vn (N.C.C.)

Citation: Phan, T.T., Hoa, V.D., & Chi, N.C. (2026). Strategic priorities for sustainable geotourism in the Lang Son UNESCO global geopark: Integrating Delphi with SWOT-AHP-TOWS. *Geojournal of Tourism and Geosites*, 66(2spl), 1738–1747. <https://doi.org/10.30892/gtg.662spl43-1804>

Abstract: UNESCO Global Geoparks (UGGps) play a vital role in linking geoheritage conservation with sustainable tourism development. However, existing studies on geotourism strategy formulation in these settings remain largely descriptive and often lack a robust quantitative basis for prioritization. This study seeks to identify and prioritize sustainable geotourism development strategies for the Lang Son UGGp using a structured, replicable decision-support framework. A mixed-method approach integrating SWOT, AHP, TOWS, and a two-round Delphi technique was employed. The SWOT analysis was first used to identify internal and external factors using triangulated data sources. The relative importance of these factors was then assessed using the Analytic Hierarchy Process (AHP) through pairwise comparisons and consistency testing. Based on the prioritized factors, the TOWS matrix was applied to generate strategic options, which were subsequently evaluated by a fixed panel of 15 experts using the Delphi method. Final strategy rankings were established using a weighted scoring model that combined AHP-derived global weights with Delphi impact scores. The results reveal a clear dominance of SO strategies, indicating a strong alignment between the geopark’s geoheritage strengths and emerging market opportunities. The highest-ranked strategies emphasize interpretation-based geotourism education and integrated geo-eco-cultural experiences designed to enhance visitor engagement and deliver greater community benefits. In addition, geosite protection and risk management were identified as critical enabling conditions for ensuring long-term sustainability and operational resilience. The study demonstrates that integrating SWOT-AHP-TOWS with Delphi enhances both analytical rigour and practical relevance in strategic prioritisation. The proposed framework provides a transparent and adaptable decision-support tool for geoparks and similar destinations facing conservation–development trade-offs.

Keywords: Geotourism; UNESCO Global Geopark. Geoheritage. SWOT-AHP-TOWS, Vietnam

* * * * *

INTRODUCTION

Geoparks are widely conceptualised as “outdoor laboratories” that facilitate the communication of Earth-science knowledge, support nature-based recreation, and contribute to regional economic development (Eder, 2008; Paskova & Josef, 2018). Within UNESCO’s policy framework, UNESCO Global Geoparks (UGGp) are defined as unified geographical areas where sites and landscapes of international geological significance are managed through an integrated approach to protection, education, research and sustainable development (UNESCO, 2022). Originating from an international cooperation network initiated in 2004 and formally endorsed by UNESCO in 2015, the UGGp model foregrounds the interdependencies among geodiversity, biodiversity, cultural heritage, and community well-being. Central to this model is the premise that geoheritage conservation provides the enabling foundation for integrated conservation and sustainable development, operationalised through learning- and interpretation-based engagement (Eder, 2008; Fujii & Ito, 2020). By the end of 2025, the UGGp network is expected to comprise 229 geoparks across 50 countries, indicating the global diffusion of a bottom-up governance approach that promotes community participation in decision-making and benefit-sharing.

Within UGGp, tourism is widely positioned as a strategic instrument for advancing sustainable development by safeguarding geoheritage, strengthening public understanding of Earth-science values, and supporting community-based livelihoods (Catana & Brilha, 2020; Ferreira & Valdati, 2022; Paskova & Josef, 2018). Accordingly, formulating geotourism development strategies requires rigorous evidence and fit-for-purpose analytical tools to ensure that tourism interventions remain consistent with the dual imperatives of geoconservation and sustainable local development.

A Scopus query covering 2002-2025 using the keyword “*geotourism*” identified 1,502 English-language publications. A content-based synthesis suggests that the field has progressed from a dispersed theme within the Earth sciences to a more consolidated research domain with clearer topical and methodological contours. Four dominant strands can be

* Corresponding author

<http://gtg.webhost.uoradea.ro/>

distinguished: (i) geoconservation and geoheritage, with emphasis on geosite identification, inventorying, assessment, and the design of interpretive programmes (Hernández-Garrido et al., 2023; Sarkar & Gayen, 2025; Williams et al., 2020); (ii) sustainable tourism and governance, examining trade-offs between environmental protection and socio-economic benefits, including geotourism's contribution to the Sustainable Development Goals (Das et al., 2025; Koupatsiaris & Drinia, 2023; Sarkar & Gayen, 2025); (iii) geoparks and local development, framing geoparks as institutional platforms for livelihoods, employment, and participatory development (Lestari et al., 2025); and (iv) geospatial and digital innovation, including GIS, remote sensing, and digital platforms (e.g., mobile applications and virtual tours) to map potential, improve accessibility, and enhance visitor experience (Das et al., 2025; Gomes & Motta Garcia, 2025; Sarkar & Gayen, 2025).

Within the research stream on tourism strategy development in geoparks, a number of studies have examined strategic planning and destination development in these settings (Farsani et al., 2011; Gupta et al., 2024; Quesada-Valverde & Quesada-Román, 2023). However, the empirical base remains largely qualitative, typically grounded in descriptive analyses, visitor surveys, and expert interviews (Herrera et al., 2020; Zgłobicki et al., 2020). More recently, a small but growing body of work has begun to employ quantitative and spatial-analytical approaches such as GIS-based assessments, multi-criteria evaluation (MCE), and MCDA techniques including SWOT and AHP to strengthen decision support for geopark planning (Lestari et al., 2025; Özgeriş & Karahan, 2021).

Nevertheless, studies that explicitly integrate qualitative strategic diagnosis (SWOT/TOWS) with quantitative prioritisation (AHP) to generate and rank geotourism development strategies for UGGp remain relatively limited. Addressing this gap, the present study applies an integrated SWOT-TOWS-AHP framework to the Lang Son UGGp, combining structured diagnosis with multi-criteria weighting to identify priority pathways for sustainable geotourism. The resulting strategy portfolio provides actionable guidance for local planning and resource allocation, while contributing methodologically by strengthening the evidence base for transparent, reproducible strategy formulation in UGGp contexts.

MATERIALS AND METHODS

1. Study area

The Lang Son UGGp is Vietnam's fourth UGGp, following Dong Van, Cao Bang and Dak Nong. Situated in northern Vietnam, the geopark covers approximately 4,842.58 km², representing about 58% of Lang Son Province (Figure 1). The area is characterised by an exceptional assemblage of ancient stratigraphic successions, rare fossil-bearing units, archaeological localities, and multi-ethnic cultural heritage, which together underpin its scientific and educational significance. In recognition of these combined geological and cultural values, Lang Son was officially designated as a UGGp on 17 April 2025.

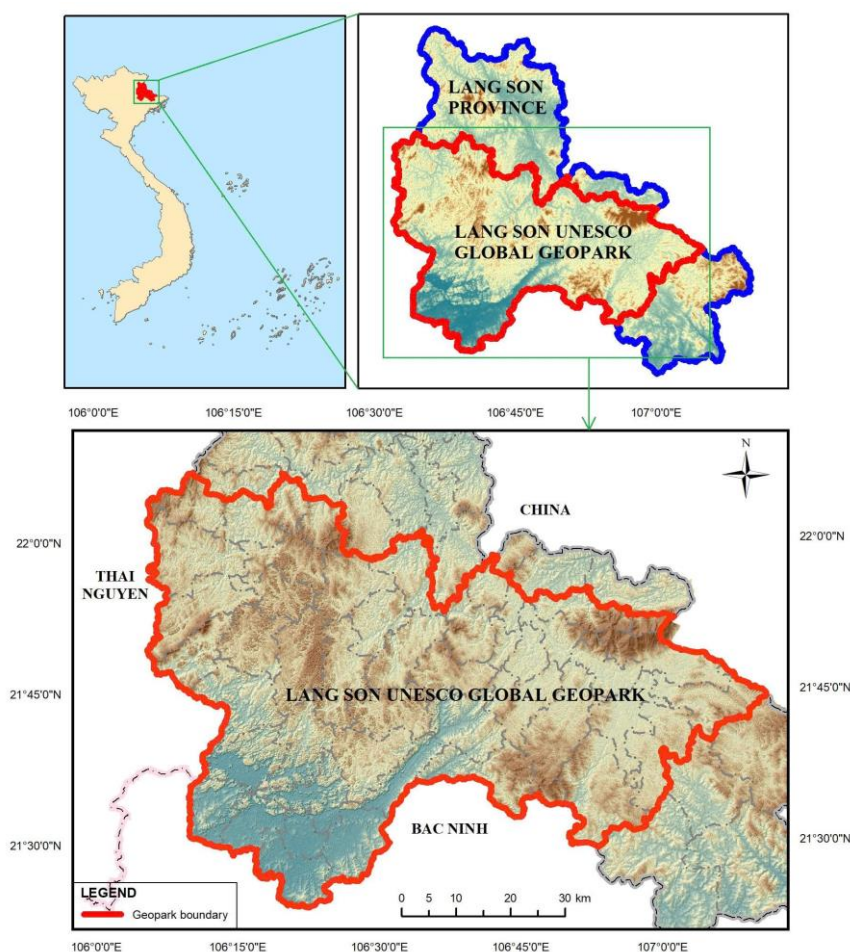


Figure 1. Location of the study area (Source: The authors, 2025)

2. Methods and Data Collection

This study employs a case-study design and a mixed-methods approach to identify priority strategies for sustainable geotourism development in the Lang Son UGGp. The analytical workflow integrates SWOT-AHP-TOWS, whereby SWOT/TOWS provides a structured diagnosis of internal and external conditions and supports the generation of strategic alternatives. At the same time, the Analytic Hierarchy Process (AHP) quantifies the relative importance of SWOT factors. This integration reduces the subjectivity typically associated with purely qualitative SWOT assessments and establishes a transparent, quantitative basis for strategy prioritisation (Kou et al., 2012; Saaty, 2013; Weihrich, 1982). The procedure followed four steps: (i) compiling secondary evidence and conducting expert consultation to identify, refine, and standardise internal and external factors within the S/W/O/T framework; (ii) estimating factor weights using AHP via pairwise comparisons and consistency testing (Saaty, 2013); (iii) applying the TOWS matrix to systematically combine factors and formulate SO, ST, WO, and WT strategy sets (Weihrich, 1982); and (iv) calculating weighted composite scores and ranking strategies by linking AHP-derived weights to each strategy’s assessed contribution to the prioritised SWOT factors, thereby identifying implementation priorities for sustainable geotourism development in the geopark (Figure 2).

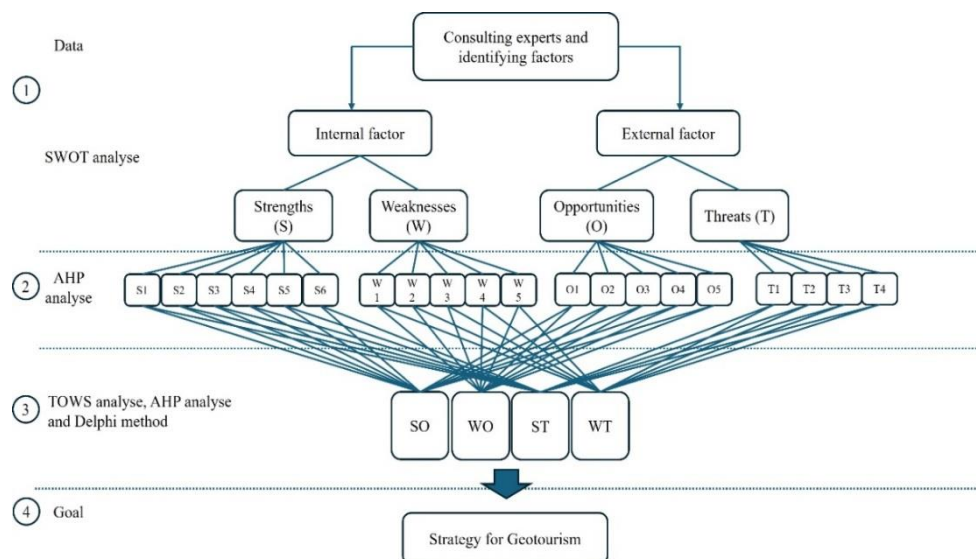


Figure 2. Methodological framework of the study (Source: The authors, 2025)

2.1. SWOT Analysis

The SWOT method is widely used as a decision-support tool for structuring strategic assessments (Kotler, 1988). It provides a systematic basis for decision-making by organising evidence around internal strengths and weaknesses and external opportunities and threats (Vu et al., 2022). As a predominantly qualitative procedure, SWOT typically relies on expert judgement throughout the planning process (Kurttila et al., 2000).

In this study, the S/W/O/T factor set for geotourism in the Lang Son UGGp was developed through methodological triangulation, combining secondary sources, field observations, and semi-structured interviews. All materials were thematically coded to remove redundancies and refined against three screening criteria: (i) clarity of formulation, (ii) direct relevance to strategic decision-making, and (iii) consistency with expert evaluability. Given that the number of AHP pairwise comparisons increases rapidly with the number of factors, the final list within each SWOT category was deliberately kept concise and consistent with A’WOT practice to maintain analytical tractability.

2.2. TOWS Matrix

Following the SWOT assessment, the TOWS matrix was applied to translate the identified factors into a structured set of strategic alternatives by systematically combining internal and external conditions. The resulting options were grouped into four strategy types: SO, WO, ST and WT (Table 1).

Table 1. TOWS Matrix (SO, strength-opportunity; ST, strength-threats; WO, weaknesses-opportunities; WT, weaknesses-threats)

	Internal Strengths (S)	Internal Weaknesses (W)
External Opportunities (O)	SO: (“Maxi-Maxi”) strategies: leverage strengths to exploit opportunities	WO: (“Mini-Maxi”) strategies: reduce weaknesses by exploiting opportunities
External Threats (T)	ST: (“Maxi-Mini”) strategies: leverage strengths to mitigate threats	WT (“Mini-Mini”) strategies: minimise weaknesses and avoid or reduce threats

2.3. AHP analysis

The AHP introduced by Saaty (1980), is a widely applied method within multi-criteria decision analysis (MCDA). Through structured pairwise comparisons, AHP accommodates both qualitative judgements and quantitative considerations to derive the relative priorities (weights) of criteria and alternatives (Saaty, 2013; Schmidt et al., 2015). In this study, AHP was used to quantify SWOT factors and provide an empirical basis for prioritising sustainable geotourism strategies in the

Lang Son UGGp. Based on the finalised SWOT factor set, a three-level hierarchy was established: (i) the overall objective (prioritisation of strategic factors), (ii) four criteria groups (S, W, O, T), and (iii) sub-factors within each group. Experts conducted pairwise comparisons using Saaty's 1–9 scale. For any two factors i and j (Saaty, 2013), the judgement matrix element is defined as:

$$a_{ij} = \frac{a_i}{a_j}, a_{ij} > 0, a_{ii} = 1, a_{ij} = \frac{1}{a_{ji}}$$

Given multiple experts, individual judgements were aggregated using the geometric mean to obtain the group pairwise-comparison matrix (Peniwati, 1998):

$$\bar{a}_{ij} = \left(\prod_{r=1}^m a_{ij}^{(r)} \right)^{\frac{1}{m}},$$

where m denotes the number of experts.

Weights were estimated using the row geometric mean method (RGMM) (Crawford & Williams, 1985):

$$M_i = \prod_{j=1}^n \bar{a}_{ij}, \tilde{w}_i = M_i^{\frac{1}{n}}, w_i = \frac{\tilde{w}_i}{\sum_{k=1}^n \tilde{w}_k},$$

where n is the matrix order and w_i is the local priority weight of factor i .

Consistency of expert judgements was assessed via the maximum eigenvalue λ_{\max} (Saaty, 2013):

$$\lambda_{\max} = \frac{1}{n} \sum_{i=1}^n \frac{(Aw)_i}{w_i},$$

followed by the Consistency Index (CI) and Consistency Ratio (CR) (Saaty, 2013):

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

where RI is the random index for matrix order n . Matrices were accepted when $CR \leq 0.10$; otherwise, inconsistent comparisons were revisited with experts prior to finalising weights.

Within the SWOT-AHP framework, each factor's global weight was computed by multiplying the weight of its SWOT group ($w_g, g \in \{S, W, O, T\}$) by its local weight within that group (w_{gi}) (Saaty, 2013)

$$w_{gi}^{Final} = w_g \times w_{gi}.$$

These global weights were used to identify dominant strategic drivers and system bottlenecks and to parameterise the subsequent TOWS/Delphi step. Strategy priorities were then derived using a weighted scoring model (Ishizaka & Nemery, 2013):

$$Score_{strategy} = \sum_{i=1}^N w_i^G \times Impact_i,$$

where w_i^G is the global weight of factor i and $Impact_i$ denotes the expected contribution of a strategy to factor i , elicited through a two-round Delphi expert assessment. Strategies were ranked in descending order of $Score_{strategy}$, with higher scores indicating higher implementation priority. Overall, the integrated SWOT-AHP-TOWS approach provides a transparent and reproducible basis for strategic decision-making in geopark tourism, particularly under conditions requiring alignment between geoheritage conservation, stakeholder interests, and destination governance (Ghosh et al., 2024).

2.4. Delphi Method

The Delphi method is a structured qualitative research technique used to gather and synthesize expert opinions through multiple iterative rounds to reach consensus on a complex issue or one for which data is unclear (Dalkey & Helmer, 1963). The Delphi technique was initiated by Dalker in 1963 with the aim of forecasting strategies for a military project. Delphi is widely applied in many fields such as education, healthcare, management, and tourism, focusing on research aimed at decision-making (Green et al., 1990; Lin & Song, 2015; Van et al., 2022).

In particular, the combination of Delphi with AHP becomes a decision support tool that ensures objectivity and reliability in tourism research (Choi & Yoon, 2026; Oh et al., 2015). This study uses a two-round Delphi method to assess the impact of TOWS strategies on SWOT factors and complements the weighting process based on AHP. The expert panel, consisting of 15 people (as in the AHP process), was also involved to ensure consistency. In round 1, independent experts assessed the impact of each strategy on related factors using a scale from 0 to 5. The aggregated results (mean, standard deviation) were then discussed in round 2 to facilitate review and consensus. Consensus was accepted when the standard deviation ($SD \leq 1$) was 0. The final average score is used as the impact value and is integrated with the global weights obtained from AHP to calculate the weighted score, as illustrated in Figure 2.

2.5. Data Collection

The study drew on both secondary and primary data sources: (i) Secondary data: Documentary materials were obtained from the Geopark Management Board, including geological and cultural resource documentation, industry reports, and relevant academic literature. These sources provided a baseline profile of the geopark's resource endowment, governance

arrangements, market conditions, infrastructure, and key development constraints. The baseline evidence informed the initial SWOT compilation and served as a reference point for triangulation with primary data; (ii) Primary data. Primary evidence comprised (i) field surveys and (ii) expert consultation. Field surveys were conducted from 20–25 September 2025 across representative geosites within the geopark to document tourism potential, accessibility, infrastructure, and service conditions, and patterns of community involvement. Expert consultation supported factor identification and AHP weighting. A purposive sampling strategy was used to recruit panellists with at least five years of relevant experience in geopark management, tourism, conservation or demonstrable contextual knowledge of the study area, thereby enhancing the stability and credibility of pairwise judgements. The expert panel included 15 members and remained constant throughout the study to minimise sampling-induced bias: Geopark Management Board (n = 2), travel agencies (n = 3), site-based tour guides (n = 2), tourism management/policy experts (n = 2), geoheritage/geotourism researchers (n = 3), and local community representatives (n = 3). Semi-structured one-to-one interviews were conducted between 1 October and 30 November 2025 (45–60 minutes each). Interview transcripts were thematically coded and used as inputs to the SWOT refinement, AHP weighting and subsequent strategy formulation and ranking steps.

3. SWOT analysis of the geotourism sector in the Lang Son UGGp

The Lang Son UGGp demonstrates strong geotourism potential underpinned by high geoheritage diversity and representativeness. The area comprises 24 stratigraphic units, including 15 units first defined in Lang Son, offering a well-preserved and information-rich geological record across space and time. Major tectonic phases (approximately 65-23 million years ago) contributed to the present structural architecture and generated a heterogeneous geomorphological setting, ranging from limestone massifs and valleys to landforms shaped by long-term landscape evolution. In combination with local topography, climate and hydrology, karstification has produced an extensive limestone cave system with well-developed speleothems and diagnostic karst features (e.g., sinkholes, underground streams and subterranean karst spaces). These attributes provide a robust foundation for experience-based and learning-oriented products, including cave exploration, trekking, sport climbing and related outdoor activities.

The geopark’s geoheritage value is further strengthened by associated ecosystems and biodiversity linked to limestone landscapes and endemic forest habitats. Conservation-significant fauna (e.g., langurs, gibbons and musk deer) and old-growth forest stands support integrated geo-eco experiences and reinforce environmental education functions. In parallel, Lang Son hosts a rich cultural-historical resource base that aligns with contemporary geotourism approaches emphasising linkages among geology, culture, and local livelihoods. More than ten ethnic groups (e.g., Nung, Tay, Kinh, Dao, San Chay, Hoa, Mong) contribute to a culturally diverse landscape, while living heritage practices (e.g., Then singing with the Tinh lute, Sli-Luon folk songs, the Na Nhem festival, the “cat-lion” dance, and Mother Goddess worship) provide community-based experiential assets. Archaeological sites (e.g., Tham Khuyen, Tham Hai, Koo Leng) and the Bac Son cultural complex add scientific depth and strengthen the destination’s potential for interpretation and storytelling.

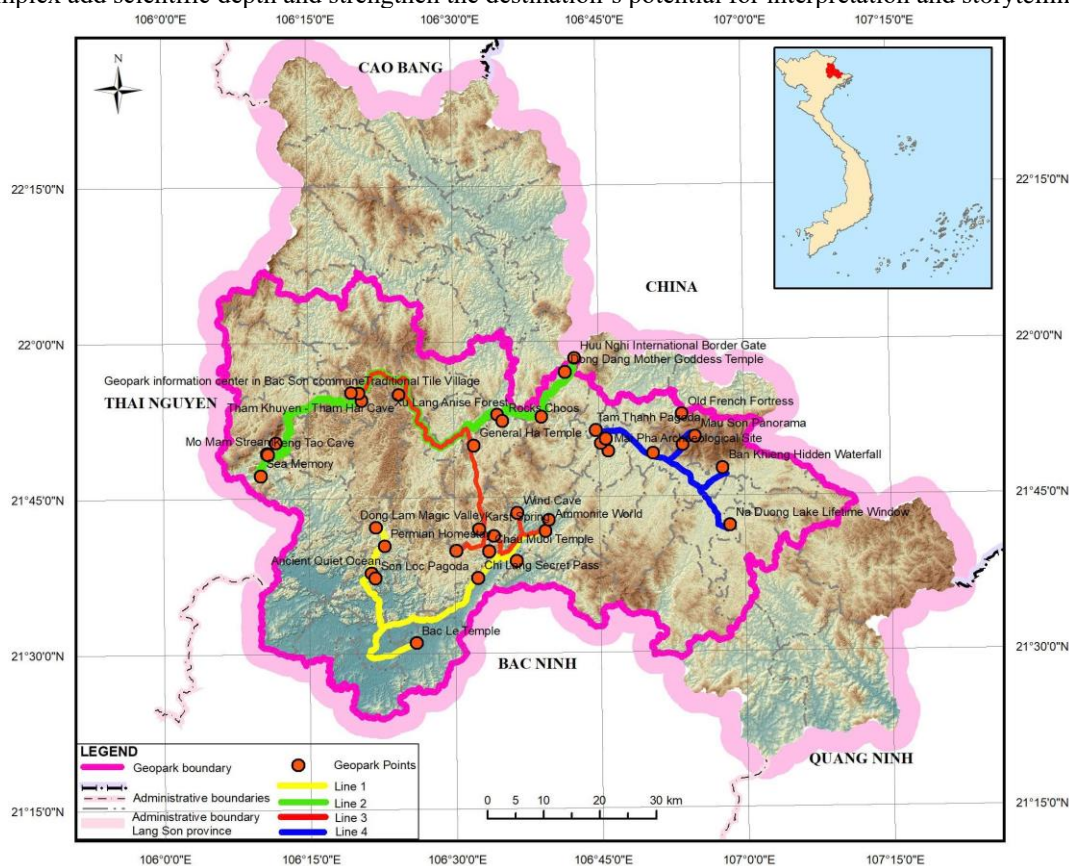


Figure 3. Main tourism sites and routes in the Lang Son UGGp (Source: The authors, 2025)

From a spatial planning perspective, the geopark has delineated four visitor routes comprising 38 geo-cultural and eco-heritage sites, largely aligned with major transport corridors (National Highways 1A, 1B, 4B and 279), thereby facilitating tour operations and visitor dispersal (Figure 3). This route-site network enables coherent linkages among karst landscapes, biodiversity, and cultural heritage, creating a clear platform for sustainable geotourism development supported by high-quality interpretation and impact-sensitive site management.

Drawing on secondary sources, field survey evidence, and expert consultation, the study identified six Strengths (S), five Weaknesses (W), five Opportunities (O), and four Threats (T) relevant to geotourism development in the Lang Son UGGp. In total, 20 factors were retained to capture the interrelationships among natural, socio-cultural, economic, and environmental dimensions shaping geotourism development in the study area. These factors were subsequently used as inputs to strategy formulation and prioritisation (Table 2).

Table 2. Summary of SWOT factors for sustainable geotourism development in the Lang Son UGGp (Source: Authors’ synthesis from secondary data, field observations, and expert consultation)

	Strength	Weakness
Internal factor	<p>S1. High accessibility and corridor-based connectivity support tour operations and market linkages.</p> <p>S2. High geodiversity (multiple stratigraphic units and a long tectonic history) enables theme-based products and the development of a coherent geostory.</p> <p>S3. High-value karst systems with strong experiential appeal and high potential for geo-interpretation and geo-education.</p> <p>S4. Biodiversity and ecological assets suitable for integrated geo-eco products and extended stays.</p> <p>S5. Multi-ethnic living heritage enabling geo-cultural integration and community-based livelihood linkages.</p> <p>S6. An existing, delineated, and operational route-site network.</p>	<p>W1. Uneven infrastructure and service standards across sites, reducing experience quality and limiting visitor dispersal.</p> <p>W2. Limited specialised human resources (e.g., geo-guides, destination managers, activity facilitators).</p> <p>W3. Weak stakeholder coordination and unclear benefit-sharing arrangements (Management Board–businesses–communities), constraining social acceptance and long-term sustainability.</p> <p>W4. Non-standardised geo-interpretation and inconsistent interpretive narratives across routes and sites.</p> <p>W5. Thin experiential offerings at several sites (limited activities and ancillary services).</p>
	Opportunities	Threats
External Factor	<p>O1. UGGp branding and network effects that strengthen partnerships and destination positioning.</p> <p>O2. Growing demand for nature-based, experiential, and learning-oriented travel.</p> <p>O3. Digital tools for geo-interpretation and destination management (e.g., QR/AR, route mapping, e-ticketing, visitor data analytics).</p> <p>O4. High-potential education and field-trip markets (schools and universities).</p> <p>O5. A strengthening policy framework for sustainable tourism, geoheritage conservation and local economic development.</p>	<p>T1. Geoheritage degradation (especially in karst/cave systems) due to overuse or weak controls, eroding core values.</p> <p>T2. Natural hazards and extreme weather affecting safety, accessibility, and operational continuity.</p> <p>T3. Increasing competition from other karst destinations/geoparks, intensifying differentiation pressures.</p> <p>T4. Cultural commodification that undermines authenticity and may trigger social backlash, weakening experience quality and community sustainability.</p>

3.1. Proposed TOWS strategies

To advance the geopark’s sustainability objectives, the Lang Son UGGp should design and implement geotourism strategies in close collaboration with relevant stakeholders. This study builds on the strategic orientations articulated in Resolution No. 223-NQ/TU (30 May 2025) of the Standing Committee of the Lang Son Provincial Party Committee on the conservation, restoration, and valorisation of the geopark for 2025-2030, with an outlook to 2035. These orientations emphasise delivering high-quality visitor experiences, generating socio-economic benefits for local communities, and minimising environmental impacts while safeguarding the authenticity of resources. Guided by the priority structure of internal and external factors identified through the SWOT analysis, a portfolio of sustainable geotourism strategies was developed through expert consultation using the TOWS matrix (Table 3).

Table 3. TOWS-derived strategy set for sustainable geotourism development

SO	WO
<p>SO1 (S2 + S3 + O2 + O4): Develop interpretation-led geotourism routes centred on tectonic evolution and karst systems to serve field-trip and educational tourism markets.</p> <p>SO2 (S4 + S5 + O2 + O5): Integrate geology, ecology, and local culture to deliver multi-layered geo-eco-cultural experiences, increase visitor expenditure, and align with policy orientations for sustainable tourism that generates community benefits.</p> <p>SO3 (S2 + S5 + O1): Strengthen destination communication and positioning to enhance Lang Son’s distinctiveness as a geotourism destination in Northeast Vietnam.</p>	<p>WO1 (W4 + W3 + O1 + O3): Standardise the geo-interpretation system and strengthen coherence of interpretive narratives using digital tools.</p> <p>WO2 (W2 + W3 + O2 + O4): Build local geotourism human resources (e.g., geo-guides and destination managers) to meet rising demand and education/field-trip markets while improving coordination capacity.</p> <p>WO3 (W1 + O2 + O3): Upgrade infrastructure and service quality in line with site-specific carrying capacity and visitor management requirements.</p>
ST	WT
<p>ST1 (S2 + S3 + T1 + T2): Establish geosite protection zoning and disaster-risk governance to reduce geoheritage degradation and climate-/hazard-related operational risks.</p> <p>ST2 (S2 + S5 + T3): Develop differentiated products based on distinctive geology–culture linkages to strengthen competitiveness against other karst destinations and geoparks.</p>	<p>WT1 (W3 + W4 + T4): Establish a co-management and benefit-sharing framework with local communities to safeguard authenticity and reduce risks of cultural commodification.</p> <p>WT2 (W1 + W2 + T2): Strengthen risk management capacity at infrastructure-sensitive sites through safety protocols and targeted training in emergency and disaster response.</p>

3.2. AHP analysis

Decision-making in complex planning contexts is rarely straightforward; therefore, strategy formulation should account for both objective evidence and informed expert judgement. Beyond defining evaluation criteria, the process must also accommodate uncertainty and potential heterogeneity in experts' preferences and salience judgements.

Tables 4 and 5 report the pairwise-comparison results and derived priority weights for the four SWOT dimensions (S, W, O, T) based on expert assessments. The SWOT-group pairwise-comparison matrix demonstrates acceptable internal consistency (CR = 0.026, meeting the threshold $CR \leq 0.10$). The resulting priority weights for the four SWOT dimensions are as follows: Strengths (S) = 0.415 (Rank 1), Opportunities (O) = 0.293 (Rank 2), Weaknesses (W) = 0.185 (Rank 3), and Threats (T) = 0.107 (Rank 4).

Table 4. Pairwise comparison of the SWOT factors (CR=0.026)

SWOT	S	W	O	T	Weight	Ranking
S	1	2	2	3	0.415	1
W	1/2	1	1/2	2	0.185	3
O	1/2	2	1	3	0.293	2
T	1/3	1/2	1/3	1	0.107	4

Table 5. Results of pairwise comparisons of SWOT factors

SWOT	Criteria	SWOT Weight	Subcriteria	Weight Factors	Global Weight of Factors
Internal	S	0.415	S1	0.125	0.052
			S2	0.245	0.102
			S3	0.205	0.085
			S4	0.145	0.060
			S5	0.170	0.071
	W	0.185	W1	0.240	0.044
			W2	0.200	0.037
			W3	0.290	0.054
			W4	0.120	0.022
			W5	0.150	0.028
External	O	0.293	O1	0.200	0.059
			O2	0.240	0.070
			O3	0.120	0.035
			O4	0.150	0.044
			O5	0.290	0.085
	T	0.107	T1	0.220	0.024
			T2	0.340	0.036
			T3	0.170	0.018
			T4	0.270	0.029

The AHP results reported in Table 5 show that, within the Strengths cluster, geodiversity and tectono-geological evolution (S2) and the high value karst-cave system (S3) receive the highest priorities. This confirms that Lang Son's core comparative advantage lies in geoheritage attributes that can be translated into experience-based interpretation and coherent geoheritage storytelling. Within the Opportunities cluster, a strengthening policy framework for sustainable tourism (O5) and rising demand for nature-based, learning-oriented travel (O2) constitute the principal exogenous drivers. Conversely, weak stakeholder coordination and unclear benefit-sharing arrangements (W3) represent the most salient internal bottleneck, while natural hazards and extreme weather (T2) pose a significant external constraint. Overall, Lang Son exhibits strong intrinsic potential for sustainable geotourism; however, governance improvements and enhanced risk-adaptive capacity are necessary to convert emerging opportunities into durable development outcomes.

Building on the AHP-based quantification of SWOT, the study next assessed the relative effectiveness of each TOWS strategy using: (i) global factor weights derived from AHP, and (ii) impact scores (0–5; 0 = no impact, 5 = powerful impact) elicited through a two-round Delphi process. Weighted composite scores were then computed for each strategy to enable prioritisation and ranking of sustainable geotourism strategies for the Lang Son UGGp (Table 6).

Table 6. Priority strategy ranking results (Delphi-AHP weighted score)

Strategy	Two-round Delphi survey	Weighted score	Rank
SO1	S2=4.6; S3=4.4; O2=4.2; O4=4.3	0.265	1
SO2	S4=4.2; S5=4.5; O2=4.0; O5=4.3	0.243	2
ST1	S2=4.0; S3=4.2; T1=4.3; T2=4.5	0.206	3
SO3	S2=4.0; S5=4.0; O1=4.4	0.189	4
WO2	W2=4.5; W3=4.0; O2=3.6; O4=4.2	0.164	5
ST2	S2=3.6; S5=3.8; T3=4.2	0.142	6
WO1	W4=4.3; W3=4.1; O1=3.8; O3=4.4	0.139	7
WO3	W1=4.4; O2=3.7; O3=3.9	0.119	8
WT2	W1=4.1; W2=3.8; T2=4.2	0.095	9
WT1	W3=4.4; W4=4.0; T4=4.3	0.090	10

The results indicate a clear predominance of SO strategies, consistent with the AHP priority structure in which Strengths (0.415) and Opportunities (0.293) receive the highest weights. SO1 ranks as the top priority because it directly couples the geopark's core geoheritage assets particularly geodiversity and tectono-geological evolution (S2) and the high-value karst-cave system (S3) with expanding market opportunities for experiential, learning-oriented travel (O2) and the field-trip segment (O4). This configuration produces a strong synergy, supporting the development of interpretation-led, education-focused geotourism products with high levels of on-site engagement. SO2 ranks second, as it operationalises an integrated geo-eco-cultural experience model grounded in ecological resources (S4) and local cultural identity (S5), while aligning with market trends (O2) and supportive policy directions for sustainable tourism (O5). In practice, SO2 is expected to lengthen stays and increase visitor expenditure while maintaining a conservation-oriented development pathway.

Within the risk-response portfolio, ST1 ranks next because it directly addresses two critical threats natural hazards and extreme weather (T2) and geoheritage degradation (T1) both of which are foundational to operational safety and the long-term integrity of the geopark's core values. The lower rankings of WO and WT strategies should not be interpreted as limited importance; rather, they reflect the logic of the AHP-TOWS structure, in which these options primarily target system-capacity strengthening (e.g., specialised human resource development, co-governance and benefit-sharing arrangements, standardisation of geo-interpretation, and infrastructure upgrading). Such interventions typically yield cumulative benefits over the medium to long term. Consequently, WO/WT strategies particularly WO2 and WO1 should be treated as enabling measures and implemented in parallel with the highest-priority SO strategies to enhance feasibility, safeguard sustainability, and support durable implementation of geotourism development in the Lang Son UGGp.

DISCUSSION AND IMPLICATIONS

1. Discussion

The findings confirm the feasibility and decision-support value of the integrated SWOT-AHP-TOWS approach for advancing sustainable geotourism development in the Lang Son UGGp. Beyond identifying strategic factors, the framework quantifies and tests their relative importance, thereby providing a more rigorous and transparent basis for prioritising interventions. The predominance of SO strategies aligns with the AHP-derived priority structure, in which Strengths (0.415) and Opportunities (0.293) receive the highest weights. This pattern suggests that, in geoparks with strong resource endowments, development pathways should focus on mobilising core comparative advantages rather than concentrating primarily on remediating internal weaknesses (Fabac & Zver, 2011; Sahani, 2021). Among the prioritised options, SO1 and SO2 receive the highest scores, indicating an effective coupling of key geoheritage assets especially geodiversity and karst-cave systems with emerging demand from educational tourism and field-trip markets. This configuration supports a sustainable geotourism model that integrates education with purposefully designed experiences while remaining consistent with market demand and supportive policy orientations. The results corroborate prior arguments that geological value is meaningfully "activated" when translated into interpretation/education and intentionally designed experiential products, rather than being consumed primarily as scenic landscape (Hose, 2012; Vu et al., 2022).

Strategies focused on geoheritage protection and risk management (ST1) are pivotal for safeguarding the geopark's long-term sustainability. Although weighted lower than the leading SO options, ST1 highlights that disaster-risk governance and geosite conservation are foundational prerequisites for sustainable geotourism operations. Accordingly, mitigation measures targeting natural hazards and extreme weather (T2) and geoheritage degradation (T1) should be embedded within the geopark's product and operations strategy to sustain long-term stability and resilience. Such protection-oriented interventions are most effective when implemented alongside growth strategies, particularly where hazard exposure and site vulnerability directly constrain visitor safety and resource integrity. Although WO and WT strategies rank lower, this should not be interpreted as a reduction in relevance. Instead, it reflects the AHP-TOWS logic whereby these strategies primarily strengthen system capacity including workforce development, co-governance and benefit-sharing arrangements, standardisation of geo-interpretation, and infrastructure upgrading. Their effects typically accrue cumulatively over the medium to long term, reinforcing the institutional and operational foundations required for sustained geopark development. Consequently, these measures should be implemented in parallel with SO strategies to maximise the effectiveness and durability of sustainability interventions (Schmidt et al., 2015).

Finally, external enabling conditions particularly digital tools (O3), the education/field-trip market (O4), and supportive policy instruments (O5) substantially shape the feasibility of implementation. Explicitly integrating these drivers into the development pathway is likely to enhance executability, accelerate uptake, and provide a stronger platform for long-term sustainable geotourism growth in Lang Son.

2. Management and policy implications

From the perspective of destination governance and policy design for the Lang Son UGGp, the findings generate several actionable implications:

First, short to medium-term resource allocation should prioritise SO1 and SO2 as the principal "growth engines", as these strategies achieved the highest weighted scores and align closely with the dominant drivers (S2, S3, S4, S5; O2, O4, O5). Operationally, this entails accelerating the design of learning and experience oriented geotourism routes and products, standardising geo-interpretation content across sites, and developing integrated geo-eco-cultural packages to extend length of stay and increase visitor expenditure while maintaining conservation orientations.

Second, ST1 should be institutionalised as a mandatory governance pillar and embedded directly into route-site planning and daily operations. Core instruments such as geosite protection zoning, carrying-capacity management, cave

safety protocols, and contingency planning for natural hazards and extreme weather should be integrated from the outset. Without this enabling layer, short-term gains from SO strategies are unlikely to be durable and may increase the risk of undermining the geopark's core values.

Third, WO/WT strategies particularly WO2 and WO1 should be implemented as an accompanying capacity-upgrading package rather than deferred. Developing specialised human resources, standardising the geo-interpretation system, and strengthening coordination and benefit-sharing mechanisms are enabling conditions that enhance experience quality, improve social acceptance, and reduce conflict risks during utilisation and management.

Overall, the findings support a two-tier pathway for Lang Son: (i) a growth tier driven by SO synergies, and (ii) a sustainability-assurance tier anchored in risk governance and system capacity strengthening (ST, WO, WT). This structure aligns with UGGp requirements for conservation, education, and sustainable development, while providing a quantified basis for transparent priority setting.

CONCLUSION AND FUTURE RESEARCH DIRECTIONS

This study proposes and empirically validates an integrated strategic decision-support framework to guide sustainable geotourism development in the Lang Son UGGp. By combining SWOT-AHP-TOWS with a two-round Delphi process, the analysis quantifies the relative salience of internal and external factors and ranks strategy groups using weighted composite scores. The results indicate a clear priority structure favouring SO strategies, underscoring the pivotal role of core resource strengths particularly geodiversity, karst-cave geoheritage and local cultural assets when aligned with expanding opportunities in experiential and learning oriented travel, the field-trip segment, and supportive sustainable tourism policy orientations. In parallel, strategies focused on risk governance and geoheritage protection emerge as enabling conditions that underpin the long term viability of growth oriented interventions.

Despite providing a systematic basis for strategy prioritisation, two limitations warrant attention. First, AHP results are inherently contingent on expert judgement and thus reflect context-specific perceptions at the time of assessment. Second, the framework does not integrate quantitative evidence on visitor flows, revenues, or environmental impacts, limiting empirical validation of real world strategy performance. Future research could extend this work by: (i) integrating dynamic approaches (e.g., scenario analysis or system dynamics) to assess long-term effects; (ii) incorporating spatial data and digital tools to quantify carrying capacity and geosite-level pressures; and (iii) conducting cross-geopark comparative analyses among karst-dominated UGGp to derive more generalisable governance insights.

Author Contributions: Conceptualization, T.P., V.H. and N.C. ; methodology, T.P. and V.H.; software, N.C. and V.H.; validation, T.P. and V.H.; formal analysis, T.P. and V.H. and N.C.; investigation, N.C.; data curation, V.H. and N.C.; writing - original draft preparation, T.P., V.H. and N.C.; writing - review and editing, T.P. and V.H.; visualization, N.C.; supervision, T.P. and V.H.; project administration, T.P. and V.H. All authors have read and agreed to the published version of the manuscript.

Funding: Not applicable.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study may be obtained on request from the corresponding author.

Acknowledgements: The research undertaken was made possible by the equal scientific involvement of all the authors concerned.

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

REFERENCE

- Catana, M., & Brilha, J. (2020). The Role of UNESCO Global Geoparks in Promoting Geosciences Education for Sustainability. *Geoheritage*, 12. <https://doi.org/10.1007/s12371-020-00440-z>
- Choi, H., & Yoon, Y. S. (2026). Local destinations as strategic units: Identifying hierarchical competitiveness structures through Delphi-AHP. *Journal of Hospitality and Tourism Management*, 66. <https://doi.org/10.1016/j.jhtm.2026.101403>
- Crawford, G., & Williams, C. (1985). A Note on the Analysis of Subjective Judgment Matrices. *Journal of Mathematical Psychology - J Math Psychol*, 29, 387–405. [https://doi.org/10.1016/0022-2496\(85\)90002-1](https://doi.org/10.1016/0022-2496(85)90002-1)
- Dalkey, N., & Helmer, O. (1963). An experimental application of the Delphi method to the use of experts. *Management Science*, 9(3), 458–467.
- Das, P., Mandal, S., Nedungadi, P., & Raman, R. (2025). Unveiling sustainable tourism themes with machine learning based topic modeling. *Discover Sustainability*, 6. <https://doi.org/10.1007/s43621-025-01065-4>
- Eder, W. (2008). Geoparks—promotion of earth sciences through geoheritage conservation, education and tourism. *Journal of the Geological Society of India*, 72(2), 149–154.
- Fabac, R., & Zver, I. (2011). Applying the modified SWOT–AHP method to the tourism of Gornje Medimurje. *Tourism and Hospitality Management*, 17(2), 201–215.
- Farsani, N. T., Coelho, C., & Costa, C. (2011). Geotourism and geoparks as novel strategies for socio-economic development in rural areas. *International Journal of Tourism Research*, 13(1), 68–81. <https://doi.org/10.1002/jtr.800>
- Ferreira, D., & Valdati, J. (2022). Geoparks and Sustainable Development: Systematic Review. *Geoheritage*, 15. <https://doi.org/10.1007/s12371-022-00775-9>

- Fujii, I., & Ito, H. (2020). How the modification of unesco global geopark program influenced Japanese geoparks. *PEOPLE: International Journal of Social Sciences*, 5, 627–641. <https://doi.org/10.20319/pijss.2020.53.627641>
- Ghosh, S., Jha, V. C., & Shukla, J. (2024). Geotourism Potentiality of Fossil Park Using Swot Matrix and Analytical Hierarchy Process (AHP) for Amkhoi Wood Fossil Park, Birbhum District, West Bengal, India. *Sociedade & Natureza*, 36, e73588. <https://doi.org/10.14393/SN-v36-2024-73588>
- Gomes, I. P., & Motta Garcia, M. da G. (2025). Methods of Evaluating Geological Sites with Tourism Potential: An Overview. *Geoheritage*, 17(2), 86. <https://doi.org/10.1007/s12371-025-01121-5>
- Green, H., Hunter, C., & Moore, B. (1990). Application of the Delphi technique in tourism. *Annals of Tourism Research*, 17, 270–279. [https://doi.org/10.1016/0160-7383\(90\)90087-8](https://doi.org/10.1016/0160-7383(90)90087-8)
- Gupta, V., Anand, S., Wei, D., Wang, G., & Tripathi, S. (2024). Exploring applied sustainable strategies through geoheritage and geotourism: A systematic literature review. *International Journal of Geoheritage and Parks*, 12. <https://doi.org/10.1016/j.ijgeop.2024.11.009>
- Hernández-Garrido, R., Orts Cardador, J. J., & Calañas, P. (2023). Geotourism management for sustainable development of tourism: A bibliometric analysis of the main research areas and domains of knowledge. *Enlightening Tourism A Pathmaking Journal*, 13, 64–105. <https://doi.org/10.33776/et.v13i2.8029>
- Herrera, F. G., Carrión, P., Alvarado, N., Morante, F., Maldonado, A., Caldevilla, P., Briones-Bitar, J., & Berrezueta, E. (2020). Geosites and Georesources to Foster Geotourism in Communities: Case Study of the Santa Elena Peninsula Geopark Project in Ecuador. *Sustainability*, 12, 4484. <https://doi.org/10.3390/su12114484>
- Hose, T. A. (2012). Geotourism and geoconservation. *Geoheritage*, 4(1), 1–5.
- Ishizaka, A., & Nemery, P. (2013). *Multi-Criteria Decision Analysis: Methods and Software*. <https://doi.org/10.1002/9781118644898>
- Kotler, P. (1988). Marketing management: Analysis, planning, implementation and control. In (*No Title*). Prentice-Hall.
- Kou, G., Ergu, D., Peng, Y., & Shi, Y. (2012). A new consistency test index for the data in the AHP/ANP. In *Data Processing for the AHP/ANP* 11–27. Springer.
- Koupatsiaris, A. A., & Drinia, H. (2023). Exploring greek UNESCO global geoparks: a systematic review of grey literature on greek universities and future research avenues for sustainable development. *Geosciences*, 13(10), 296.
- Kurttila, M., Pesonen, M., Kangas, J., & Kajanus, M. (2000). Utilizing the analytic hierarchy process (AHP) in SWOT analysis - A hybrid method and its application to a forest-certification case. *Forest Policy and Economics*, 1, 41–52. [https://doi.org/10.1016/S1389-9341\(99\)00004-0](https://doi.org/10.1016/S1389-9341(99)00004-0)
- Lestari, F., Prabowo, Y. D., & Nugraheni, M. D. (2025). Geotrails: Blending Geotourism and Geological Discovery at the Bayah Dome Geopark, Indonesia. *Geo Journal of Tourism and Geosites*, 59(2), 725–736.
- Lin, V. S., & Song, H. (2015). A review of Delphi forecasting research in tourism. *Current Issues in Tourism*, 18, 1099–1131. <https://doi.org/10.1080/13683500.2014.967187>
- Oh, M., Kim, S., & Lee, A. (2015). Development of an Evaluation Scale for Inter-Country Tourism Industry Competitiveness using the Delphi Technique and Analytic Hierarchy Process. *International Journal of Tourism Sciences*, 13, 1–32. <https://doi.org/10.1080/15980634.2013.11434671>
- Özgeriş, M., & Karahan, F. (2021). Use of geopark resource values for a sustainable tourism: A case study from Turkey (Cittaslow Uzundere). *Environ. Dev. Sustain*, 23, 4270–4284. <https://doi.org/10.1007/s10668-020-00773-3>
- Paskova, M., & Josef, Z. (2018). Sustainability Management of Unesco Global Geoparks. *Sustainable Geoscience and Geotourism*, 2, 44–64. <https://doi.org/10.18052/www.scipress.com/SGG.2.44>
- Peniwati, K. (1998). Aggregating individual judgments and priorities with the Analytic Hierarchy Process. *European Journal of Operational Research*, 108, 165–169. [https://doi.org/10.1016/S0377-2217\(97\)00244-0](https://doi.org/10.1016/S0377-2217(97)00244-0)
- Quesada-Valverde, M. E., & Quesada-Román, A. (2023). Worldwide trends in methods and resources promoting geoconservation, geotourism, and geoheritage. *Geosciences*, 13(2), 39. <https://doi.org/10.3390/geosciences13020039>
- Saaty, T. L. (2013). Analytic hierarchy process. In *Encyclopedia of operations research and management science* 52–64. Springer.
- Sahani, N. (2021). Application of hybrid SWOT-AHP-FuzzyAHP model for formulation and prioritization of ecotourism strategies in Western Himalaya, India. *International Journal of Geoheritage and Parks*, 9. <https://doi.org/10.1016/j.ijgeop.2021.08.001>
- Sarkar, A., & Gayen, S. (2025). Mapping the Field: A Systematic Bibliographic Review of Geotourism Trends in the Twenty-First Century. *Geoheritage*, 17, 57. <https://doi.org/10.1007/s12371-025-01090-9>
- Schmidt, K., Aumann, I., Hollander, I., Damm, K., & Graf von der Schulenburg, J. M. (2015). Applying the Analytic Hierarchy Process in healthcare research: A systematic literature review and evaluation of reporting. *BMC Medical Informatics and Decision Making*, 15. <https://doi.org/10.1186/s12911-015-0234-7>
- Van, N., Tucek, D., & Pham, N. T. (2022). Indicators for TQM 4.0 model: Delphi Method and Analytic Hierarchy Process (AHP) analysis. *Total Quality Management & Business Excellence*, 34, 1–15. <https://doi.org/10.1080/14783363.2022.2039062>
- Vu, H., Nguyen, N., Ngo, Y., & Le, T. (2022). Geotourism current state and future prospects: a case study in the Cao Bang Unesco global geopark, Vietnam. *GeoJournal of Tourism and Geosites*, 43, 1063–1070. <https://doi.org/10.30892/gtg.43327-921>
- Wehrich, H. (1982). The TOWS matrix—A tool for situational analysis. *Long Range Planning - LONG RANGE PLANN*, 15, 54–66. [https://doi.org/10.1016/0024-6301\(82\)90120-0](https://doi.org/10.1016/0024-6301(82)90120-0)
- Williams, M., McHenry, M., & Boothroyd, A. (2020). Geoconservation and Geotourism: Challenges and Unifying Themes. *Geoheritage*, 12. <https://doi.org/10.1007/s12371-020-00492-1>
- Zgłobicki, W., Kukiełka, S., & Baran-Zgłobicka, B. (2020). Regional geotourist resources—assessment and management (a case study in SE Poland). *Resources*, 9(2), 18. <https://doi.org/10.3390/resources9020018>