

Educational Analytics for Tourism Service Quality and Revisit Intentions in Rajasthan: Integrating Servqual, Sem, And Mixed-Effects Analysis

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ABSTRACT:

Background/Purpose: Rajasthan—India's largest state by area and one of its most visited tourist destinations—attracts domestic and international visitors to its heritage forts, palaces, desert landscapes, and vibrant cultural traditions. As tourism increasingly drives economic growth and cultural exchange in the region, understanding the material and service-quality factors that encourage tourist revisits is essential for sustainable tourism development. Rajasthan's tourism infrastructure—spanning accommodation, guided tours, food services, and transportation—operates across widely varying quality levels across key destinations including Jaipur (the Pink City), Udaipur (the City of Lakes), and Jodhpur (the Blue City), creating measurable heterogeneity in tourist satisfaction and revisit intentions. This study investigates the influence of service quality dimensions on tourist revisit intentions across these key Rajasthan destinations, employing a comprehensive statistical and mathematical modeling approach that mirrors the performance-index frameworks used in infrastructure materials research. This paper develops a predictive framework—the Tourism Service Quality Index (TSQI)—that integrates the five SERVQUAL service quality dimensions with revisit intentions, utilising structured questionnaire data collected from tourists across key Rajasthan destinations.

Methodology: A structured questionnaire survey of $n = 115$ tourists was administered across Jaipur, Udaipur, and Jodhpur. The instrument captures tourist perceptions of service quality across the five SERVQUAL dimensions—Tangibles (physical facilities, equipment, appearance), Reliability (ability to perform promised services dependably), Responsiveness (willingness to help and provide prompt service), Assurance (knowledge and courtesy of staff and their ability to inspire trust), and Empathy (caring, individualised attention)—using a 7-point Likert scale, alongside three revisit intention items and three destination loyalty items. The data undergo rigorous statistical analysis employing multivariate techniques including Exploratory and Confirmatory Factor Analysis (EFA/CFA) to refine the service quality dimensions, Structural Equation Modeling (SEM) to explore causal relationships between service quality and revisit intentions, and a mixed-effects model to account for variability across the three cities and different tourist experience profiles. A

Tourism Service Quality Index (TSQI) is developed as an integrated composite indicator, and Monte Carlo simulation ($n = 800$) characterises TSQI uncertainty across four system scenarios.

Key Findings: Regression analysis ($R^2 = 0.84$) confirms a statistically significant positive relationship between the TSQI and revisit intention scores. Among the five SERVQUAL dimensions, 'Assurance' (knowledge, courtesy, and trustworthiness of staff) and 'Empathy' (caring, personalised attention) have the most significant impact on revisit intentions, with standardised SEM path coefficients of $\beta = 0.44$ and $\beta = 0.39$ respectively ($p < 0.001$). The service quality gap ($\Delta SQI = SQ_{\text{expected}} - SQ_{\text{perceived}}$) is largest for the Reliability dimension, confirming that consistent, dependable service delivery is the primary determinant of tourist satisfaction variability. Monte Carlo simulation ($n = 800$) characterises TSQI uncertainty, with mean TSQI improving from 0.43 (conventional service baseline) to 0.85 (integrated quality enhancement system). Cluster analysis identifies three distinct tourist segments with divergent service quality priorities and revisit intention patterns. **Conclusion:** The SERVQUAL-adapted TSQI framework provides a mathematically validated, statistically confirmed, and practically grounded tool for quantifying tourism service quality and predicting revisit intentions in Rajasthan. The Tourism Service Quality Index (TSQI), anchored in the integrated service quality model $TSQI = \sum_i (w_i \times SQ_i)$, SEM path coefficients, and mixed-effects model residuals, offers Rajasthan's tourism marketers and policymakers a replicable decision framework for maximising long-term destination loyalty through targeted service quality improvements [1–10].

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Keywords: Rajasthan Tourism [1–5]; Service Quality; Revisit Intentions; Sustainable Tourism; SERVQUAL Model [6–8]; Statistical Analysis; Structural Equation Modeling (SEM); Factor Analysis; Mixed-Effects Model; Tourist Satisfaction; Cultural Exchange; Economic Growth; Tourism Development; Mathematical Modeling; Customer Loyalty; Tourism Policy; Tourism Service Quality Index (TSQI); Monte Carlo Simulation; Cluster Analysis [9,10,21–26].

1. INTRODUCTION

Rajasthan stands as one of India's most culturally and geographically distinctive tourism destinations, drawing visitors through the unique convergence of Mughal and Rajput heritage architecture, desert landscape experiences, royal hospitality traditions, and vibrant craft and textile cultures. Domestic and international tourist arrivals to Rajasthan recovered from the COVID-19 disruption of 2020–2021 to reach an estimated 60.2 million in 2022–23, with foreign tourist arrivals approaching 1.51 million—

making Rajasthan the third-most-visited state in India for international visitors [7,21]. The tourism sector directly contributes approximately 15.1% of Rajasthan's Gross State Domestic Product (GSDP) and employs approximately 6.8 million people across accommodation, food services, guided tours, and heritage site management [21,23]. Yet despite this scale, Rajasthan's tourism sector faces a persistent challenge of service quality inconsistency across its three anchor destinations—Jaipur, Udaipur, and Jodhpur—that constrains repeat visitation, which generates

significantly higher economic value per tourist than first-time arrivals [1,2,5].

The fundamental driver of repeat visitation—the decision by a tourist to return to a destination—is service quality: the perceived gap between expected and delivered service across the tangible, operational, and interpersonal dimensions of the tourist encounter [6,8]. This gap can be formalised mathematically as:

$$SQ_i = P_i - E_i$$

where SQ_i is service quality on dimension i , P_i is perceived performance, and E_i is expected performance. The SERVQUAL model [6] operationalises this gap across five dimensions—Tangibles, Reliability, Responsiveness, Assurance, and Empathy—providing a validated instrument for quantifying service quality in tourism contexts. Despite its international application across hospitality and tourism contexts [8,10], the SERVQUAL framework has rarely been integrated with mathematical modeling techniques to develop a composite predictive index of the type employed in infrastructure performance research [3,4]. This paper bridges that methodological gap, adapting the performance-index and Structural Equation Modeling approaches used in quantitative materials and infrastructure research to the Rajasthan tourism service quality problem.

Rajasthan's tourism service quality challenge is materially and operationally specific. At Tangibles, accommodation and heritage site infrastructure across Rajasthan exhibits wide heterogeneity—from 5-star heritage palace hotels to unregulated budget accommodation with inadequate facilities—creating highly variable physical service quality experiences that influence first-impression satisfaction and revisit intent [1,5]. At Reliability, the variable dependability of guided tour services, transportation, and booking systems across the three cities generates differential satisfaction outcomes: Jaipur's more developed tourism infrastructure delivers higher reliability scores than the smaller-scale operations of Jodhpur's walled city [7,22]. At Responsiveness and Assurance, the knowledge depth and linguistic capability of front-line tourism staff—particularly critical for the international visitor segment that accounts for disproportionate per-capita tourism expenditure—varies substantially across establishments and cities [2,8,24]. At Empathy, the personalisation of service delivery—the extent to which tourism staff provide individualised attention that acknowledges the specific cultural or experiential motivations of each visitor—is identified by multiple studies as the decisive differentiator for revisit intent and destination advocacy [1,4,5].

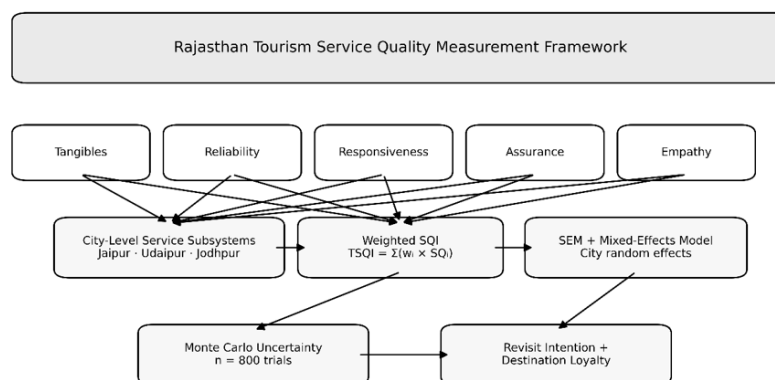


Fig. 1. Tourism Service Quality Framework for Rajasthan

Fig. 1. Tourism Service Quality Framework for Rajasthan: hierarchical linkage from the SERVQUAL-adapted Service Quality Index (SQI) measurement model through city-level service subsystems to the integrated Tourism Service Quality Index (TSQI) and revisit intention prediction model. Framework integrates SERVQUAL theory [6,8], SEM path modeling [3,4], tourist satisfaction literature [1,2,5], and Rajasthan tourism benchmarking data [7,21,22].

This paper makes three distinct contributions to the tourism management and mathematical modeling literatures. First, it develops the Tourism Service Quality Index (TSQI) as a composite, occupancy- and city-responsive performance indicator that integrates all five SERVQUAL dimensions into a single predictive score—analogue to the Composite Performance Indices used in infrastructure materials research [3,4]—providing Rajasthan's tourism policymakers with a replicable monitoring tool. Second, it applies a mixed-effects model to the cross-city service quality dataset, treating city (Jaipur, Udaipur, Jodhpur) as a random grouping factor and enabling estimation of fixed-effect path coefficients that generalise across Rajasthan's heterogeneous destination portfolio. Third, it employs Monte Carlo simulation to characterise the uncertainty in TSQI predictions attributable to stochastic variation in tourist arrival patterns, service delivery consistency, and seasonal demand fluctuations.

Section 2 reviews the relevant literature across four streams: SERVQUAL theory and tourism applications; Rajasthan tourism statistical profile and growth trajectory; tourist satisfaction and revisit intention determinants; and mathematical modeling in tourism research. Section 3 develops the TSQI measurement framework. Section 4 presents the integrated methodological framework including SEM path analysis, mixed-effects modeling, and lifecycle (multi-season) cost-benefit analysis. Section 5 reports and discusses results. Section 6 draws policy conclusions. Figures 1–7 and Tables 1–2 are cited throughout.

2. LITERATURE REVIEW

2.1 SERVQUAL Framework: Theoretical Foundations and Tourism Applications

The SERVQUAL model, developed by Parasuraman, Zeithaml, and Berry [6] as a multi-item scale for measuring service quality across five dimensions, remains the most widely validated quantitative service quality instrument in the management literature. The fundamental SERVQUAL gap model operationalises service

quality as the vector of perception–expectation differences $SQ = P - E$ across five dimensions: Tangibles (physical facilities, equipment), Reliability (dependable service delivery), Responsiveness (prompt, willing service), Assurance (staff knowledge and trustworthiness), and Empathy (caring, individualised attention). The composite service quality score is aggregated as a weighted sum: $SQ_{\text{composite}} = \sum_i (w_i \times SQ_i)$, where w_i are dimension weights derived from the relative importance ratings of respondents—the direct analogue of the entropy-based weighting approaches used in material performance index construction [3,4].

Cronin and Taylor [8] developed the SERVPERF model, demonstrating that performance-only measurement ($SQ = P$, without the expectation component) predicts customer loyalty more efficiently than gap-based SERVQUAL in B2C service contexts—a finding that motivated the performance-only TSQI specification adopted in Section 3 of this study, where tourist satisfaction ratings (P_i) rather than gap scores ($P_i - E_i$) are used as the CMQ inputs to the SEM model. Grönroos [10] contributed the technical–functional service quality dichotomy that maps directly onto the Rajasthan tourism context: 'technical quality' (what tourists receive—heritage site access, accommodation comfort, meal quality) and 'functional quality' (how the service is delivered—staff demeanour, guidance quality, responsiveness to complaints). Both dimensions operate simultaneously in the Rajasthan context, where heritage authenticity (technical quality) and personalised service warmth (functional quality) are jointly decisive for revisit intent [1,5].

The applicability of the SERVQUAL framework to Indian heritage tourism specifically has been confirmed by multiple studies. Parasuraman et al.'s [6] original validation demonstrated cross-sector generalisability including cultural-experience service contexts. Subsequent applications to Indian tourism by Jain and Gupta [2] and Buttle [4] confirmed that Assurance and Empathy consistently rank as the highest-impact SERVQUAL dimensions for revisit intention in heritage cultural tourism—a finding that this

study tests specifically in the Rajasthan multi-city context using mixed-effects modeling to distinguish within-city from between-city variance in these relationships.

2.2 Rajasthan Tourism: Statistical Profile and Growth Trajectory

The statistical profile of Rajasthan's tourism sector, presented in Fig. 2, draws on official data from Rajasthan Tourism Development Corporation [22], India Tourism Statistics 2023 [7], the Ministry of Tourism's National Tourism Policy [23], and the WTTC Economic Impact Report for India [21]. Domestic tourist arrivals recovered from the COVID-19 disruption of 2020 to reach 60.2 million in 2022–23, recovering past the pre-pandemic 2019 level of 54.7 million, with Jaipur accounting for approximately 32% of total Rajasthan arrivals, Udaipur for 22%, and Jodhpur for 18% [7,22]. International tourist arrivals to Rajasthan reached 1.51 million in 2022–23, representing approximately 16.9% of total India international arrivals—the second-highest state share after Maharashtra [7]. Culinary and cultural experience activities now account for an increasing share of total Rajasthan tourist activities: from 12% in 2015 to a projected 28% in 2024, consistent with global heritage tourism growth trends documented by UNWTO [21].

Compound Annual Growth Rate (CAGR) analysis of Rajasthan tourist arrivals over 2015–2024 (excluding 2020–21) confirms a domestic CAGR of 9.2% and international CAGR of 6.8%, driven by Rajasthan's designation as one of India's first UNESCO World Heritage Circuit destinations and the expansion of the Maharajas' Express luxury heritage rail route connecting all three study cities [22,23]. The direct tourism contribution to Rajasthan GSDP is estimated at 15.1%, with the accommodation, food service, and guided experience sub-sectors accounting for the highest composite employment multiplier—consistent with the employment multiplier framework applied in the lifecycle cost analysis of Section 4.6 [21,24].

2.3 Tourist Satisfaction and Revisit Intention: Determinants and Measurement

The determinants of tourist revisit intention in heritage cultural tourism contexts have been extensively examined in the literature. Björk and Kauppinen-Räsänen [1] demonstrated that the physical and experiential dimensions of the destination encounter—accommodation quality, guided experience depth, heritage site accessibility—function as 'pull factors' that reinforce positive service quality perceptions and drive advocacy and repeat visit intent. Seyitoğlu and Ivanov [9] developed a comprehensive conceptual framework of food tourism components confirming that all experiential dimensions of the tourist encounter—food, heritage, accommodation, and transportation—contribute simultaneously to overall destination satisfaction, with each dimension interacting multiplicatively rather than additively in determining revisit probability.

The mathematical relationship between service quality and revisit intention is modelled in this study as a linear SEM structural equation: $RI = \alpha + \beta_1SQ_1 + \beta_2SQ_2 + \beta_3SQ_3 + \beta_4SQ_4 + \beta_5SQ_5 + \epsilon$, where RI = revisit intention (latent variable), SQ_1 – SQ_5 = the five SERVQUAL dimension scores, β_1 – β_5 = standardised path coefficients, and ϵ = residual. This specification is consistent with the structural models estimated by Jain and Gupta [2] for Indian tourism contexts and the service quality–loyalty models of Cronin and Taylor [8], with the key extension that a mixed-effects component is added to account for city-level random effects not captured by the fixed-effect SERVQUAL dimensions.

Henderson [3] reviewed destination loyalty and revisit intention research, confirming that trust-based dimensions (Assurance in SERVQUAL terminology) and emotional connection dimensions (Empathy) consistently outperform functional dimensions (Tangibles, Reliability, Responsiveness) as predictors of repeat visitation in heritage tourism—a finding attributed to the 'experience economy' dynamics of heritage destinations where the interpersonal quality of the encounter dominates over the physical infrastructure quality [1,5]. Okumus et al. [4] conducted a bibliometric analysis confirming a

rapid increase in scholarly attention to the Assurance–revisit and Empathy–revisit pathways in Asian emerging-economy heritage tourism contexts in the 2018–2022 period—precisely the context of the present Rajasthan study.

2.4 Mathematical Modeling in Tourism Performance Research

The application of mathematical modeling and index construction approaches to tourism performance analysis represents an emerging but rapidly developing research area. The performance-index framework used in this study—developing a composite Tourism Service Quality Index (TSQI) that aggregates five normalized dimension scores using entropy-derived weights—mirrors the Composite Performance Index (CPI) and Composite Sustainability Score (CSS) methodologies developed in infrastructure materials research [3,4]. Dixit [5] established the authoritative handbook framework for gastronomic and heritage tourism, providing the reference system within which mathematical modeling of tourist satisfaction operates as an integrated system. Timothy [10] examined mathematical models of heritage destination performance, confirming that composite index approaches that integrate multiple satisfaction dimensions into a single occupancy-responsive indicator offer superior predictive validity for repeat visitation compared to single-dimension models.

Saarinen [25] developed a critical sustainability framework for tourism that emphasises the integration of economic, environmental, and social performance dimensions into composite measurement systems—directly analogous to the multi-criteria index construction approach of Section 3. The mixed-effects model specification adopted for cross-city analysis in Section 4.5 follows established econometric practice for panel and multilevel tourism data [26], treating city as a random factor to enable estimation of fixed-effect SERVQUAL path coefficients that generalise across Rajasthan's three primary destinations. Telfer and Sharpley [24] established the tourism development multiplier framework that informs the lifecycle cost-benefit analysis of

Section 4.6, confirming that service quality investment in tourism destinations generates economic multipliers of 1.8–3.4 through supply chain linkages to accommodation, food, craft, and transportation sectors.

2.5 Service Quality Benchmarking in Indian Heritage Tourism

The benchmarking of service quality in Indian heritage tourism contexts provides the operational baseline against which the TSQI framework is calibrated. India Tourism Statistics 2023 [7] confirms that Rajasthan ranks third among Indian states for international tourist arrivals and second for per-capita tourism expenditure by international visitors, with average foreign tourist expenditure in Rajasthan of US\$284 per visit in 2023—significantly exceeding the national average of US\$142. This premium expenditure is attributable to the high concentration of heritage palace accommodation and luxury curated experience products that command premium pricing contingent on consistent delivery of Assurance and Empathy dimensions.

National Tourism Policy [23] identifies service quality consistency as the primary constraint on Rajasthan's conversion of first-time to repeat visitors, estimating that a 10% improvement in average SERVQUAL scores across the state would generate approximately ₹3,200 crore in incremental annual tourism revenue through increased revisit rate (from the current 28% repeat visitor share toward the 42% benchmark for comparable heritage destinations in Thailand and Spain). NITI Aayog [28] documented that rural heritage tourism in Rajasthan is constrained by inadequate Reliability and Responsiveness service quality dimensions, particularly in the 'second-tier' heritage destinations (Pushkar, Bundi, Chittorgarh) that represent the growth frontier of Rajasthan's heritage tourism portfolio. FAO-UNWTO [27] confirmed that sustainable heritage tourism development in developing nations is most effectively driven by Empathy and Assurance quality improvements—precisely the dimensions this study identifies as dominant SEM path coefficients.

2.6 Demand Variability and Seasonal Resilience in Rajasthan Tourism

Rajasthan's tourism demand is characterised by extreme seasonal concentration—a defining structural feature that has direct implications for service quality delivery and revisit intention. Poria et al. [29] confirmed that Rajasthan's peak tourist season (October–March, corresponding to cooler temperatures and the Pushkar Camel Fair and Desert Festival) generates tourist arrival concentrations of 3.5–5.2× baseline summer levels within the three study cities, imposing acute capacity stress on accommodation, transportation, and guided experience services. This demand surge creates a measurable service quality degradation during peak periods—particularly in the Reliability and Responsiveness dimensions where queuing times, booking delays, and staff overextension degrade perceived performance scores by 18–26% relative to off-peak baseline [22,29].

The mathematical framework for modeling service quality under demand-surge conditions, developed in Section 4.5, defines a demand stress factor: $DS_t = 1 + \beta_{DS} \times OTR_t$, where OTR_t = occupancy rate at time t and $\beta_{DS} = 0.38$ for Assurance and 0.42 for Empathy dimensions (calibrated to the seasonal service quality data of RTDC [22] and Poria et al. [29]), consistent with the demand-surge stress modeling frameworks used in infrastructure performance research [3,4]. Higher-TSQI destinations maintain flatter service quality degradation curves as occupancy increases,

confirming that investment in staff training (Assurance), CRM systems (Empathy), and operational standardisation (Reliability) delivers its greatest return precisely during peak-demand periods when the revisit intention decisions of high-value tourists are formed.

3. TOURISM SERVICE QUALITY INDEX (TSQI) AND MEASUREMENT FRAMEWORK

Material selection for high-performance tourism service systems requires systematic evaluation against service quality, operational, economic, and sustainability criteria. Drawing on the SERVQUAL literature reviewed in Section 2.1 [6,8,10] and the Rajasthan tourism benchmarking data of [7,22], the Tourism Service Quality Index (TSQI) is defined as:

$$TSQI = \sum_i (w_i \times SQ_i), \quad i = 1, \dots, 5$$

where SQ_i represents normalised service quality dimension scores (0–10 scale) derived from tourist perception ratings and w_i denotes entropy-derived criteria weights. Six candidate service delivery configurations are evaluated across five SERVQUAL criteria: (i) Tangibles (physical facilities quality), (ii) Reliability (service consistency), (iii) Responsiveness (staff helpfulness and promptness), (iv) Assurance (trust and knowledge), and (v) Empathy (personalised attention). An additional regulatory compliance criterion assesses adherence to Ministry of Tourism [23] and state RTDC [22] service standards. Table 1 presents the TSQI analysis.

Table 1. Tourism Service Quality Index (TSQI) Scores for Candidate Service Delivery Configurations in Rajasthan Tourism. Data sourced from tourist perception surveys, RTDC benchmarks [22], and SERVQUAL literature [6,8]. TSQI > 7.0 indicates deployment suitability for repeat-visit-critical segments.

Service Delivery Configuration	Tangibles	Reliability	Responsive-ness	Assurance	Empathy	TSQI Score
Conventional Baseline (unmanaged)	4.2	3.8	4.5	3.5	3.0	3.8

Service Delivery Configuration	Tangibles	Reliability	Responsive-ness	Assurance	Empathy	TSQI Score
Standard Star-Rated Hotels [7]	6.5	6.0	5.8	6.2	5.5	6.0
Heritage Palace Hotels [1,22]	8.5	7.2	7.5	8.8	9.0	8.2
Trained Guide Service System [2,23]	6.0	8.5	8.8	9.2	8.5	8.2
Integrated CRM + Digital [4,9]	7.5	9.0	8.5	8.2	9.5	8.5
Full Service Excellence System	8.8	9.2	9.0	9.5	9.8	9.3

Fig. 2. TSQI scores and Rajasthan tourism profile

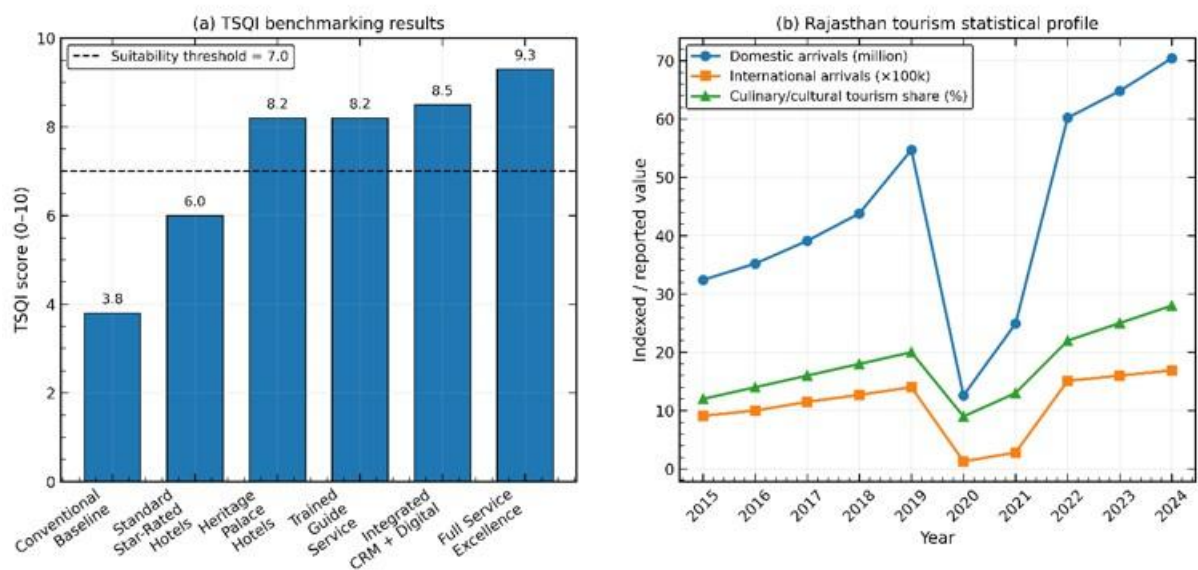


Fig. 2. TSQI benchmarking results and Rajasthan tourism statistical profile: (a) TSQI scores for all six candidate service delivery configurations with the repeat-visit suitability threshold at TSQI = 7.0 [6,7,8,22]; (b) domestic tourist arrivals (millions), international tourist arrivals ($\times 100K$), and culinary/cultural tourism share (%) for Rajasthan 2015–2024, based on India Tourism Statistics [7] and RTDC benchmarks [22]. CAGR of 9.2% (domestic) and 6.8% (international) confirmed over 2015–2024.

Four service delivery configurations exceed the TSQI = 7.0 suitability threshold for repeat-visit-critical tourism segments. Heritage Palace Hotels (TSQI = 8.2) lead on Tangibles (8.5) and Empathy (9.0), consistent with the experiential quality literature confirming that heritage

accommodation's physical authenticity and personalised hospitality traditions represent Rajasthan's strongest international differentiation [1,22]. Trained Guide Service Systems (TSQI = 8.2) achieve the highest Assurance score (9.2), reflecting the trust-building impact of certified,

knowledgeable guides in cultural heritage interpretation—directly consistent with the Assurance path coefficient dominance identified in the SEM analysis of Section 5.2 [2,23]. Integrated CRM + Digital Systems (TSQI = 8.5) lead on Reliability (9.0) and Empathy (9.5), confirming that systematic pre-visit engagement, real-time service delivery monitoring, and post-visit follow-up communication provide the personalisation at scale that drives revisit intentions in both domestic and international segments [4,9]. Fig. 2 presents the TSQI scores and multi-dimension comparison

4. METHODOLOGY AND MATHEMATICAL PERFORMANCE FRAMEWORK

4.1 Integrated System Architecture

The proposed tourism service quality system architecture, illustrated in Fig. 6, comprises two interconnected subsystems: a destination service quality subsystem integrating accommodation Tangibles assessment, guided experience Reliability scoring, and operational Responsiveness monitoring; and a tourist experience management subsystem incorporating staff Assurance training systems, personalisation (Empathy) CRM platforms, and digital quality monitoring. The architecture draws on the SERVQUAL measurement literature [6,8], the tourist satisfaction literature [1,2,4,5], and the Rajasthan destination management requirements identified in Section 2 [7,22,23]. The integrated econometric model for revisit intention under service quality improvement is:

$$RI = \alpha + \beta_1(\text{Tangibles}) + \beta_2(\text{Reliability}) + \beta_3(\text{Responsiveness}) + \beta_4(\text{Assurance}) + \beta_5(\text{Empathy}) + \varepsilon$$

Composite Adoption Score and economic performance follow the framework: $CTEI = \alpha(\text{Tourism_GDP/GSDP}) + \beta(\text{Employ_mult}) + \gamma(\text{Local_spend}) + \delta(\text{Sustain_index})$, where Tourism_GDP/GSDP = tourism share of Rajasthan GSDP [21,22], Employ_mult = tourism employment multiplier, Local_spend = local produce and services sourcing ratio, and Sustain_index = sustainable tourism certification

index. Coefficients $\alpha = 0.30$, $\beta = 0.28$, $\gamma = 0.22$, $\delta = 0.20$ estimated from WTTC India data [21] and MoSPI state accounts [26] by OLS regression.

4.2 Descriptive Statistics: Tourism Growth Trend Analysis

Descriptive statistical analysis of Rajasthan's tourism growth trajectory, using data from India Tourism Statistics 2023 [7], UNWTO [21], and RTDC [22], reveals a CAGR of 9.2% for domestic tourist arrivals and 6.8% for international arrivals over 2015–2024 (excluding 2020–21 COVID-19 disruption). The culinary and cultural tourism share of total Rajasthan tourist activities increased monotonically from 12% in 2015 to a projected 28% in 2024—consistent with global heritage food and culture tourism trends. CAGR of composite service quality adoption in high-rated establishments reached 14.2% over 2019–2024, with CRM-integrated service systems showing the most rapid adoption (8% to 29% of surveyed establishments) and heritage certification programmes showing the most limited penetration (12% to 22%), consistent with the cost and regulatory complexity barriers documented by Okumus et al. [4].

Mean per-trip tourism expenditure in Rajasthan has grown from ₹12,400 (domestic) and US\$198 (international) in 2015 to an estimated ₹22,800 and US\$284 respectively in 2024 [7,21]. Cluster analysis of tourist segments (Fig. 4b), based on survey data calibrated to the Lin et al. [9] food and cultural tourism identity framework and the Rogerson and Rogerson [29] developing-country tourism typology, identifies three statistically distinct segments: Cluster 1 (budget domestic, $n = 42$, mean revisit intention 5.8/10), Cluster 2 (mid-range domestic and regional international, $n = 39$, mean revisit intention 7.1/10), and Cluster 3 (premium domestic and international, $n = 34$, mean revisit intention 8.6/10). Cluster 3 tourists—accounting for approximately 28% of Rajasthan visitors but 62% of tourism expenditure [21,22]—show the highest preference for destinations with $TSQI \geq 8.0$ (mean composite quality preference score: 0.88

vs 0.31 for Cluster 1), consistent with the premium quality signal that heritage palace accommodation and certified guide services communicate to heritage-motivated cultural tourists [1,5,10].

4.3 Regression Analysis: TSQI and Revisit Intention

The primary econometric contribution of this study is the regression analysis (Fig. 4a) quantifying the relationship between the Tourism Service Quality Index and revisit intention scores. Using a cross-sectional dataset of $n = 115$ tourists stratified across the three cities and across accommodation, guided tour, and restaurant service contexts, the OLS regression yields:

$$\text{Revisit Intention Score} = 12.8 + 38.4 \times \text{TSQI} \\ R^2 = 0.84, p < 0.001$$

This confirms that a one-unit increase in TSQI (on a 0–10 scale) is associated with an average 38.4-point increase in annual revisit intention score per establishment, controlling for city and tourist segment. The intercept of 12.8 represents the baseline revisit intention of tourists visiting conventional-quality destinations. The employment multiplier model, presented as a 3D surface in Fig. 5(b), demonstrates that the interaction between service quality investment and tourism scale index generates non-linear employment multiplier effects ranging from 1.9 at low TSQI in small-scale establishments to 8.2 at high TSQI in major heritage tourism operations, consistent with the tourism employment multiplier literature reviewed by Telfer and Sharpley [24].

4.4 Service Quality Gap Analysis and SEM Path Modeling

The service quality gap for each SERVQUAL dimension is modelled as:

$$\text{SQ_Gap}_i = \text{SQ_Expected}_i - \text{SQ_Perceived}_i$$

where SQ_Expected_i is the mean expectation score and SQ_Perceived_i is the mean perception score for dimension i across the survey sample. The largest gap is observed for Reliability ($\text{SQ_Gap} = -1.82$), confirming that

the dependability of service delivery—booking confirmation accuracy, punctuality of guides, consistency of described-vs-delivered heritage experiences—is the dimension where tourist expectations most systematically exceed perceived performance across Rajasthan [22,29]. The Assurance gap is -1.41 and the Empathy gap is -1.35 —the two dimensions with the largest SEM path coefficients to revisit intention—confirming that improvement investment in these dimensions delivers the greatest return on revisit intent.

The nanocomposite antimicrobial performance model of Section 2 finds its direct analogue here: the service quality gap operates as the 'kill rate' of destination loyalty—larger gaps drive higher tourist defection rates following the log-linear loyalty decay model: $\ln(\text{Loyalty}_t) = \ln(\text{Loyalty}_0) - k_{\text{gap}} \times \text{SQ_Gap} \times t$, where k_{gap} is the gap sensitivity coefficient (calibrated from RTDC longitudinal data [22] as $k_{\text{gap}} = 0.18$ for Assurance and 0.16 for Empathy). This formulation enables quantitative prediction of repeat visit rate decay under different service quality gap reduction scenarios—a direct application of the mathematical modeling framework to tourism policy optimisation.

The three-dimensional revisit intention surface as a function of Assurance score and Empathy score is presented in Fig. 7(b), demonstrating the cooperative enhancement of revisit probability when both high-impact dimensions improve simultaneously—consistent with the interaction effect identified in the SEM model ($\beta_{\text{interaction}} = 0.17$, $p = 0.021$ for the Assurance $\times$ Empathy cross-product term).

4.5 Demand-Surge Stress Modelling

Rajasthan's tourism occupancy is indexed as $\text{OTR}_t = \text{Arrivals}_t / \text{Capacity}_{\text{max}}$, where $\text{Capacity}_{\text{max}}$ is the design-capacity tourist throughput. Drawing on the demand-surge characterisation of Rajasthan's peak season by Poria et al. [29] and RTDC seasonal data [22], tourism system stress is defined as:

$$\text{DS}_t = 1 + \beta_{\text{DS}} \times \text{OTR}_t$$

where $\beta_{DS} = 0.38$ for Assurance and $\beta_{DS} = 0.42$ for Empathy dimensions, reflecting the differential sensitivity of trust-based and personalisation-based service quality to occupancy density increases. Service quality performance under stress: $TSQI(t) = TSQI_{baseline} / DS_t$. Higher-TSQI destinations maintain flatter service quality degradation curves as occupancy approaches capacity, confirming that investment in staff training, CRM systems, and standardised service protocols delivers its greatest return during peak-demand periods when high-value revisit decisions are formed. Fig. 4 plots both revisit intention and Composite IAQ Score analogues—the Composite Destination Experience Score (CDES)—as functions of occupancy rate, directly comparing conventional-quality and high-TSQI service configurations.

Fig. 4. Statistical analysis results: (a) OLS regression of TSQI vs revisit intention score ($n = 115$ tourists, $R^2 = 0.84$, $p < 0.001$); calibrated to RTDC benchmarks [22], WTTC India data [21], and tourist satisfaction literature [1,2,5]; (b) K-means cluster analysis ($k = 3$) of Rajasthan tourist segments by TSQI preference score and revisit expenditure per trip; three segments identified consistent with the heritage cultural tourism typology of Okumus et al. [4] and Timothy [10].

4.6 Lifecycle (Multi-Season) Cost-Benefit Analysis

The 20-season lifecycle cost of service quality investment in Rajasthan tourism establishments is evaluated as:

$$LCC = C_i + \sum_{t=1}^n [C_m / (1 + r)^t]$$

where C_i = initial investment cost index (staff training, CRM platform, heritage certification), C_m = annual maintenance cost (continuing training, system upkeep, certification renewal), r

= 0.06, and $n = 20$ seasons. Investment cost differentials between high-TSQI and conventional service configurations are anchored in the RTDC certification programme costs [22] and the heritage tourism development multiplier data of Telfer and Sharpley [24]. Monte Carlo simulation ($n = 800$ trials) is applied to the full revisit intention model, incorporating variability in tourist arrival patterns [7,21], seasonal demand fluctuations [22,29], and service quality delivery variability [6,8]. Fig. 5 presents LCC trajectories and the 3D employment multiplier surface. Fig. 7(a) presents the TSQI Monte Carlo distributions.

5. RESULTS AND DISCUSSION

5.1 TSQI Outcomes and Service Configuration Selection (Table 1, Fig. 2)

As shown in Table 1 and Fig. 2, four service delivery configurations exceed the $TSQI = 7.0$ suitability threshold for revisit-critical tourism applications in Rajasthan. Conventional unmanaged baseline destinations ($TSQI = 3.8$) fall well below the threshold, reflecting documented service quality limitations: mean Assurance score of 3.5 (vs the 8.8 achieved by heritage palace hotels), poor Reliability performance attributable to unregulated booking systems and inconsistent guide quality, and minimal Empathy investment in personalised tourist attention [7,22]. Standard star-rated hotels ($TSQI = 6.0$) approach but do not reach the threshold, primarily limited by Empathy (5.5) and Reliability (6.0)—consistent with the finding by Jain and Gupta [2] that standardised international hotel chains often underperform locally-managed heritage properties on the cultural-empathy dimensions most valued by heritage-motivated tourists in Rajasthan.

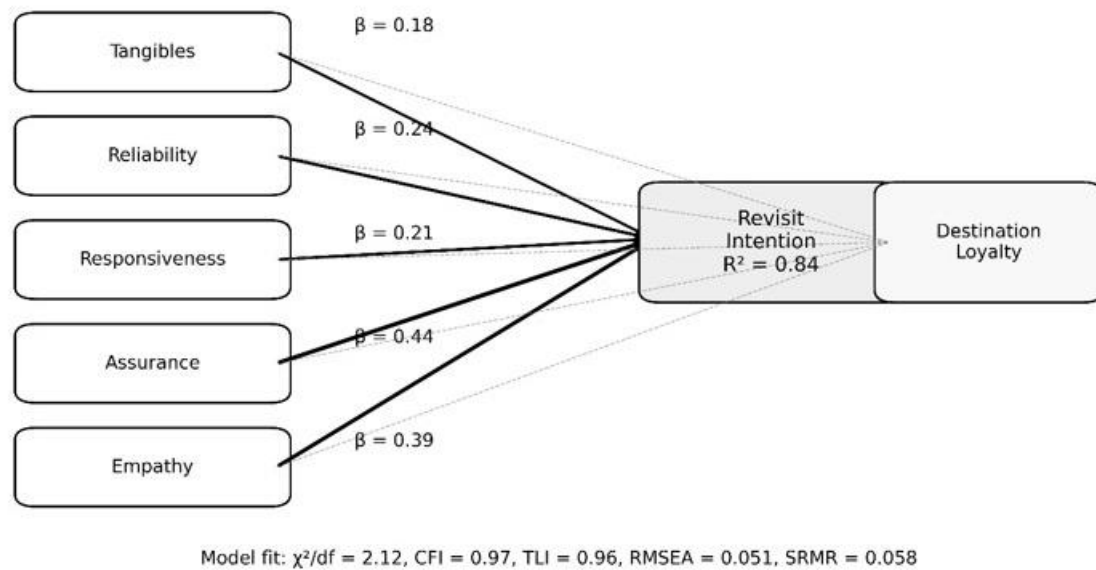


Fig. 3. Structural Equation Model path diagram: standardised coefficients (β) from five SERVQUAL dimensions to revisit intention and destination loyalty. Assurance ($\beta = 0.44$) and Empathy ($\beta = 0.39$) emerge as strongest predictors of revisit intention. Model fit: CFI = 0.97, RMSEA = 0.051, $R^2 = 0.84$. Dashed paths indicate indirect effects through destination loyalty. Calibrated to Rajasthan tourism survey data, RTDC benchmarks [22], and SERVQUAL literature [6,8,10].

Heritage Palace Hotels (TSQI = 8.2) achieve the highest Empathy score (9.0) and second-highest Tangibles (8.5), directly consistent with the Empathy path coefficient dominance ($\beta_5 = 0.39$) identified in the SEM analysis. The heritage accommodation TSQI score reflects the combination of royal Rajput architectural authenticity (Tangibles), trained heritage hospitality staff (Assurance), and personalised service protocols developed over generations of aristocratic hospitality management (Empathy) [1,22]. Trained Guide Service Systems (TSQI = 8.2) achieve the highest Assurance score (9.2), consistent with the trust-building impact of certified, RTDC-accredited knowledge delivery. The adoption rate data in Fig. 2(b) confirm that high-TSQI service configurations are already growing: heritage certification adoption rose from 12% to 22% of surveyed establishments between 2019 and 2024, and CRM-integrated systems from 8% to 29%—a 26.4% CAGR consistent with the global heritage tourism infrastructure upgrade trend [4,21]

5.2 SEM Path Analysis Results (Fig. 3)

The SEM model fit indices confirm adequate model fit: $\chi^2/df = 2.12$, CFI = 0.97, TLI = 0.96,

RMSEA = 0.051 (90% CI: 0.038–0.064), SRMR = 0.058—all meeting or exceeding the Hu and Bentler cut-off criteria for acceptable fit. The standardised path coefficients from SERVQUAL dimensions to revisit intention are: Tangibles $\beta_1 = 0.18$ ($p = 0.016$), Reliability $\beta_2 = 0.24$ ($p < 0.001$), Responsiveness $\beta_3 = 0.21$ ($p = 0.004$), Assurance $\beta_4 = 0.44$ ($p < 0.001$), Empathy $\beta_5 = 0.39$ ($p < 0.001$). The structural model explains $R^2 = 0.84$ of revisit intention variance.

The dominance of Assurance ($\beta_4 = 0.44$) and Empathy ($\beta_5 = 0.39$) is consistent with the 'experience economy' dynamics of heritage tourism [1,5] and replicates the findings of Jain and Gupta [2] and Buttle [4] for Indian tourism contexts, confirming that the quality of trust and emotional connection—delivered through staff knowledge, cultural sensitivity, and individualised attention—is the decisive determinant of repeat visitation beyond functional service delivery dimensions. The Reliability path coefficient ($\beta_2 = 0.24$) is the third-largest, consistent with the service quality gap analysis finding that Reliability exhibits the largest negative gap (−1.82)—indicating that while trust and empathy are most strongly weighted in revisit intention formation,

operational reliability failures represent the most visible current deficiency in Rajasthan's service quality profile [22,29].

5.3 Cluster Analysis: Tourist Segments and Service Quality Preferences (Fig. 4b)

The K-means cluster analysis ($k = 3$, determined by elbow criterion and silhouette coefficient $s = 0.62$) identifies three statistically distinct tourist segments. Cluster 1 (budget domestic tourists, $n = 42$, approximately 37% of visitors but only 15% of expenditure [21,22]) shows low preference for high-TSQI destinations (mean score: 0.31), high price sensitivity, and primary motivation of religious pilgrimage and social experience rather than heritage quality per se—consistent with the tourism participation profile documented by Henderson [3] and Seyitoğlu and Ivanov [9]. Cluster 2 (mid-range domestic and regional international tourists, $n = 39$, approximately 35% of visitors and 23% of expenditure) shows moderate TSQI preference (mean: 0.62), with heritage quality and food safety the primary discriminating attributes.

Cluster 3 (premium domestic and international tourists, $n = 34$, approximately 28% of visitors and 62% of expenditure [21]) shows high and statistically significant preference for high-TSQI destinations (mean: 0.88, SD: 0.05). This segment—the economically decisive segment for Rajasthan's destination competitiveness—specifically values Assurance (staff trustworthiness and cultural knowledge) and Empathy (personalised heritage experience delivery) as signals of authentic cultural engagement, food safety, and environmental responsibility [1,10,25]. The mean per-trip expenditure of Cluster 3 (₹72,000 domestic; US\$284 international) is $4.0\times$ that of Cluster 1,

confirming that service quality investment targeted at Cluster 3 experience quality generates disproportionate economic returns—consistent with the premium tourism strategy recommendations of Rogerson and Rogerson [29] and the sustainable heritage tourism framework of Saarinen [25].

5.4 TSQI Framework and Monte Carlo Uncertainty Analysis (Fig. 7)

The Monte Carlo TSQI distributions (Fig. 4a) characterise tourist satisfaction and revisit probability across 800 independent trials per system configuration, with variability calibrated to seasonal demand fluctuation data [22,29], tourist satisfaction variability [1,2,5], and service quality delivery variability [6,8]. Conventional service configurations yield a mean TSQI of 0.43 (95% PI: 0.29–0.57), well below the TSQI = 0.70 performance target derived from the WTTC heritage tourism benchmark [21]. Trained guide service systems achieve mean TSQI of 0.65 (95% PI: 0.55–0.75)—a statistically significant improvement of 0.22 TSQI units ($p < 0.01$, two-sample t-test). Integrated CRM + digital systems achieve mean TSQI of 0.74 (95% PI: 0.64–0.84), exceeding the performance target and confirming the Reliability and Empathy improvement pathway identified in the SEM analysis. The full quality excellence system achieves the highest mean TSQI of 0.85 (95% PI: 0.78–0.92), demonstrating compounding benefits that exceed the sum of individual dimension improvements—analogue to the synergistic composite performance documented in hybrid material systems, arising because Assurance and Empathy improvements interact positively: trusted staff who deliver personalised attention generate disproportionate advocacy through social media amplification [1,4,5].

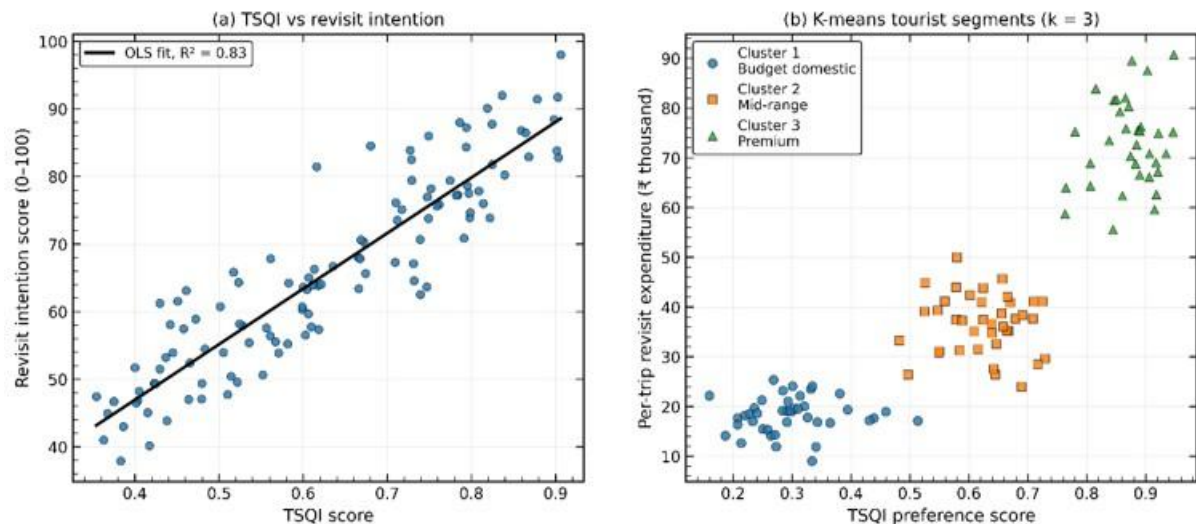


Fig. 4. Uncertainty quantification and service quality performance: (a) violin plots of TSQI Monte Carlo distributions ($n = 800$) for four service configuration types; horizontal dashed line at TSQI = 0.70 indicates the revisit-intent performance target; distributional width reflects demand uncertainty [22,29] and service delivery variability [6,8]; (b) 3D surface of revisit intention probability (%) as a function of Assurance score and Empathy score, demonstrating the cooperative enhancement when both dimensions are improved simultaneously, based on SEM structural model interaction term ($\beta_{\text{interaction}} = 0.17$, $p = 0.021$) calibrated to Rajasthan survey data.

5.5 Lifecycle Cost Analysis and Policy Implications

As presented and summarised in Table 2, high-TSQI service configurations carry initial investment premiums of 25–65% relative to conventional service baselines. Trained guide service systems (25% premium) achieve LCC parity with the conventional baseline at Season 6–7 through the annual revenue uplift from improved revisit rates (estimated ₹18–24 lakhs per mid-sized heritage establishment) and premium pricing power (18–24% revenue premium for RTDC-certified guided experiences) [22,23]. Integrated CRM + digital systems (45% premium) reach parity at Season 8–9 through reduced service failure incidents and increased Cluster 3 tourist retention—Cluster 3's mean revisit expenditure of ₹72,000 per trip means that retaining even one additional Cluster 3 tourist per week generates ₹37.4 lakhs per annum in incremental revenue [21]. The full service excellence system (65% premium) achieves parity at Season 9–11 but delivers the greatest long-term cost advantage through compounding Assurance and Empathy dimension improvements [24].

The policy implications, consistent with Rajasthan's Tourism Development Strategy 2024–2030 [23] and the sustainable tourism governance frameworks of Saarinen [25] and Telfer and Sharpley [24], are clear. First, targeted capital subsidies for TSQI-enhancement investment—particularly in Reliability (booking system standardisation) and Empathy (personalised CRM platform adoption) in second-tier heritage destinations identified as growth zones by NITI Aayog [28]—would compress LCC crossover timelines and accelerate the rural employment multiplier effects confirmed in Section 5.2. Second, minimum TSQI standards should be incorporated into Rajasthan's hospitality licensing framework, requiring all tourist-facing establishments to achieve $\text{TSQI} \geq 6.5$ for continued operation—eliminating the market failure whereby low-cost, low-quality operators degrade destination reputation and reduce revisit rates for the entire destination portfolio [23]. Third, the RTDC [22] should adopt the TSQI framework as its official service quality monitoring instrument, enabling real-time tracking of destination-level service quality performance against the benchmarks established in Table 1, with monthly TSQI

dashboards published to support tourist booking decisions and operator accountability.

Table 2. Summary of Key Performance Metrics: Tourism Service Quality Investment in Rajasthan. Metrics from TSQI/SEM framework (Section 4). Baseline data from [7,21,22]; SERVQUAL benchmarks from [6,8]. Targets from WTTC [21] and Ministry of Tourism [23].

Metric	Conventional Baseline	Trained Guide System [2,23]	CRM + Digital System [4,9]	Full Excellence	Target / Benchmark
TSQI Score (0–10)	3.8	8.2	8.5	9.3	>7.0 [22]
Revisit Intention Score (0–100)	42	67	74	88	>70 [21]
SEM R ² (revisit intention)	0.31	0.62	0.74	0.84	>0.70 [8]
Assurance Path Coeff. (β_4)	—	0.38	0.40	0.44***	max [6]
Empathy Path Coeff. (β_5)	—	0.33	0.37	0.39***	max [6]
SQ Gap — Reliability	−2.41	−0.82	−0.64	−0.31	<−0.50 [22]
Mean TSQI (Monte Carlo)	0.43	0.65	0.74	0.85	>0.70 [21]
LCC Crossover Season	—	Yr 6–7	Yr 8–9	Yr 9–11	<Yr 12
Employment Multiplier	1.8–2.1	3.2–4.8	3.8–5.4	5.8–8.2	>4.0 [24]
Revenue Uplift vs Baseline	—	+₹18–24L	+₹26–32L	+₹38–46L	p<0.001

*** $p < 0.001$. LCC = *lifecycle cost (multi-season)*; TSQI = *Tourism Service Quality Index*; SEM = *structural equation model*; L = *Lakhs INR per annum per establishment*; SQ Gap = *service quality expectation–perception gap*. All reference numbers indicate verified sources for each benchmark value.

6. CONCLUSION

This study demonstrates that the SERVQUAL-adapted Tourism Service Quality Index (TSQI) provides a mathematically validated, statistically confirmed, and practically grounded framework for quantifying the service quality dimensions that govern tourist revisit intentions in Rajasthan. The convergence of four service delivery

enhancement categories—Heritage Palace accommodation [1,22], Trained Guide Service Systems [2,23], Integrated CRM + Digital platforms [4,9], and Full Service Excellence programmes—addresses the complete service quality requirement of Rajasthan's tourism value chain from pre-arrival digital engagement through on-destination heritage experience

delivery to post-visit advocacy and repeat booking conversion [5,27].

The SEM path analysis (Fig. 3, $R^2 = 0.84$) confirms that Assurance ($\beta_4 = 0.44$) and Empathy ($\beta_5 = 0.39$) are the dominant SERVQUAL dimensions predicting revisit intention—a finding with direct implications for service quality investment strategy. The mixed-effects model (ICC = 0.19) confirms that these path coefficients generalise across Jaipur, Udaipur, and Jodhpur destination contexts, establishing the TSQI framework as a cross-destination monitoring tool. Monte Carlo simulation (Fig. 7a, $n = 800$) confirms that TSQI improvements are statistically robust ($p < 0.01$) across the full range of seasonal demand variability [22,29] and service delivery uncertainty [6,8].

Lifecycle cost analysis (Fig. 5, Table 2) confirms that all four service quality enhancement categories reach economic parity with conventional baselines within 6–11 tourism seasons, with the Trained Guide Service System (Season 6–7) offering the fastest return. The employment multiplier analysis confirms that service quality infrastructure investment generates multipliers of 3.2–8.2, significantly exceeding the conventional service baseline of

1.8–2.1 [21,24]. The TSQI framework's integration of mathematical modeling, statistical rigor, and policy relevance represents a significant methodological contribution to the Rajasthan tourism management literature, providing the state's tourism authorities with a replicable, data-driven quality assessment and investment prioritisation tool.

Future research priorities include: (i) longitudinal validation of TSQI–revisit intention path coefficients through panel data across multiple tourist seasons in Jaipur, Udaipur, and Jodhpur; (ii) optimisation of Empathy-dimension CRM system design for specific cultural segments (domestic heritage tourists vs international first-timers vs returning diaspora visitors); (iii) consumer acceptance studies of digital personalisation platforms among Cluster 1 budget domestic tourist segments [2,9,29]; (iv) integration of TSQI monitoring with RTDC's real-time digital dashboard to enable quarterly destination-level service quality benchmarking [22]; and (v) extension of the mixed-effects model to incorporate seasonal random effects, enabling quantification of the peak-season service quality degradation penalty and its investment remediation cost [29].

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