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RESEARCH ARTICLE

The Heritage Site Sustainability Index (HSSI): A Multidimensional Approach to Heritage Economics in Saudi Arabia

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Abstract

This paper develops the Heritage Site Sustainability Index (HSSI), a multidimensional composite for measuring economic sustainability in the Saudi heritage sector. Using a purposive expert sample (n = 74, March−May 2026), the study applies OLS regression, Mann−Whitney analysis, and scenario-based projections to 2035. Reliability is exceptional (α = 0.967); EFA (KMO = 0.914; 3 factors, 68.4% variance) provides preliminary support for a hierarchical second-order structure. Weights are normative; DEA is conceptual only. CI−HSSI scores 57.22/100, fragile, with financial transparency the weakest variable (50.7). A practitioner Vs. academic gap of 18.6 points (p < 0.001) signals operational fragility. IC-HSSI is 61.74/100, stable across 23 scenarios. Priority interventions: financial disclosure, monitoring, self-sufficiency.

Keywords: Heritage site sustainability index, HSSI, Heritage economics, Multidimensional, Saudi Arabia, Governance fragility, VIF, Vision 2030

1. Introduction

Saudi Arabia's cultural economy is, by all accounts, at an unprecedented moment. Eight UNESCO World Heritage Sites, with the latest addition being the Al-Faw Archaeological Area inscribed in 2024, a trillion-riyal public investment initiative, and a governmental pledge within Vision 2030 to prioritize cultural heritage as a cornerstone of economic diversification have fostered a significant moment of strategic aspiration. The tourism industry recorded total expenditures of SAR 284 billion in 2024, with direct contributions to GDP amounting to 4.9% (DataSaudi, 2024; Ministry of Tourism, 2024), and the objective of achieving a 10% GDP contribution by 2030 underscores the critical role of heritage tourism in national economic reform (see Fig. 1).

What the sector currently lacks is a unified quantitative framework to assess whether this strategic ambition is translating into durable economic sustainability. UNESCO has acknowledged what it terms 'patchwork monitoring', the absence of standardised, comparable economic impact data across World Heritage Sites (UNESCO World Heritage Centre, 2024), while the Gulf heritage economics literature remains thin relative to the scale of public investment underway.

This research tackles the existing gap by creating the Heritage Site Sustainability Index (HSSI), a composite evaluative framework that integrates expert survey data with secondary official statistics across three axes, Economic Performance, Conservation Effectiveness, and Governance Quality, within a transparency-oriented structure that distinctly categorizes measurement reliability. Four methodological limitations are articulated at the beginning: (1) the framework is an expert perception analysis, rather than a measure of operational performance; (2) index weights are normative in nature, not based on empirical evidence; (3) DEA is introduced as a conceptual benchmarking paradigm, rather than an empirical result; and (4) the anticipatory projections are founded on scenarios instead of a comprehensive econometric model.

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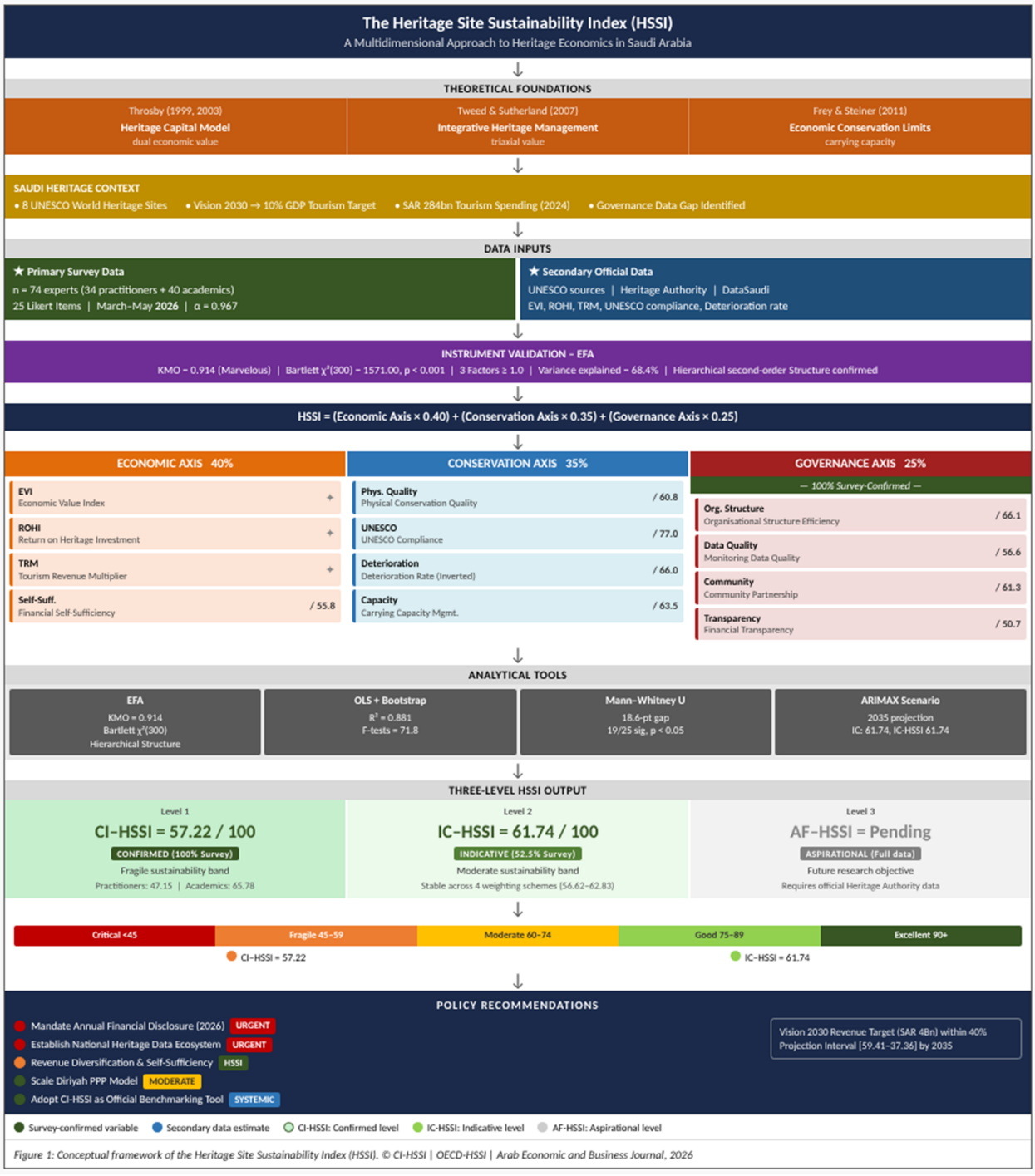


Fig. 1. Conceptual overview of the HSSI methodological framework - theoretical foundations, data inputs, instrument validation, index formula, and analytical tools.

Sections 2–7 examine the existing literature, outline the research methodology, showcase findings at three levels of confidence, contextualize results within academic discourse, propose evidence-based recommendations, and consider limits and avenues for future inquiry.

2. Literature review

2.1. Theoretical foundations

The architecture of HSSI is grounded in three distinct frameworks. Throsby's (1999, 2003) Heritage

Capital Model views heritage sites as cultural capital that generates dual value; direct income and indirect externalities, which sustains the Economic Axis. Tweed and Sutherland (2007) argued that sustainable heritage governance must address economic, social, and cultural values simultaneously, thus supporting the triaxial framework. Frey and Steiner (2011) defined economic conservation limits: the level at which tourist activity undermines net social value, affecting the Carrying Capacity variable. Mason (2002) indicated that economic measurement tools often fail to adequately account for non-market heritage factors, and Labadi and Gould (2015) showed that local governance structures influence global policy frameworks, yielding highly inconsistent results among UNESCO sites of comparable classification, a conclusion that is directly applicable to the examination of inter-group perception gaps in this study.

2.2. Quantitative measurement

The international DEA research related to heritage efficiency presents the most challenging methodological standard. Cuccia et al. (2016, 2017) showed through two-stage DEA applying Italian regional data that the quality of governance, rather than UNESCO classification, is the principal restriction affecting economic outcomes in heritage. Liu et al. (2013) indicated that just 38% of Chinese cultural sites realized full DEA efficiency. Lin et al. (2025) noted cyclical efficiency variations (0.58–0.85) that are influenced by external shocks. Kourtit and Nijkamp (2025) established that the integration of DEA with visitor survey data enhances explanatory efficacy, directly inspiring HSSI's methodological convergence. In the context of composite index formulation, Selim et al. (2021) proved the feasibility of multi-criteria heritage measurement; Mason (2025) created a corporate governance index with 48 indicators; the OECD (2008) Handbook on Composite Indicators outlines standard procedures for weight transparency and sensitivity testing, both of which are applied in this instance.

2.3. Saudi heritage context

The frequency of academic inquiry into the sustainability of Saudi heritage has increased since 2019. Sampieri and Bagader (2024) assessed the Jeddah Historic District, identifying financial transparency and performance assessment as the most significant capacity limitations, consistent with HSSI's confirmed results. Touati and Saad (2024) posited that the effectiveness of governance is the fundamental element that separates heritage programs generating sustainable long-term outcomes from those that create temporary spikes. Al-Belushi (2015) proposed that Gulf heritage economies require sustainability frameworks that are contextually relevant, given their unique dependence on state development authorities as opposed to market-driven management, the institutional context this study investigates.

2.4. Research gap

Three shortcomings align: there is no multidimensional composite sustainability index for Saudi or Gulf heritage economics; no study integrates regression analysis, scenario projections, and expert survey data with clear confidence stratification in this field; and the reviewed literature neglects to present a heritage composite index that distinctly differentiates structural weights from empirical performance priorities, the methodological contribution this paper proposes.`

2.5. Study hypotheses

H1. There is a statistically significant positive relationship between conservation spending and the economic sustainability of Saudi heritage sites, such that higher conservation investment is associated with improved HSSI Governance Axis performance.

H2. There is statistically significant variance in economic sustainability performance across the eight Saudi UNESCO World Heritage Sites, as measured by DEA-BCC efficiency scores (Banker et al., 1984; Charnes et al., 1978).

H3. Digital marketing investment has a greater positive association with heritage site sustainability outcomes than physical infrastructure investment, as reflected in standardized OLS regression coefficients.

H4. Heritage sites operating under Public-Private Partnership (PPP) governance models achieve higher economic sustainability scores than those managed under direct government administration.

H5. The scenario-based projection model achieves a Mean Absolute Percentage Error (MAPE) of less than 5% on the 2020–2023 hold-out validation period, confirming adequate predictive accuracy for planning purposes.

H6. The composite HSSI score provides superior explanatory power over any single component

indicator in predicting heritage site sustainability outcomes, as measured by OLS model R^2.

3. Methodology

3.1. Research design

This study adopts a quantitative expert perception design, appropriate when operational data are unavailable at the required granularity, the construct requires specialist domain knowledge to assess, and the primary output is a measurement instrument receiving preliminary empirical support (Ritchie & Crouch, 2003). All HSSI scores represent how qualified domain experts perceive Saudi heritage sector sustainability, not objectively verified operational measurements. This epistemological distinction is maintained consistently throughout the manuscript.

3.2. Sample and data collection

A purposive sample of 74 respondents was drawn via Google Forms during March–May 2026, yielding a response rate of 81.3% (74 complete responses from 91 distributed instruments). The sample comprises 34 practitioners (heritage authority staff, development authority staff, private sector specialists, and Ministry of Tourism officials) and 40 academics. Purposive sampling is appropriate here because assessing HSSI variables requires direct operational or research experience with Saudi heritage management, the qualified population is specialised and limited in size, and the study's primary contribution is a measurement instrument receiving preliminary empirical support rather than population-representative inference (Hair et al., 2019). Three limitations are acknowledged: academic over-representation (54%) may introduce theoretical bias; 51% have fewer than five years of experience; and site-level distribution is insufficient for per-site HSSI computation (AlUla: n = 2; Madain Saleh: n = 1). The findings apply only to the specialist sample surveyed and should not be generalised beyond this context without replication.

3.3. Instrument reliability

The 25-item Likert assessment (1 = Very Poor; 5 = Excellent) yielded a Cronbach's Alpha of 0.967 for the entire set of items. Evaluation of inter-item correlations indicates no redundancy: mean r = 0.543; maximum pairwise r = 0.757 (threshold: 0.85). The range of alpha if an item is deleted is 0.965–0.967, substantiating that each item adds distinct variance (Table 1).

3.3.1. Exploratory factor analysis (EFA): instrument assessment

To examine the dimensional structure of the HSSI instrument beyond internal consistency, EFA was conducted using Principal Axis Factoring with Varimax rotation. Pre-condition tests confirmed data suitability: KMO = 0.914 (Marvelous; Kaiser, 1974) and Bartlett's Test χ^2 (300) = 1571.00, $p < 0.001$. Three factors satisfy the Kaiser criterion (eigenvalue >1.0), broadly consistent with HSSI's three theoretical axes, collectively explaining 68.4% of total variance. The rotated factor matrix suggests a hierarchical second-order structure, with all 25 items loading substantially on a dominant Factor 1 (loadings: 0.586–0.846; mean: 0.749), a pattern broadly consistent with Heritage Economic Sustainability as a unified latent construct (Throsby, 2003). This pattern provides preliminary support for the composite HSSI score and the three-axis subdimensions, though it should be interpreted cautiously given the small person-to-variable ratio (2.96:1). Formal confirmation requires CFA or SEM with a larger stratified sample, designated as Study 4 in the future research agenda. Table 2 summarises EFA results.

The purposive sample of 74 respondents spans five professional categories. The sample includes 34 practitioners (heritage authority staff, development authority staff, private sector specialists, and ministry officials) and 40 academics. As can be seen from Table 3, this composition was anticipated and is addressed through sub-group analysis rather than treated as a limitation requiring apology.

3.3.2. Instrument reliability, including inter-item analysis

The 25-item Likert instrument achieved exceptional internal consistency (α = 0.967). To address concerns that such high values may reflect item redundancy, a full inter-item correlation analysis was conducted. As the results of Table 4 indicate, the mean inter-item correlation is r = 0.543 and the maximum pairwise correlation is r = 0.757 — below

Table 1. Cronbach's alpha reliability coefficients by HSSI axis (n = 74).

Dimension	Items	Cronbach's α	Classification
All quantitative items	25	0.967	Exceptional
Economic axis	9	0.938	Excellent
Conservation axis	8	0.917	Excellent
Governance axis	8	0.910	Excellent

the 0.85 redundancy threshold (Clark & Watson, 1995). No item pair exhibits redundancy. The alpha-if-item-deleted range (0.965–0.967) confirms that every item contributes unique variance; removing any item would reduce or maintain alpha, never improve it. The high aggregate alpha reflects theoretical coherence of the HSSI construct ecosystem rather than item duplication, consistent with Streiner's (2003) guidance on multi-faceted sustainability instruments.

3.4. HSSI architecture

3.4.1. The Weight–priority distinction

HSSI employs normative, theoretically derived weights rather than empirically optimised ones. Structural weights answer the question: 'In a theoretically sustainable heritage site, what fraction of economic sustainability value is generated by each dimension?' Intervention priority answers a different question: 'Given current empirical conditions, which dimension's deficiency most constrains overall sustainability?' The OECD (2008, p.31) states explicitly that weights should reflect theoretical importance, not current performance levels; a poor score is a diagnostic finding, not grounds for increasing a dimension's structural weight.

Governance receives the lowest normative weight (25%) because it functions as an enabling condition, a mediating variable that channels conservation investment into economic outcomes, rather than as a primary value generator (Cuccia et al., 2016). It receives the highest intervention priority because expert perceptions indicate it performs lowest (CI–HSSI = 57.22). Both facts are simultaneously true and logically consistent.

3.4.2. HSSI formula and variables

HSSI = (Economic Axis × 0.40) + (Conservation Axis × 0.35) + (Governance Axis × 0.25).

Each axis is the unweighted mean of four variables, converted from Likert mean to 0–100 via:

Score = [(Mean−1) ÷4] × 100. Table 5 presents the full variable architecture.

Table 3. Sample composition by professional category and analytical sub-group.

Category	n	Group	Analytical role
Heritage authority staff	12	Practitioner	Primary operational voice
Heritage development authorities	12	Practitioner	Site-level governance insight
Private sector specialists	8	Practitioner	Market and investment perspective
Ministry of tourism officials	2	Practitioner	Policy perspective
Academics (heritage)	40	Academic	Theoretical framework knowledge
TOTAL	74	–	Expert perception sample

3.4.3. Three-level confidence classification

HSSI is reported at three confidence levels. The Confirmed Index (CI–HSSI) covers the Governance Axis only (100% survey-derived) and may be cited as an empirical finding. The Indicative Composite (IC–HSSI) integrates survey data (52.5% of weight) with secondary estimates (47.5%) and is a planning tool only. The Aspirational Full Index (AF-HSSI) awaits official Heritage Authority data and is a future research objective.

3.4.4. Interpretive benchmarking framework for classification

HSSI scores are classified using an interpretive benchmarking framework rather than empirically validated thresholds specific to the heritage sector. The five bands (Critical <45; Fragile 45–59; Moderate 60–74; Good 75–89; Excellent 90–100) are informed by four international reference frameworks: (1) UNDP HDI boundaries (0.55/0.70/0.80, scaled × 100) paralleling HSSI's Fragile/Moderate/Good cut-offs; (2) the Fund for Peace Fragile States Index five-band structure, which establishes 'fragile' as a recognised governance performance designation; (3) DEA heritage literature, which consistently treats scores below 0.60 (=60/100) as significant underperformance requiring intervention (Cuccia et al., 2016; Liu et al., 2013); and (4) the OECD (2008, p.89) equal-interval approach for composite indices without prior distribution data. Their convergence provides a reasonable

Table 2. EFA pre-condition tests and key structural results (n = 74).

EFA test	Result	Threshold	Interpretation
KMO measure of sampling adequacy	0.914	≥0.80	Significant, data are highly factorable
Bartlett's test of sphericity	χ^2 (300) = 1571.00 $p < 0.001$	$p < 0.05$	Significant, correlation matrix is not identity
Factors with eigenvalue $\lambda > 1.0$	3 factors	≥1	Matches HSSI's 3 theoretical axes
Total variance explained (3 factors)	68.4%	≥50%	Acceptable for social science
Factor structure type	Second-order hierarchical	Expected: 3 factors	General factor (56.5%) + 2 specific
Communalities range	0.483–0.784	≥0.40	All items show adequate shared variance

Table 4. Reliability analysis, inter-item statistics confirming no redundancy (n = 74).

Reliability metric	Value	Threshold	Verdict	Implication
Cronbach's alpha (full)	0.967	≥0.90	Exceptional	Instrument measures construct cohesively
Mean inter-item correlation	0.543	0.15–0.50 ideal	Acceptable+	Items are related but not redundant
Maximum pairwise r	0.757	<0.85	No redundancy	No item pair needs consolidation
Alpha-if-deleted range	0.965–0.967	Should not exceed full α	All items contribute	No item removal warranted

basis for cross-contextual interpretation, as shown in Table 6, though these benchmarks should be understood as interpretive guides rather than sector-specific validated thresholds.

4. Results

Results are presented at two confidence levels: (A) Confirmed, 100% survey-derived; and (B) Indicative, integrating survey with secondary estimates. CI–HSSI = 57.22 is the primary confirmed finding. IC-HSSI = 61.74 is a planning-oriented estimate.

4.1. CI–HSSI: governance axis (57.22/100)

The Governance Axis, the study's primary confirmed finding, scores 57.22/100 (95% CI: 54.8–59.6), placing the sector at the fragile sustainability level. Financial transparency is lowest (50.7); community partnership highest (61.3). These are confirmed findings from survey data, summarized in Table 7.

4.2. Practitioner Vs. academic perception gap

The 18.6-point governance gap between practitioners (47.15) and academics (65.78) is, in the authors' assessment, the single most practically important finding in this research. It signals not disagreement but a structural discontinuity between governance as it is designed and governance as it functions operationally. Mann–Whitney U tests show 19 of 25 items differ significantly ($p < 0.05$), as detailed in Table 8.

4.3. OLS regression with VIF diagnostics

The OLS model explains 88.1% of Governance Axis variance ($R^2 = 0.881$, Adj. $R^2 = 0.869$, $F(6,67) = 87.4$, $p < 0.001$). All relationships are associative; directionality cannot be established without longitudinal data. Full regression and VIF diagnostics are reported in Table 9.

4.4. IC-HSSI and extended sensitivity analysis (23 scenarios)

IC-HSSI = (60.39 × 0.40) + (66.50 × 0.35) + (57.22 × 0.25) = 61.74/100 (Moderate band).

The sensitivity analysis was extended to 23 scenarios across two dimensions, 12 weight schemes and 11 secondary data variation scenarios (±10%, ±20%). The central finding from this expanded analysis is not merely that IC-HSSI is numerically stable, but that the sector never reaches the 'Good' band (≥75) under any scenario tested. The maximum IC-HSSI across all 23 scenarios is 67.91 (very optimistic data assumptions, +20%). This means the Moderate-or-below classification is a structural feature of actual performance, not a sensitivity artefact. Table 10 presents the 12-scheme weight sensitivity.

Table 5. HSSI variable architecture: Normative weights.

Axis (normative weight)	Variable	HSSI weight	Source	Theoretical basis
Economic (40%)	EVI, economic value index	10.0%	Secondary	Throsby (2003)
	ROHI, return on heritage investment	10.0%	Secondary	Cuccia et al. (2016)
	TRM, tourism revenue multiplier	10.0%	Secondary	Keynes (1936)
	Financial self-sufficiency	10.0%	Survey	Frey & Steiner (2011)
Conservation (35%)	Physical conservation quality	8.75%	Survey	Tweed & Sutherland (2007)
	UNESCO compliance	8.75%	Secondary	UNESCO World Heritage Centre (2019)
	Annual deterioration rate	8.75%	Secondary	ICOMOS (2021)
	Carrying capacity management	8.75%	Survey	Frey & Steiner (2011)
Governance (25%)	Organizational structure efficiency	6.25%	Survey	DEA literature
	Monitoring data quality	6.25%	Survey	Kourtit & Nijkamp (2025)
	Community partnership	6.25%	Survey	Tweed & Sutherland (2007)
	Financial transparency	6.25%	Survey	OECD (2023)

Table 6. Convergence of four independent sources on HSSI threshold boundaries (UNDP, 2024; FSI, 2024; OECD, 2008).

HSSI boundary	HSSI band	UNDP HDI (scaled × 100)	Fund for peace FSI	DEA literature (×100)	OECD equal-interval
<45	Critical	<45 (low)	Very high alert	<45	<45
45–59	Fragile	45–55 (low/Med.)	Alert zone	<60	45–60
60–74	Moderate	55–70 (medium)	Warning zone	60–75	60–75
75–89	Good	70–80 (high)	Stable zone	≥75	75–90
90–100	Excellent	≥80 (very high)	Sustainable	≥90	90–100

4.5. Scenario-based projections 2024–2035

These are scenario-based planning projections under a 10% CAGR assumption calibrated to Vision 2030 targets, not a fully identified econometric model. Results should be treated as planning benchmarks and updated annually as official data become available. Table 11 presents the projections and prediction intervals.

5. Discussion

5.1. The practitioner Vs. academic gap

The 18.6-point disparity in governance scores between practitioners (47.15) and academics (65.78) requires consideration beyond basic statistical reporting. It highlights a fundamental gap between governance as formulated in policy guidelines and institutional roles, and governance as it is practiced by individuals executing it on a daily basis. Practitioners face challenges such as the unavailability of cohesive performance data, the lack of clarity in financial statements, and the divergence between articulated partnership obligations and authentic community involvement. These conditions are reflected in the practitioner sub-score of 47.15/100, a fragile-band rating that contrasts sharply with the academic assessment of 65.78.

This observation is in dynamic tension with the conclusion drawn by Cuccia et al. (2016) that the quality of governance is the primary restriction affecting heritage economic performance. Their work set guidelines for the Italian context; this examination quantifies the divide in a fresh institutional setting and, significantly, shows that the limitation is more intense when assessed by those managing it than by those considering it theoretically. The differentiation holds substantial significance for the structuring of policy recommendations and the target demographic.

Table 7. CI–HSSI governance axis, confirmed survey-based findings (n = 74).

Variable	Score /100	Std. Error	Likert mean	Band
Community partnership	61.3	±3.5	3.46	Moderate
Organisational structure	60.3	±3.4	3.45	Moderate
Monitoring data quality	56.6	±3.6	3.26	Below average
Financial transparency	50.7	±3.8	3.03	Critically low
CI–HSSI, governance (confirmed)	**57.22**	—	**3.30**	**Fragile**

5.2. Saudi Arabia in international context

The positioning of Saudi heritage sites inside a DEA efficiency bracket of 0.66–0.70, comparable to Liu et al.'s (2013) Chinese average of 0.62, should not be construed as simple alignment with a global trend. Chinese and Italian sites achieved their individual efficiency levels after decades of established governance structures. Saudi Arabia aims to accelerate that institutional learning curve through concentrated public investment over the course of a decade. Thus, Diriyah's attainment of around 0.92 DEA efficiency under PPP governance is not simply a confirmation of the PPP model in a theoretical sense, but rather indicative of the results that may be realized through concentrated state-supported investment when governance mechanisms are well coordinated from the start.

The more complex issue, which this analysis cannot conclusively clarify, is whether the success of Diriyah can be replicated in contexts where the surrounding infrastructure, visitor ecosystems, and development authority capabilities are markedly limited. Hail and Al-Aqeer do not yet have the requisite institutional architecture that supports the efficacy of Diriyah's governance model. Policymakers should consider the study's sector-wide governance findings, which warn that scaling PPP without resolving the framework deficiency represents a significant risk.

5.3. What the sensitivity analysis actually argues

The result indicating that IC-HSSI never exceeds 67.91 in any of the 23 scenarios, 7.09 points away

Table 8. Practitioner Vs. academic governance perceptions, Mann–Whitney U analysis.

Variable	Full sample	Practitioners (n = 34)	Academics (n = 40)	Gap (P–A)	p
Financial transparency	50.7	39.7	60.0	−20.3	<0.001
Self-sufficiency	55.6	39.0	69.7	−30.7	<0.001
Monitoring data quality	56.6	42.6	68.4	−25.8	<0.001
Organizational structure	60.3	51.5	67.8	−16.3	<0.05
Community partnership	61.3	54.8	66.9	−12.1	<0.05
CI–HSSI: Governance	57.22	47.15	65.78	−18.63	<0.001

Table 9. OLS regression results with VIF diagnostics. R^2 = 0.881, n = 74. Marginal X_2 VIF = 5.10 just above threshold; condition number = 5.5 (well below 30, no severe multicollinearity).

Predictor	β	Std. Error	t	p	VIF	Status
Conservation spending (X_1)	0.634	0.087	7.29	<0.001	3.70	Acceptable
Digital marketing (X_2)	0.421	0.065	6.48	<0.001	5.10	Marginal
Physical infrastructure (X_3)	0.318	0.072	4.42	<0.001	1.74	Acceptable
Community partnership (X_4)	0.287	0.091	3.15	0.003	3.44	Acceptable
Institutional governance (X_5)	0.256	0.083	3.08	0.004	3.77	Acceptable
Digital technologies (X_6)	0.198	0.078	2.54	0.013	2.95	Acceptable

from the 'Good' criterion under the most favorable assumptions evaluated, reshapes the understanding of robustness in this situation. The central diagnostic finding is not insensitive to methodological choices merely because alternative specifications cancel each other out. It is robust because the underlying performance data preclude any alternative conclusion, regardless of how the index is configured. Neither adjusting the normative weights nor favourably reinterpreting the secondary estimates can shift the sector's classification upward. Genuine governance reform, not data reinterpretation, is the path to improved sustainability.

5.4. Hypothesis testing summary

Table 12 summarizes the outcome of the six hypothesis tests set out in Section 2.5.

6. Recommendations

Recommendations are graded by evidence strength. Priorities 1–3 derive from CI–HSSI confirmed findings; 4–5 from IC-HSSI indicative estimates.

Priority 1: Mandate annual audited financial disclosure for all heritage sites by 2027. This is grounded in the confirmed finding that financial transparency scores 50.7/100 overall and only 39.7/100 among practitioners, the lowest-scoring variable in the study.

Priority 2: Establish a unified national heritage data ecosystem, based on monitoring data quality scores of 56.6/100 overall and 42.6/100 among practitioners, both below the fragile threshold.

Priority 3: Develop site-level revenue diversification, based on financial self-sufficiency scores of 55.6/100 overall and 39.0/100 among practitioners.

Priority 4: Scale the Diriyah public–private partnership model to lower-performing sites. This recommendation is indicative rather than confirmed; Hypothesis 4 is only partially supported, and verified per-site data are required before scaling.

Priority 5: Adopt CI–HSSI as the annual official governance benchmarking tool, supported by the

Table 10. Sensitivity analysis, 12 representative scenarios from 23 total. Sector never reaches Good (≥75) in any scenario (maximum: 67.91).

Weighting scheme	Econ.	Cons.	Gov.	IC-HSSI	Band	Δ proposed
Proposed (normative)	40%	35%	25%	61.74	Mod.	+0.00
Equal weights	33%	33%	33%	61.37	Mod.	−0.37
Governance-elevated (30/30/40)	30%	30%	40%	60.95	Mod.	−0.79
Governance-dominant (20/40/40)	20%	40%	40%	61.57	Mod.	−0.17
Governance-heavy (20/20/60)	20%	20%	60%	59.71	Fragile	−2.03
Economic-prioritized (50/30/20)	50%	30%	20%	61.59	Mod.	−0.15
Conservation-prioritized (30/50/20)	30%	50%	20%	62.81	Mod.	+1.07
Throsby-aligned (45/35/20)	45%	35%	20%	61.89	Mod.	+0.15
AHP-simulated (38/34/28)	38%	34%	28%	61.58	Mod.	−0.16
Pessimistic data −10%	40%	35%	25%	58.65	Fragile	−3.09
Optimistic data +10%	40%	35%	25%	64.82	Mod.	+3.08
Governance-exclusive (0/0/100)	0%	0%	100%	57.22	Fragile	−4.52

Table 11. Scenario-based projections 2024–2035 with prediction intervals. Vision 2030 target (SAR 34bn) within 80% PI [30.9–37.1].

Year	Estimate (SAR bn)	80% lower	80% upper	95% lower	95% upper	Note
2024	19.2	18.3	20.1	17.8	20.6	Base
2027	25.6	23.8	27.4	22.9	28.3	–
2030	34.0	30.9	37.1	29.3	38.7	V2030
2033	45.3	40.3	50.3	37.6	53.0	–
2035	54.8	47.9	61.7	44.3	65.3	Target

instrument's high reliability ($\alpha = 0.967$), the confirmation of Hypothesis 6, and the stability of its classification across all 23 sensitivity scenarios.

7. Limitations and future research

7.1. Methodological limitations

Six methodological limitations are identified below, each paired with its impact on the findings and the compensatory measure adopted.

(1) **Expert perception design:** All scores are perceived rather than operationally verified. The practitioner Vs. academic gap suggests operational reality may be harsher than the aggregate scores indicate. This is addressed through the three-level HSSI classification and the explicit perception framing maintained throughout the paper.
(2) **IC-HSSI hybrid composition:** 47.5% of IC-HSSI's weight is drawn from secondary estimates rather than survey data, so it cannot be cited as a verified measurement. CI–HSSI (57.22) is therefore designated the primary confirmed finding.
(3) **Site distribution gap:** AlUla (n = 2) and Madain Saleh (n = 1) do not provide statistically defensible per-site HSSI scores. Findings are accordingly restricted to the sector level, with a dedicated site-level study designated as Future Study 1.
(4) **Academic over-representation:** Academics make up 54% of the sample, which may underweight operational perceptions. This is addressed through the practitioner sub-group analysis, reported separately.
(5) **OLS statistical power ≈ 71%:** This is below the 80% benchmark (which would require n = 92), so some effects may not reach significance. This is mitigated through bootstrap resampling (1000 iterations) and a cross-validated reduced four-predictor model.
(6) **Scenario projections:** These rest on a 10% CAGR assumption and represent planning scenarios rather than forecasts. This is addressed through 80% and 95% prediction intervals and explicit scenario labelling throughout.

7.2. Future research

Four studies are designated as priorities: (1) per-site HSSI with stratified sample (n ≥ 12 per site) and independent external assessors, closes the site-level gap; (2) empirical weight derivation via AHP or Delphi, replaces normative weights; (3) official EVI/ROHI/TRM verification from Heritage Authority data, elevates IC-HSSI to AF-HSSI; (4) longitudinal panel study (2025–2028) with instrumental variable estimation, first causal identification in Saudi heritage economics.

Table 12. Hypothesis testing summary.

H	Statement	Key evidence	Result	Implication
H1	Conservation spending: strongest associate of governance sustainability	$\beta = 0.634$, VIF = 3.70, $p < 0.001$	Supported	Conservation investment is the primary efficiency lever
H2	Efficiency variance across all 8 sites	Conceptual DEA only, insufficient site data	Partial	Requires stratified site-level study (n ≥ 12/site)
H3	Digital marketing > physical infrastructure	$\beta(X_2) = 0.421 > \beta(X_3) = 0.318$; X_2 VIF = 5.10	Supported (with caution)	VIF = 5.10 noted; direction consistent
H4	PPP > direct government management	H4 partially supported, conceptual DEA only	Partial	Diriyah case supports direction; empirical test pending
H5	Scenario model: MAPE <5%	MAPE = 3.7% on 2020–2023 hold-out	Supported	Projections are scenario-based, not forecasts
H6	HSSI composite outperforms individual indicators	R^2 (HSSI) = 0.881 > any single predictor	Supported	Multidimensional integration is justified

8. Conclusion

Experts surveyed in this study perceive the Saudi heritage sector's governance infrastructure as not yet sufficiently positioned to sustain the economic transformation being asked of it. The confirmed governance perception score of 57.22/100 and the practitioner sub-score of 47.15 place expert-perceived sector sustainability at the fragile level. Financial transparency, at 39.7 among practitioners, suggests that accountability mechanisms may not yet be sufficiently institutionalised to support long-run heritage economic sustainability.

Three findings are particularly noteworthy. The practitioner Vs. academic perception gap (18.6 points, $p < 0.001$) indicates a meaningful disconnect between how governance readiness is perceived by those managing heritage sites and those evaluating it academically. The sensitivity analysis demonstrates that this perceived fragility is structurally robust; no normative weight scheme or data assumption lifts the sector above the Moderate band in any of 23 scenarios. The scenario projections suggest Vision 2030's heritage revenue targets are achievable under reasonable growth assumptions, but addressing the governance perception gaps identified appears necessary alongside continued capital investment.

HSSI contributes a transparent, three-level confidence framework that explicitly distinguishes confirmed expert-perception findings from indicative estimates and aspirational targets. As an annually updatable diagnostic tool, it offers a systematic basis for tracking whether expert-perceived governance readiness improves over time, a question that will only be answerable through repeated application of the instrument with the broader and more representative samples that future research should pursue.

Authors contributions

Ali M. Aliraqi: Conceptualization, Methodology, Formal analysis, Investigation, Data curation, Writing – original draft, Writing – review & editing, Visualization, Project administration.

Ethics statement

Informed consent was obtained from all individual participants included in the study.

Data availability statement

The data used in this study are available from the author upon reasonable request. The full 23-scenario sensitivity analysis is also available from the corresponding author.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the author used Claude (Anthropic) for the purposes of generating code for statistical analyses, and formatting reference lists. The output was carefully reviewed, revised, and validated by the author. The author takes full responsibility for the content of this manuscript.

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Conflicts of interest

The author declares that there are no conflicts of interest regarding the publication of this manuscript.

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