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Multicriteria Sustainability Evaluation of Urban Heritage: An Integrative Model Applied to the Casbah of Algiers

Keywords

AHP-ANP
Casbah of Algiers
Multicriteria Evaluation
Sustainability
Urban Heritage

Abstract

Assessing urban heritage in historic cities remains challenging where building decay, urban pressure and difficult-to-regulate tourism dynamics intersect. Monetary approaches reflect market benefits but inadequately account for non-market values, conservation limits, and the complexity of inhabited historic fabric. This paper operationalises a sustainability-based multicriteria decision-support framework, integrating economic dimensions, for the tourist route of the Casbah of Algiers. The model is formalised as a reproducible protocol integrating five dimensions: heritage, environmental (urban), social, economic and institutional, weighted through structured questionnaires administered to ten (10) qualified experts in economics, sociology, environment, heritage, and administrative management. A hierarchical structuring (AHP) is complemented by a network-based modelling of interdependencies (ANP), implemented in SuperDecisions. The results generate weights, final priorities and a limit matrix, supporting a structured interpretation of vulnerabilities and value patterns at the route scale.

Introduction

Historic urban centres are complex socio-spatial systems in which architectural heritage, economic functions and cultural practices converge. Their conservation involves demanding governance trade-offs, particularly under conditions of constrained public resources and rapidly shifting urban dynamics. In this setting, economic evaluation has progressively become a key instrument for appreciating multiple benefits (both tangible and intangible) associated with heritage conservation and enhancement (Alaouchiche et al., 2025; Pujol Galindo, 2023; Throsby, 2012; Basílio et al., 2022). International frameworks emphasise that urban heritage, in its material and immaterial components, constitutes a strategic resource for improving liveability while supporting economic development and social cohesion (UNESCO, 2011). Development actors likewise increasingly recognise heritage as a lever for local growth and territorial cohesion (World Bank, 2012; Licciardi and Amirtahmasebi, 2012; Kyte, 2012).

Yet, standard economic appraisal tools often fail to capture the full economic value of heritage assets embedded in inhabited historic fabrics (Dalmas et al., 2014). Conventional approaches tend to privilege market-visible flows while under-representing indirect use values (positive externalities, induced effects) and non-use values (identity, collective memory, existence and bequest), for which no straightforward monetary measurement exists (Dalmas et al., 2014; Dalmas et al., 2015). This limitation strengthens the case for evaluation frameworks that can account for both market and non-market benefits, and that can represent trade-offs across heterogeneous dimensions of value.

Recent conceptual renewals have therefore mobilised the Total Economic Value framework and the notion of strong sustainability to argue for integrated evaluation approaches capable of reflecting the multidimensionality of urban heritage (Dalmas et al., 2015). Unlike weak sustainability, whereby different forms of capital are considered broadly substitutable, strong sustainability assumes that certain heritage components are effectively non-substitutable: beyond critical thresholds, losses in one dimension cannot be compensated by gains in another (Dalmas et al., 2015). This premise calls for multicriteria decision analysis (MCDA) in which monetary and non-monetary indicators are combined to reflect, in a single decision-support architecture, the economic, social, cultural, environmental and institutional dimensions of heritage value (Alaouchiche et al., 2025; Della Spina, 2020; Ferretti and Comino, 2015). Such an orientation is consistent with the broader international shift-promoted by UNESCO, ICOMOS and further elaborated in the Historic Urban Landscape approach, towards holistic heritage management aligned with sustainable development objectives (UNESCO, 2011; Bandarin and van Oers, 2012). In particular, the UNESCO recommendation on the Historic Urban Landscape explicitly encourages the integration of conservation policies into wider urban strategies, thereby reinforcing the need for decision-support tools that would allow for the application of multiple criteria instead of relying solely on market logics (UNESCO, 2011).

Within this methodological landscape, an integrative framework was recently proposed to connect strong-sustainability reasoning with multicriteria evaluation for urban heritage, by structuring value dimensions and ensuring procedural transparency in decision-making (Alaouchiche et al., 2025). The present paper operationalises that study on the tourist heritage route of the Casbah of Algiers, identified as a structuring axis in the Permanent Plan for Safeguarding and Enhancement of the Safeguarded Sector (PPSMVSS) (Ministry of Culture of Algeria, 2009). Inscribed on the UNESCO World Heritage List since 1992, the Casbah offers a particularly demanding testing ground: it concentrates outstanding heritage values while facing persistent vulnerabilities related to building con-

dition, residential pressures, and implementation capacity (UNESCO World Heritage Centre, 2023; Djedi and Belakehal, 2022). Although safeguarding instruments have been elaborated over time, the capacity to monitor, evaluate and adjust interventions remains limited, which constrains evidence-based prioritisation and weakens long-term effectiveness (UNESCO World Heritage Centre, 2023). This evaluation gap motivates the use of multicriteria tools that can support explicit prioritisation under strong sustainability constraints.

Heritage routes, in this sense, constitute a relevant operational unit because they organise a sequence of heritage assets and everyday urban functions into a readable system that can be managed, compared and prioritised (Zhang et al., 2024). The route is therefore treated here not as a mere itinerary of visits but as an integrated urban-heritage device, combining monuments, residential fabric, public space and local activities, hence requiring a multidimensional evaluation (Lin et al., 2024). Consistently with this framing, the study develops an MCDA protocol that: elicits expert preferences through pairwise comparisons within an Analytic Hierarchy Process (AHP) structure (Talukder and Hipel, 2021), models interdependencies through an Analytic Network Process (ANP) and applies a ratings procedure to consolidate performance levels when direct quantitative evidence is uneven (Zhang et al., 2023). This operational chain is implemented in SuperDecisions to ensure traceability and reproducibility of the calculations (Saaty, 2016).

To the best of our knowledge, MCDA applications addressing Algerian urban heritage in indexed academic outlets have primarily relied on the AHP for specific planning or delimitation purposes: such as the definition of Historic Urban Landscape (HUL) boundaries in Algiers (Boukratem and Djelal, 2021), rather than on an integrated decision-support chain combining AHP, ANP and performance ratings to derive a synthetic index of (global value) for an inhabited heritage route treated as a system. Building on the UNESCO Historic Urban Landscape framework (UNESCO, 2011), which explicitly calls for the integration of heritage conservation with broader urban development, social and governance processes, this study operationalises sustainability as a formal decision constraint embedded directly within the multicriteria structure itself (through the definition of criteria, the weighting scheme and the modelling of interdependencies) rather than treating sustainability as a purely descriptive or narrative background.

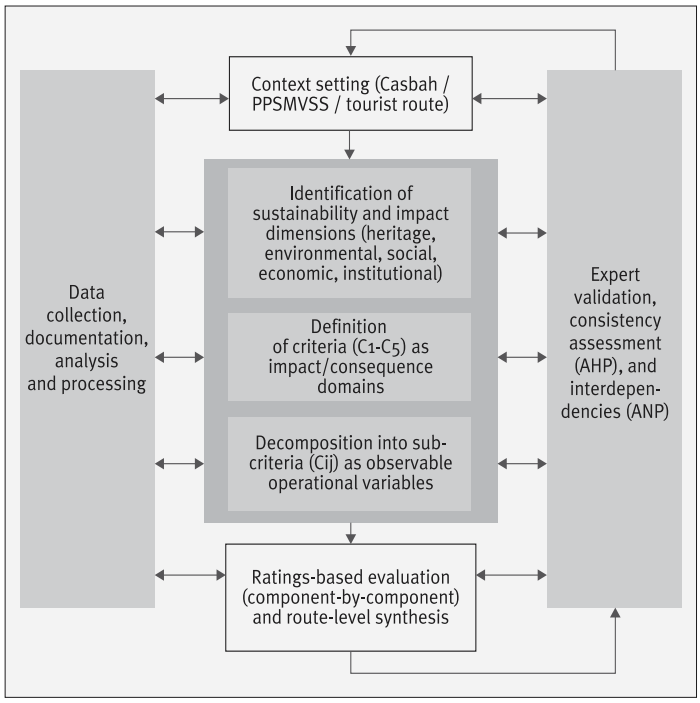


Fig. 1 Methodological workflow (from the selection of the MCDA approach to the AHP-ANP implementation) (Authors, 2026)

Methodology

Overall research design

This study adopts a mixed-methods design combining qualitative inputs and quantitative processing to operationalise a sustainability-based multi-criteria evaluation framework for urban heritage (Fig. 1). Rather than reducing heritage value to a single monetary metric, the approach constructs a multi-criteria value intended as a decision-support output, integrating heritage, environmental, social, economic, and institutional dimensions within a transparent aggregation procedure.

Unit of analysis: the heritage tourism route

The case study focuses on the heritage tourism route of the Casbah of Algiers (Fig. 2), a historic urban area inscribed on the UNESCO World Heritage List since 1992. Rather than being considered a simple sequence of monuments, the route is approached as an integrated urban-heritage system, combining architectural assets, residential fabric, public spaces, everyday practices and local activities. This approach is consistent with the Historic Urban Landscape perspective, which emphasises the interaction between tangible heritage, social life and urban dynamics in living historic centres.

The selected route constitutes a structuring spatial axis within the Casbah, identified

Fig. 2 Case study: the heritage tourism route of the Casbah of Algiers (Authors, 2026)

through the Permanent Safeguard and Enhancement Plan (PPSMVSS) and updated through field observation. It brings together a heterogeneous set of components, including major monuments, religious buildings, historic housing units, commercial spaces, public facilities and urban open spaces. These elements are spatially and functionally interconnected, forming a coherent itinerary that supports both heritage interpretation and daily urban use. The diversity of components makes the route particularly suitable for testing a multi-criteria evaluation framework grounded in sustainability principles.

The choice of the tourism route was further validated through an expert survey, which compared several potential heritage devices within the Casbah (including individual monuments and larger complexes). Experts converged on the route as the most relevant operational scale for an integrated evaluation, as it allows the articulation of conservation issues, urban conditions, social practices and economic dynamics within a single analytical framework. This validation ensures that the case study is not only contextually relevant but also methodologically justified.

By considering the route as a global entity rather than disaggregated objects, the case study enables an assessment of the overall sustainable value of the Casbah's heritage system. It provides an operational testing ground for the combined AHP-ANP model and allows the identification of structural strengths, vulnerabilities and priority areas for intervention. In this sense, the Casbah of Algiers is not treated as an isolated or exceptional case, but as a representative example of a dense, inhabited Mediterranean historic centre facing the challenge of balancing heritage conservation, social continuity and sustainable tourism development.

Sustainability-based analytical framework

A structured literature-based review was used to define and stabilise the evaluation framework around five core sustainability dimensions: environmental (C2), social (C3) and economic (C4) (Purvis, Mao and Robinson, 2019; Barbier, 1987), widely recognised as the foundational pillars of sustainable development. Complemented by: the cultural/heritage (C1) dimension increasingly formalised as a distinct sustainability domain (Soini and Dessein, 2016; UNESCO, 2013), and an institutional/governance (C5) dimension capturing implementation capacity, regulatory effectiveness and coordination mechanisms required for long-term sustainability (Biermann, Kanie and Kim, 2017).

Following the definition of the five core sustainability dimensions, a set of context-specific sub-criteria was identified through a structured literature review and adapted to the urban and heritage specificities of the Casbah of Algiers to capture operational and observable variables (Table I; Fig.3). This step ensured that the assessment grid reflects both technical attributes and the broader sustainability requirements associated with inhabited historic urban fabrics (Labadi et al., 2021).

Expert survey: validation and elicitation of judgments (AHP and ANP)

An expert survey was designed as the core instrument for model calibration (O'Hagan, 2019). The questionnaire was administered to a panel of 10 qualified experts with complementary profiles in economics, sociology, environmental issues, heritage, and administrative management. The experts were selected on the basis of their professional experience, institutional involvement, and familiarity with both the Casbah of Algiers and heritage evaluation issues.

The questionnaire was organised into sections enabling:

- validation of the evaluation support, through the selection and ordinal ranking of pre-identified heritage valorisation devices (tourism route, mosque route, Bastion 23, Citadel), complemented by open-ended justifications;

Table I Sub-criteria, Theoretical Basis and References (Authors, 2026)

Criterion	Sub-criterion	Scientific Justification	Reference
C1 Heritage	Heritage value	Captures historical, architectural and symbolic significance fundamental to heritage evaluation and transmission.	(Jokilehto, 2006)
	Conservation condition	Physical state determines viability for sustained use and long-term preservation.	(Rypkema and Cheong, 2011).
	Authenticity/Integrity	Critical for judging heritage value and consistent with international conservation principles.	(UNESCO, 2011).
	Historical value	Reflects stratification and depth that enhance cultural significance.	(Bandarin and van Oers, 2012).
	Urban permanencies	Invariants like street patterns and focal points underpin spatial coherence.	(Rossi,1982)
	Historical layering	Multiple chronological layers contribute to narrative richness.	(Bandarin and van Oers., 2012)
	Key monumental anchors	Major monuments structure spatial experience and generate positive externalities.	(Rypkema, 2005)
C2 Urban/ Environmental	Urban quality	Defines legibility, accessibility and comfort essential for sustainable routes.	(UN-Habitat., 2020).
	Immediate environment	Local environmental conditions directly affect usability and visitor/inhabitant experience.	(Licciardi and Amirtahmasebi, 2012)
	Life-cycle condition	Addresses vulnerability due to aging fabric and maintenance needs.	(Dalmas et al., 2015)
C3 Social	Local uses and practices	Daily uses preserve vitality and prevent functional stagnation.	(Throsby, 2012)
	Social revitalization and intangible heritage	Living heritage (practices, traditions) underpins cultural continuity.	(UNESCO, 2003) (Djedi and Belakehal, 2022)
C4 Economic	Facilities	Infrastructure supporting use and services contributes to economic activation.	(Rypkema, 2005)
	Functional diversity	Mixed functions enhance resilience and local economic vitality.	{World Bank, 2012)
	Local activities	Local economic activities generate spillovers and enhance sustainability.	(Throsby, 2012)
	Local economic viability	Economic vitality is an indicator of sustainability of heritage uses.	(Licciardi and Amirtahmasebi, 2012)
	Leverage effects	Heritage can catalyze wider economic investment and multipliers.	(Rypkema and Cheong, 2011).
	Heritage marketing	Interpretation and information systems contribute to sustainable engagement.	(Ashworth and Tunbridge, 2000)
C5 Institutional/ Governance	Legal status	Legal recognition ensures protection and defines regulatory frameworks.	(UNESCO, 2011)
	Institutional coordination	Effective coordination is key to implementing multi-actor heritage strategies.	(Labadi et al., 2021)
	Governance regime	Governance shapes decision processes and prioritization capacity.	(Ostrom, 2010)
	Management capacity	Technical and human resources determine operational effectiveness.	(World Bank, 2012)
	Maintenance capacity	Routine maintenance is crucial to avoid deterioration and risk accumulation.	(Jokilehto, 2006)

- content validation of criteria and sub-criteria (relevance checks, additions, deletions, reformulations) to ensure contextual adequacy;
- pairwise comparisons for weighting criteria and sub-criteria, based on Saaty's fundamental scale (1-9, with intermediate values), providing the comparison matrices required for AHP-derived priorities (Saaty, 1990)
- identification of direct influences among dimensions, using a 0-3 intensity scale, to specify the network structure compatible with ANP modelling (Saaty, 2006);
- interpretive reinforcement through open-ended questions, addressing investment priorities, vulnerabilities, bottlenecks, and governance-related messages.

Accordingly, the expert survey functions not merely as a validation step but as a structured elicitation device producing the inputs needed for weighting (AHP), interdependence modelling (ANP), and sustainability-oriented interpretation. The consistency of pairwise comparison matrices was systematically verified using Saaty's Consistency Ratio (CR), and only matrices with CR values below 0.10 were retained. In the final model, six main pairwise comparison matrices were controlled: the 5×5 objective-criteria matrix, the 7×7 patrimonial sub-criteria matrix, the 3×3 environmental sub-criteria matrix, the 2×2 social sub-criteria matrix, the 6×6 economic sub-criteria matrix, and the 5×5 institutional sub-criteria matrix. All non-trivial matrices remained below the conventional threshold of 0.10, with CR values of 0.098 for the objective-criteria matrix, 0.089 for the patrimonial matrix, 0.046 for the environmental matrix, 0.084 for the economic matrix, and 0.069 for the institutional matrix. The social matrix, being a 2×2 comparison, had a CR of 0 by construction. These results confirm that the expert judgments used for priority extraction were sufficiently consistent.

Performance scoring: component-by-component assessment and treatment of missing information (Delphi)

In the second phase, the model was populated through a rating procedure aimed at evaluating the route component by component

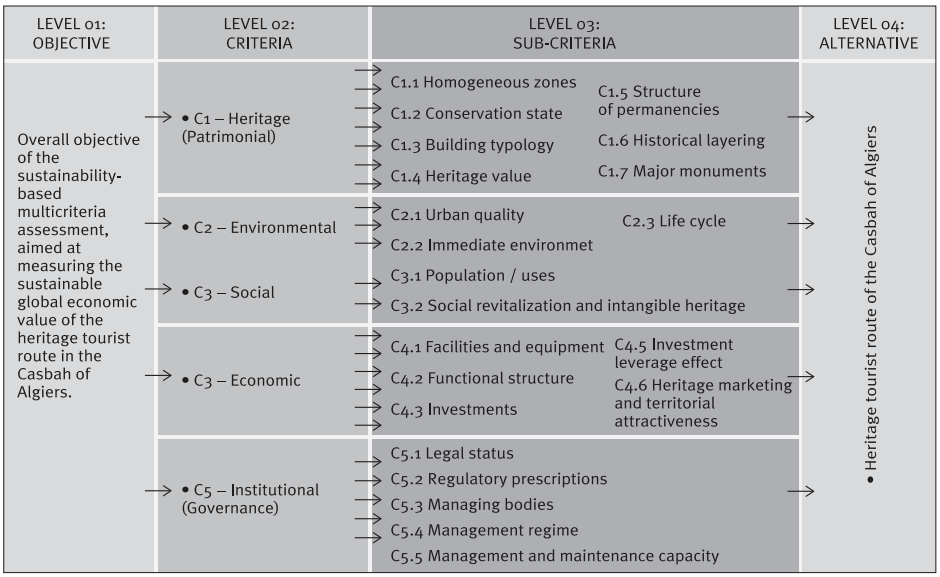


Fig. 3 Multicriteria model and hierarchical structuring of criteria and sub-criteria (Authors, 2026)

through 37 individually assessed components (Fig.4), including monuments, residential segments, public spaces, facilities, and urban sequences, against the selected sub-criteria (Nocca, Bosone and Orabona, 2024; Creative Decisions Foundation, 2024). The scoring process relied on documentary, spatial, field, and institutional sources, and was consolidated whenever relevant sub-criteria could not be documented directly or in a fully quantitative manner.

Rather than excluding such dimensions, which would have artificially narrowed the evaluation scope, a Delphi procedure was used to address information gaps and stabilise score attribution. This Delphi stage involved five experts selected for their direct knowledge of the study area and the evaluation framework. It was conducted in two rounds: the first to propose and justify plausible values for insufficiently documented scoring fields, and the second to promote convergence where disagreement or uncertainty remained. Responses were synthesised using the median, while the interquartile range (IQR) was used to assess the degree of consensus. This step was intended to preserve the integrity of the model by maintaining sub-criteria deemed necessary for the overall evaluation, while ensuring transparency regarding the origin and consolidation of performance data (Beiderbeck et al., 2021; Boulkedid et al., 2011).

Implementation and computation in SuperDecisions: AHP, ANP, and Ratings

The full model was implemented in SuperDecisions (Creative Decisions Foundation, 2024), used as a single computational environment ensuring traceability and reproducibility. Three modules were employed:

– AHP, to derive hierarchical weights for criteria and sub-criteria from pairwise comparisons (Fig.3);

– ANP, to account for interdependencies through the construction of supermatrices (unweighted, weighted, and limit) and the interpretation of stabilised priorities;

Ratings, to transform ordinal performance levels assigned to route components into aggregated priorities.

Within this framework, the route can also be treated as a single global entity when the objective is to produce a decision-oriented synthesis at the system level. Exported outputs (priorities, matrices, and synthesis tables) constitute the basis for the tables and figures presented in the Results section. To ensure reproducibility, the full SuperDecisions outputs, including the unweighted supermatrix, weighted supermatrix, limit matrix, and cluster matrix, are provided as supplementary material.

Outputs and reporting strategy

The reported results rely on: AHP weights (criteria and sub-criteria priorities), ANP stabilised priorities (limit matrix), and Ratings synthesis (global score and contributions). Interpretation focuses on producing a sustainability-oriented reading of the route's overall multi-criteria value, highlighting dominant dimensions, critical vulnerabilities, and decision implications (intervention priorities, governance leverage points, coordination needs, and maintenance capacity).

Results

Delphi consolidation: final values integrated for partially documented sub-criteria

For sub-criteria that could not be documented in a sufficiently discriminant manner through documentary sources and observation alone, a Delphi procedure was applied in order to stabilise ratings through an expert consensus process. In accordance with ordinal data practice, the median was used as the final consolidated score and convergence was monitored through the interquartile range (IQR).

The final values integrated into the scoring table are:

C2.1 = 3; C2.2 = 2; C2.3 = 3; C3.1 = 4; C3.2 = 4; C4.3 = 3; C4.4 = 3; C4.5 = 3; C4.6 = 2; C5.4 = 3; C5.5 = 3.

This consolidation strengthens the completeness and internal coherence of the dataset while maintaining traceability between documented or observed information and consensus-based expert inputs (Table II).

Scoring results (1-5): descriptive performance profile of the route

In parallel with ANP priorities, the rating-based scoring (ordinal scale 1-5) provides a descriptive profile of the route's relative performance across criteria. The aggregation of scores (sub-criteria means and criterion means) results in the following profile:

Overall mean score
(all sub-criteria combined): = 3.17 / 5

Mean scores by criterion:

C1 Heritage: = 3.54 / 5
C2 Environmental/urban: = 2.50 / 5
C3 Social: = 4.00 / 5
C4 Economic: = 2.78 / 5
C5 Institutional: = 3.12 / 5

This distribution indicates a relatively strong performance on the social dimension and intermediate performance on the heritage dimension, while the environmental/urban and economic dimensions appear more constrained. The institutional dimension remains at a medium level, suggesting the presence of actors and frameworks without uniformly strong coordination and operational capacity.

The central result emerges when scores are interpreted jointly with ANP priorities: the most heavily weighted criteria (C1 and C2) are not necessarily those achieving the highest mean scores. This contrast points to a structural gap within the model, as the dimensions driving the global priority system are also those where performance levels remain moderate to limited.

The weighted synthesis combines the descriptive scoring profile with the priorities derived from the ANP model. In this perspective, the overall weighted pathway score reported in Table II (1.7439) should not be interpreted as a monetary value or as an isolated raw output, but as a composite decision-support index resulting from the aggregation of performance levels and multicriteria priorities. More specifically, this value is obtained by summing the weighted contributions of the 23 sub-criteria (ANP global weight X average pathway score). Since the ANP weights used in this table sum to 0.5329 rather than 1.0, the resulting figure should be read as a raw composite index rather than directly as a score on the original 1-5 scale. Given the sum of ANP weights used in this table, the theoretical range of the raw composite score extends from 0.5329 to 2.6643. Expressed as a normalized weighted mean,

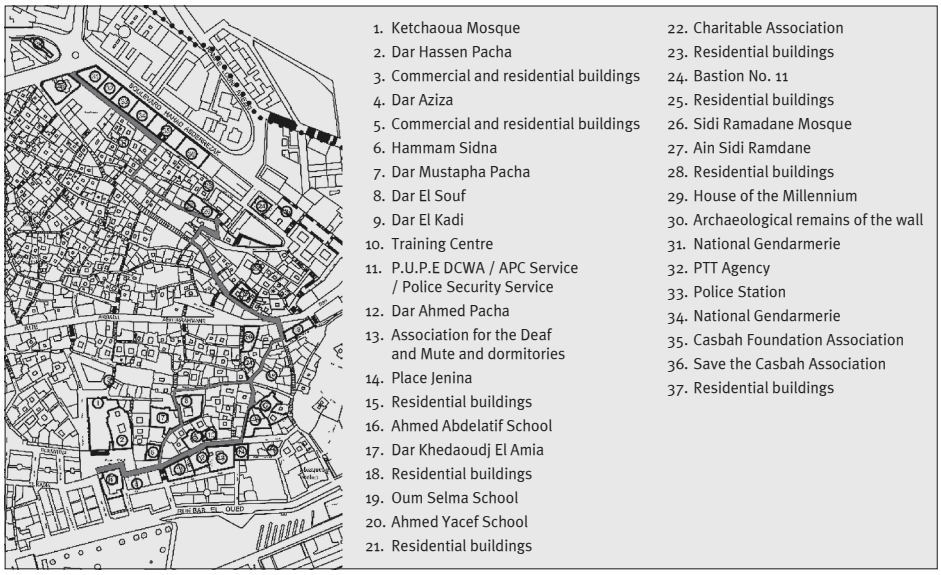
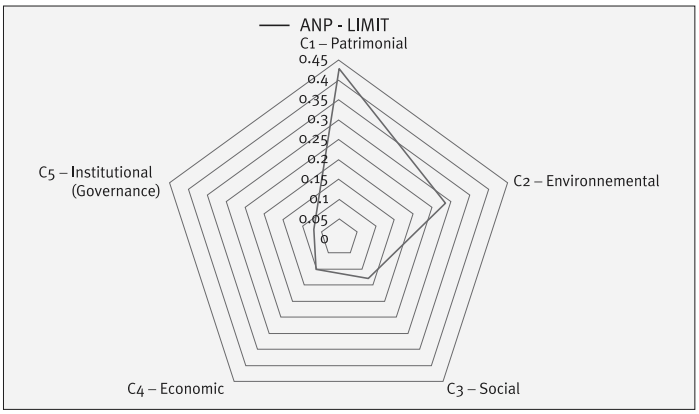


Fig. 4 Location of the evaluated components of the heritage tourism route in the Casbah of Algiers (Authors, 2026)

Table II Implications for the "integral value" reading of the route (model-based synthesis) (Authors, 2026)

Criterion	Code	Sub-criterion	ANP global weight	Average pathway score (1-5)	Weighted contribution (weight×score)
C1	C1.1	Homogeneous zones	0.021592064	4.027027027	0.086951826
C1	C1.2	State of conservation	0.025680168	3.945945946	0.101332553
C1	C1.3	Building typology	0.020215782	3.75	0.075809182
C1	C1.4	Heritage value	0.049399487	3.555555556	0.175642619
C1	C1.5	Structure of permanencies	0.027088187	2.833333333	0.076749864
C1	C1.6	Historical layering	0.027209132	3.649	0.099286122
C1	C1.7	Major monuments	0.043255752	3.135135135	0.135612627
C2	C2.1	Urban quality	0.069847423	3	0.209542268
C2	C2.2	Immediate environment	0.044001161	2	0.088002322
C2	C2.3	Life-cycle performance	0.027718917	3	0.08315675
C3	C3.1	Population / uses	0.015636	4	0.062544
C3	C3.2	Social revitalization and intangible heritage	0.046908	4	0.187632
C4	C4.1	Facilities / amenities	0.003264344	3.411764706	0.011137175
C4	C4.2	Functional structure	0.003264344	2.285714286	0.007461359
C4	C4.3	Investments	0.005930888	3	0.017792664
C4	C4.4	Local economic vitality	0.012250983	3	0.036752949
C4	C4.5	Investment leverage effect	0.021879628	3	0.065638885
C4	C4.6	Heritage marketing and territorial attractiveness	0.001987715	2	0.003975429
C5	C5.1	Legal status	0.032190482	3.5	0.112666687
C5	C5.2	Regulatory prescriptions	0.017383758	3.540540541	0.061547901
C5	C5.3	Managing bodies	0.008306254	2.540540541	0.021102375
C5	C5.4	Management regime	0.004959547	3	0.014878642
C5	C5.5	Management/maintenance capacity	0.002898958	3	0.008696875
Overall weighted pathway score (Σ weight×score)					1.743913074



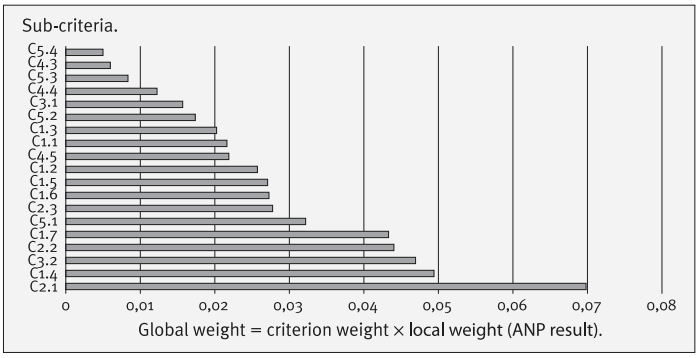


Fig. 5 Structure of global priorities (macro-level weighting of criteria) (Authors, 2026)

Fig. 6 Identification of structuring levers of sub-criteria (Authors, 2026)

this result corresponds to approximately 3.27/5, indicating an overall intermediate level of systemic performance. In this sense, the score of 1.7439 expresses not a low patrimonial significance of the route, but a moderate overall performance once the structural priorities of the model are considered. This result should therefore be interpreted as a relative performance indicator within the model, rather than as an absolute or standalone measure.

ANP outputs: macro-level weighting of criteria (C1-C5)

The ANP computation performed in SuperDecisions (weighted supermatrix and limit matrix) provides a clear structure of global priorities aligned with the objective of a multicriteria assessment of the heritage tourism route of the Casbah of Algiers. The final limit priorities highlight the predominance of the heritage dimension C1 (0.4289) and the environmental/urban dimension C2 (0.2831). Social, economic and institutional dimensions occupy secondary but non-marginal positions, with C3 (0.1251), C4 (0.0972) and C5 (0.0657), respectively (Fig. 5).

This hierarchy indicates that the overall performance of the route is primarily driven by heritage-related attributes (value, integrity and conservation) and by urban/environmental conditions, whereas social, economic and governance-related dimensions act as enabling layers within a constrained and inhabited heritage system.

Global contribution of sub-criteria: identification of structuring levers

The analysis of global sub-criterion weights derived from the ANP structure shows that influence is not evenly distributed across variables. Instead, the model focuses on a reduced set of dominant levers structuring the multi-criteria value of the route.

The most influential sub-criteria are:

C2.1 Urban quality (0.06985), ranked as the primary determinant of the system.

C1.4 Heritage value (0.04940), confirming the role of intrinsic historical/architectural significance as the central foundation of the route's overall value.

C3.2 Social revitalisation and intangible heritage (0.04691), highlighting the contribution of "living heritage" dynamics to the system's value.

C2.2 Immediate environment (0.04400) and C1.7 Major monuments (0.04326), both functioning as structuring factors for coherence and attractiveness.

C5.1 Legal status (0.03219), reflecting the relevance of legal/security conditions as a prerequisite for effective protection.

A second core group of influential variables relates to temporal depth, integrity and conservation performance, including: C2.3 Life cycle (0.02772), C1.6 Historical layering (0.02721), C1.5 Structure of permanencies (0.02709) and C1.2 State of conservation (0.02568).

Conversely, sub-criteria linked to tourism equipment and micro-economic structuring receive substantially lower weights within the ANP outputs, particularly C4.6 Heritage marketing (0.00199), and at a low level C4.1 Facilities (0.00326) and C4.2 Functional structure (0.00326). In the context of this model, these variables therefore appear as less determinant than the heritage-urban-social core variables shaping the global value of the route (Fig. 6).

Systemic interpretation: contribution of interdependencies to the final priorities

A key contribution of the ANP approach is to incorporate interdependencies rather than relying on a strictly hierarchical decision structure. The supermatrix outputs and their synthetic readings indicate that governance-related performance (C5) remains strongly conditioned by the other dimensions. Institu-

tional capacity is influenced by social pressures (C3), urban/environmental constraints (C2), and heritage protection and conservation requirements (C1).

This configuration is consistent with the functioning of an inhabited historic urban fabric, whereby governance acts primarily as a coordination and arbitration mechanism within multiple constraints. Within this systemic interpretation, the multi-criteria value of the route results from the interaction of: heritage capital as a reference base (C1), urban/environmental quality as an enabling condition (C2), social continuity and appropriation (C3), partial economic translation into benefits (C4), and institutional effectiveness and long-term stabilisation (C5) (Table III).

Table III Criteria interdependencies (weighted supermatrix synthesis) (Authors, 2026)

	C1 – Patrimonial	**C2 – Environmental**	**C3 – Social**	**C4 – Economic**	**C5 – Institutional / governance**
C1 – Patrimonial		0.083333		0.16374	
C2 – Environmental	0.040481				
C3 – Social				0.129961	
C4 – Economic	0.094197		0.0625		
C5 – Institutional	0.365322	0.416667	0.4375	0.206299	

Overall, the results converge toward a consistent interpretation: the multi-criteria economic value of the route is not governed by a single register (e.g., tourism attractiveness), but by the system's capacity to preserve an equilibrium between:

– a strongly significant heritage capital (C1 as dominant criterion),
– urban and environmental conditions that act as a primary lever (C2.1 and C2.2 among the most influential sub-criteria, while the mean score of C2 remains comparatively low),
– a relatively robust living and social base (C3, strongly scored and non-marginally weighted),
– economic and marketing variables that remain weakly weighted within the ANP structure, and
– institutional capacity required to stabilise long-term trajectories (C5).

In this configuration, the model provides a quantified basis for understanding how the global value of the heritage route emerges from combined heritage, urban and social determinants, with economic and institutional dimensions functioning as enabling conditions within the system.

Discussion

Interpreting the ANP structure under a strong sustainability perspective

The ANP results confirm that the multi-criteria economic assessment of the heritage tourism route in the Casbah of Algiers cannot be interpreted as a simple aggregation of monetary performance or tourism attractiveness indicators. The criterion priorities-dominated by the heritage dimension C1 (0.4289) and the environmental/urban dimension C2 (0.2831)-are fully consistent with a strong sustainability stance, in which the overall value depends primarily on the long-term integrity of heritage capital (material and symbolic) and on the urban-environmental conditions that enable conservation, appropriation, and use without irreversible degradation. In this configuration, the route is not treated as a tourism "product", but as a living heritage system in which economic outcomes appear as contingent effects rather than autonomous determinants. This reading is particularly relevant for dense Mediterranean historic centres, where fragility of the built fabric, urban carrying constraints, social vulnerability, and institutional complexity strongly shape the sustainability of valorisation strategies.

Urban quality (C2.1) as the primary leverage mechanism

A central outcome of the sub-criteria ranking is the dominance of C2.1 Urban quality (0.06985) as the most influential variable in global weight. This highlights a structural mechanism typical of historic urban fabrics: intrinsic heritage significance alone is not sufficient to generate territorial benefits if the urban environment does not allow for effective "heritage experience" through legible, continuous, safe and comfortable movement. In route-based valorisation, urban quality operates as a conversion mechanism between heritage assets and visitor experience-and therefore between cultural potential and practical operability. The Casbah simultaneously concentrates exceptional heritage density and significant urban constraints; thus, the model logically assigns high influence on the urban dimension. Importantly, this confirms the analytical value of separating what pertains to the heritage object (heritage components) from what pertains to the surrounding medium (urban conditions) when operationalising a sustainability-based multi-criteria framework.

Structuring heritage coherence: value and anchors within the route

Within the heritage criterion, C1.4 Heritage value (0.04940) and C1.7 Major monuments (0.04326) belong to the most determinant sub-criteria, confirming that the overall route

experience depends on internal hierarchies and strong "anchors" capable of structuring attention and strengthening the overall image and coherence of the system. In the Casbah, major monuments function as strategic poles that can generate positive spillovers across surrounding sequences; however, such spillovers remain conditional on the sustainability of connecting urban segments, directly reinforcing the previous finding on the pivotal role of C2.1.

Additionally, the non-negligible influence of C1.6 Historical layering (0.02721) and C1.5 Structure of permanencies (0.02709) shows that the route's value is strongly tied to narrative readability and temporal depth. This indicates that evaluation is not reducible to the physical state of components alone but is also dependent on the intelligibility of heritage stratification and urban continuity, consistent with the Casbah being interpreted as a palimpsest system rather than a collection of isolated assets.

Social performance and the role of living heritage

The high global weight of C3.2 Social revitalisation and intangible heritage (0.04691), combined with favourable social mean scores (= 4/5), underlines a core characteristic of the Casbah: its value is strongly linked to practices, everyday uses, social relations, knowledge, and forms of inhabiting, in addition to built heritage components. This dimension supports the model in two complementary ways. First, it constitutes a resilience factor, as appropriation and active use can reduce vacancy and accelerate neither physical nor functional decline. Second, it reflects a key set of non-market values that remain central in an expanded economic assessment of heritage, particularly for existence- and transmission-related value components. Nevertheless, the interpretation of this result requires caution: in historic centres potentially exposed to tourism pressure, valorisation may generate substitution effects (changes in uses, conflicts, commodification pressures) that can weaken social sustainability. Therefore, the route must remain interpretable as a means compatible with everyday inhabiting, rather than a strictly tourist staging of space.

Economic dimension: low weights as a structural positioning, not irrelevance

The economic criterion C4 (0.0972) is weighted lower than heritage and urban/environmental dimensions, and some economic subcriteria appear particularly weak in global weight, notably C4.6 Heritage marketing (0.00199), as well as C4.1 Facilities (0.00326) and C4.2 Functional structure (0.00326). This outcome should be interpreted with precision: it does not imply that these variables are useless, but rather that within the model's systemic logic and expert-informed interdependencies, they are positioned as amplifiers rather than core determinants of value.

In the context of the Casbah, this finding is consistent with the idea that tourism equipment or marketing, if disconnected from urban constraints and conservation requirements, may increase pressure without improving sustainability. The ANP structure therefore remains coherent with a strong sustainability perspective: economic dynamics are placed in service of a fragile heritage system rather than treated as the overriding driver of value.

Institutional dimension as a condition of effectiveness

The institutional criterion C5 (0.0657) is the lowest among macro-level priorities, yet relevant governance variables remain significant within the system, particularly C5.1 Legal status (0.03219), alongside the management regime and maintenance capacity elements consolidated through Delphi. These results suggest that governance functions primarily as a condition of activation: without legal security, clear responsibility allocation and minimum coordination capacity, conservation and valorisation remain unstable. The relatively lower weight of C5 may also reflect a contextual effect typical of complex governance environments, in which institutional dimensions operate more as structural constraints than as fully controllable variables in the short term. Consequently, governance enters the model not as an autonomous generator of value, but as a necessary layer ensuring continuity, feasibility, and long-term effectiveness.

Methodological robustness and limitations

The combined design (AHP structuring, ANP network modelling, ordinal scoring 1-5, and Delphi consolidation) presents several methodological strengths. First, it ensures traceability by connecting documentary and observational inputs to explicit scoring procedures, rather than relying on implicit assumptions. Second, ANP integration of interdependencies is particularly appropriate for historic urban systems, where heritage, social dynamics, urban conditions and governance interact through feedback mechanisms. Third, the Delphi procedure reinforces dataset completeness without masking uncertainty, and the

use of median (and IQR monitoring) is compatible with ordinal-scale logic.

At the same time, two limitations remain structurally inherent to the approach. The 1-5 scoring scale improves comparability but may reduce nuance; this effect is mitigated by transparent reporting and cross-reading with ANP weights. Data availability remains heterogeneous across sub-criteria; the Delphi step addresses this constraint but requires maintaining a clear distinction between documented and consensus-derived values.

Implications derived from the model's internal logic

The ANP-based results indicate that maximising the route's overall multi-criteria value under a strong sustainability perspective requires a sequenced strategy that treats the heritage route as a coherent urban-heritage system rather than a set of isolated assets. Priority should be given to upgrading urban quality and continuity, as these conditions are the main "conversion" mechanism through which intrinsic heritage significance becomes usable, socially appropriable, and economically productive. In parallel, conservation efforts should be targeted according to heritage value and structuring anchors, while safeguarding living heritage and everyday appropriation as a core determinant of resilience. Economic activation (services, interpretation, and communication) should remain incremental and proportionate, designed to amplify benefits without overloading a fragile fabric. Finally, governance should focus on operational capacity-clear responsibilities, legal security, and maintenance routines-so that interventions remain effective and durable over time (Fig.7).

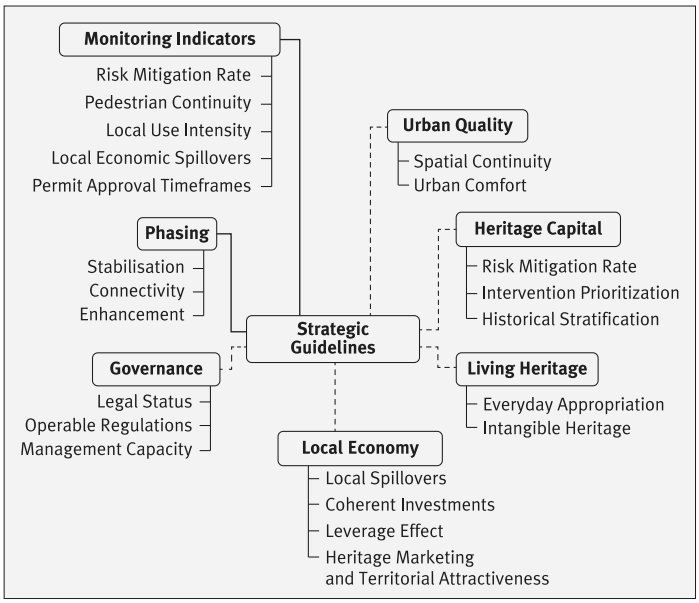


Fig. 7 Strategic Guidelines for the Sustainable Enhancement of the Casbah of Algiers' Heritage Tourism Route (Authors, 2026)

Conclusion

This study developed and implemented a sustainability-based multicriteria economic evaluation applied to the heritage tourism route of the Casbah of Algiers, considered as an integrated urban heritage system rather than a mere sequence of monuments. By adopting a strong sustainability perspective, the framework prioritizes the long-term integrity of heritage capital and the urban conditions that enable tourism use without irreversible degradation.

Methodologically, the model combined AHP and ANP to structure priorities across five dimensions-heritage, environmental, social, economic, and institutional-while a 1-5 rating scale ensured consistent assessment across route components. Where documentary and observational information was insufficient, a two-round Delphi procedure was used to stabilize ordinal scores using medians and interquartile ranges, ensuring transparency and completeness.

The ANP results highlight the predominance of heritage and environmental dimensions, confirming that overall value is primarily driven by conservation-related attributes and by the quality of the urban setting that supports access, legibility, and safe appropriation. Social dynamics also emerge as a major asset, reinforcing the importance of living heritage in sustaining the route. Economic and institutional dimensions, although less dominant, remain crucial as enabling conditions for converting heritage value into territorial benefits.

Beyond its empirical application, this study contributes by developing a fully operational and reproducible evaluation protocol for urban heritage. Its contribution is therefore not limited to a case-specific application: it demonstrates how a sustainability-based multicriteria framework can be implemented in practice through the articulation of weighting, interdependencies, scoring, and expert-based consolidation within a single coherent decision-support structure. In this sense, the study provides a methodological bridge between conceptual heritage valuation and operational urban heritage management.

Limitations relate to the simplified resolution of the 1-5 scale and the unequal availability of fine-grained data. Future work may integrate more detailed quantitative indicators where feasible. Overall, the proposed framework provides a transferable decision-support tool to prioritize interventions for sustainable heritage route management in complex historical urban contexts.

Bibliography

1. Alaouchiche, A., Necissa, Y., Behiri, A., Monjo-Carrió, J. and Ramírez-Pacheco, G. (2025) 'Economic valuation of urban heritage: modelling an integrative framework based on sustainability principles', *Prostor: A Scholarly Journal of Architecture and Urban Planning*, 33(2(70)), pp. 248-259. https://doi.org/10.31522/p.33.2(70).6
2. Ashworth, G.J. and Tunbridge, J.E. (2000) *The Tourist-Historic City: Retrospect and Prospect of Managing the Heritage City*. Routledge. https://books.google.com/books/about/The_Tourist_Historic_City.html?id=1VupAgAAQBAJ
3. Bandarin, F. and van Oers, R. (2012) *The Historic Urban Landscape: Managing Heritage in an Urban Century*. Wiley-Blackwell. https://doi.org/10.1002/9781119968115
4. Barbier, E.B. (1987) 'The concept of sustainable economic development', *Environmental Conservation*, 14(2), pp. 101-110. https://doi.org/10.1017/S0376892900011449
5. Basílio, J., Ferreira, F.A.F., Carayannis, E.G. and Ferreira, J.J.M. (2022) 'A systematic review of the applications of multi-criteria decision aid methods (1977-2022)', *Electronics*, 11(11), 1720. https://doi.org/10.3390/electronics11111720
6. Beiderbeck, D, Frevel, N, von der Gracht, H.A., Schmidt, S.L. and Schweitzer, V.M. (2021) 'Preparing, conducting, and analyzing Delphi surveys: Cross-disciplinary practices, new directions, and advancements', *MethodsX*, 8, 101401. https://doi.org/10.1016/j.mex.2021.101401
7. Biermann, F., Kanie, N. and Kim, R.E. (2017) 'Global governance by goal-setting: the novel approach of the UN Sustainable Development Goals', *Current Opinion in Environmental Sustainability*, 26-27, pp. 26-31. https://doi.org/10.1016/j.cosust.2017.01.010
8. Boukratem, O. and Djelal, N. (2021) 'Assessment process in the delimitation of historic urban landscape of Algiers by AHP', *Miscellanea Geographica*, 25(1), pp. 1-11. https://doi.org/10.2478/mgrsd-2020-0053
9. Boulkedid, R., Abdoul, H., Loustau, M., Sibony, O. and Alberti, C. (2011) 'Using and reporting the Delphi method for selecting healthcare quality indicators: a systematic review', *PLOS ONE*, 6(6), e20476. https://doi.org/10.1371/journal.pone.0020476
10. Creative Decisions Foundation (2024) *SuperDecisions software (version gratuite)*. Creative Decisions Foundation. https://www.superdecisions.com/
11. Dalmas, L., Geronimi, V., Noël, J.-F. and Tsang King Sang, J. (2014) 'L'évaluation économique du patrimoine urbain et ses enjeux : une approche par la soutenabilité', *Revue d'Économie Régionale and Urbaine*, 5, pp. 843-863. https://doi.org/10.3917/reru.145.0843
12. Dalmas, L., Geronimi, V., Noël, J.-F. and Tsang King Sang, J. (2015) 'Economic evaluation of urban heritage: An inclusive approach under a sustainability perspective', *Journal of Cultural Heritage*, 16(5), pp. 681-687. https://doi.org/10.1016/j.culher.2015.01.009
13. Della Spina, L. (2020) 'Adaptive Sustainable Reuse for Cultural Heritage: A Multiple Criteria Decision Aiding Approach Supporting Urban Development Processes', *Sustainability*, 12(4), article 1363. https://doi.org/10.3390/su12041363
14. Djedi, H. and Belakehal, A. (2022) 'Les ambiances patrimoniales à l'épreuve de l'appropriation : cas de la Casbah d'Alger', *Bulletin de la Société Géographique de Liege*, 79(2022/2). https://doi.org/10.25518/0770-7576.7009
15. Ferretti, V. and Comino, E. (2015) 'An integrated framework to assess complex cultural and natural heritage systems with Multi-Attribute Value Theory', *Journal of Cultural Heritage*, 16(5), pp. 688-697. https://doi.org/10.1016/j.culher.2015.01.007
16. Labadi, S., Giliberto, F., Rosetti, I., Shetabi, L. and Yildirim, E. (2021) *Heritage and the Sustainable Development Goals: Policy Guidance for Heritage and Development Actors*. International Council on Monuments and Sites (ICOMOS), Paris. https://www.icomos.no/wp-content/uploads/2020/08/ICOMOS_SDGs_Policy_Guidance_2021.pdf
17. Jokilehto, J. (2006) 'Integrity and authenticity in cultural heritage', *City and Time*, 2(1), pp. 1-16. http://www.ct.ceci-br.org/novo/revista/docs2006/CT-2006-44.pdf
18. Kyte, R. (2012) 'Heritage anchors people to their history and culture and builds identity', in Licciardi, G. and Amirtahmasebi, R. (Eds.), *The Economics of Uniqueness: Investing in Historic City Cores and Cultural Heritage Assets for Sustainable Development* (p. xv). Washington, DC: World Bank. https://doi.org/10.1596/978-0-8213-9650-6
19. Licciardi, G. and Amirtahmasebi, R. (2012) *The Economics of Uniqueness: Investing in Historic City Cores and Cultural Heritage Assets for Sustainable Development*. Washington, DC: World Bank. https://doi.org/10.1596/978-0-8213-9650-6
20. Lin, X., Shen, Z., Teng, X. and Mao, Q. (2024) 'Cultural Routes as Cultural Tourism Products for Heritage Conservation and Regional Development: A Systematic Review', *Heritage*, 7(5),

pp. 2399-2425. https://doi.org/10.3390/heritage7050114

21. Ministry of Culture of Algeria (2009) *Permanent Plan for the Safeguarding and Enhancement of the Safeguarded Sector of the Casbah of Algiers (PPSMVSS)*. Algiers: Ministry of Culture.
22. Nocca, F., Bosone, M. and Orabona, M. (2024) 'Multicriteria evaluation framework for industrial heritage adaptive reuse', *Land*, 13(8), 1266. https://doi.org/10.3390/land13081266
23. O'Hagan, A. (2019) 'Expert knowledge elicitation: subjective but scientific', *The American Statistician*, 73(sup1), pp. 69-81. https://doi.org/10.1080/00031305.2018.1518265
24. Ostrom, E. (2010) 'Beyond markets and states: Polycentric governance of complex economic systems', *American Economic Review*, 100(3), pp. 641-672. https://doi.org/10.1257/aer.100.3.641
25. Pujol Galindo, M. D. (2023) *Diseño de un modelo de valoración no monetaria de centros históricos: aplicación al centro histórico de Cartagena*. Tesis doctoral. Universidad Politécnica de Madrid. https://doi.org/10.20868/UPM.thesis.75789
26. Purvis, B., Mao, Y. and Robinson, D. (2019) 'Three pillars of sustainability: in search of conceptual origins', *Sustainability Science*, 14(3), pp. 681-695. https://doi.org/10.1007/s11625-018-0627-5
27. Rossi, A. (1982) *The Architecture of the City*. Cambridge, MA: MIT Press. https://archive.org/details/architectureofcioooorоss
28. Rypkema, D. and Cheong, C. (2011) *Measuring Economic Impacts of Historic Preservation: A Report to the Advisory Council on Historic Preservation*. Washington, DC: PlaceEconomics. https://www.novoco.com/public-media/documents/htc_measuring_economic_impacts_of_historic_preservation_1111.pdf
29. Rypkema, D.D. (2005) *The Economics of Historic Preservation: A Community Leader's Guide*. Washington, DC: National Trust for Historic Preservation. https://www.placeeconomics.com/resources/the-economics-of-historic-preservation-a-community-leaders-guide/
30. Saaty, T.L. (1990) 'How to make a decision: the analytic hierarchy process', *European Journal of Operational Research*, 48(1), pp. 9-26. https://doi.org/10.1016/0377-2217(90)90057-I
31. Saaty, T.L. (2006) 'The Analytic Network Process', in Saaty, T.L. and Vargas, L.G. *Decision Making with the Analytic Network Process: Economic, Political, Social and Technological Applications with Benefits, Opportunities, Costs and Risks*. New York: Springer. https://doi.org/10.1007/0-387-33987-6_1
32. Saaty, T.L. (2016) 'The analytic hierarchy and analytic network processes for the measurement of intangible criteria and for decision-making', in Greco, S., Ehrgott, M. and Figueira, J.R. (eds.) *Multiple Criteria Decision Analysis: State of the Art Surveys*. 2nd edn. New York: Springer, pp. 363-419. https://doi.org/10.1007/978-1-4939-3094-4_10
33. Soini, K. and Dessein, J. (2016) 'Culture-sustainability relation: towards a conceptual framework', *Sustainability*, 8(2), 167. https://doi.org/10.3390/su8020167
34. Talukder, B. and Hipel, K.W. (2021) 'Review and Selection of Multi-criteria Decision Analysis (MCDA) Technique for Sustainability Assessment', in Ren, J. (ed.) *Multi-Criteria Decision Analysis for Sustainability Assessment and Engineering*. Green Energy and Technology. Cham: Springer, pp. 125-144. https://doi.org/10.1007/978-3-030-67529-5_7
35. Throsby, D. (2012) *The Economics of Cultural Policy*. Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9780511845253
36. UNESCO (2003) *Convention for the Safeguarding of the Intangible Cultural Heritage*. Paris: UNESCO. https://ich.unesco.org/en/convention
37. UNESCO (2011) *Recommendation on the Historic Urban Landscape, including a glossary of definitions*. Paris: UNESCO. https://whc.unesco.org/en/hul/
38. UNESCO World Heritage Centre (2023) *Kasbah of Algiers*. https://whc.unesco.org/en/list/565/
39. UN-Habitat (2020) *World Cities Report 2020: The Value of Sustainable Urbanization*. Nairobi: United Nations Human Settlements Programme. https://unhabitat.org/sites/default/files/2020/10/wcr_2020_report.pdf
40. World Bank (2012) *World Development Report 2012: Gender Equality and Development*. Washington, DC: The World Bank. https://doi.org/10.1596/978-0-8213-8810-5
41. Zhang, K., González del Valle-Brena, A., Ramos Riera, I. and Zhao, J. (2024) 'Ancient routes, new gateways: a systematic literature review of China's cultural route heritage', *Journal of Cultural Heritage Management and Sustainable Development*, 14(2), pp. 266-281. https://doi.org/10.1108/JCHMSD-06-2021-0114
42. Zhang, S., Lin, J., Feng, Z., Wu, Y., Zhao, Q., Liu, S., Ren, Y. and Li, H. (2023) 'Construction of cultural heritage evaluation system and personalized cultural tourism path decision model: An international historical and cultural city', *Journal of Urban Management*, 12(2), pp. 96-111. https://doi.org/10.1016/j.jum.2022.10.001

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