Infrastructure, accessibility, and regional challenges in sustainable tourism: Evidence from Ha'il, Saudi Arabia

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ABSTRACT

This study examines how infrastructure and accessibility quality (IAQ) and regional challenges (RC) influence sustainable tourism development (STD) in Ha'il, Saudi Arabia, a heritage-rich but peripheral region under Vision 2030. Drawing on sustainable tourism and governance frameworks, we test whether IAQ supports sustainability and whether RC constrains it. A cross-sectional survey of 282 tourists conducted in 2024 was analyzed using Partial Least Squares Structural Equation Modelling (PLS-SEM). Results show IAQ has a strong positive association with STD (β = 0.538, p < 0.001), while RC has a significant negative association (β = -0.424, p < 0.001). The model explains 66.6% of the variance in STD (R^2 = 0.666), indicating substantial explanatory power. Findings suggest infrastructure is necessary but insufficient; governance and environmental stewardship are essential for long-term viability. Policymakers should align infrastructure investment with integrated governance and participatory planning, with conservation principles guiding development. This study provides empirical evidence for sustainable tourism in arid peripheral regions.

Contribution/ Originality: This study advances sustainable tourism research by empirically demonstrating how infrastructure and accessibility quality enhance sustainability outcomes, while regional challenges impede them. It offers evidence from an underexamined semi-arid region and provides a framework linking infrastructural development with governance capacity, enriching both theory and policy on sustainable destination development.

1. INTRODUCTION

Sustainable tourism development (STD) has become a central framework for aligning tourism growth with environmental protection and socio-cultural integrity (Elkington, 1998). Tourism is now recognized not only as an economic sector but also as a strategic vehicle for regional diversification, community empowerment, and ecological stewardship (Sharpley, 2000). Sustainability reflects the long-term capacity of tourism systems to balance profitability, social equity, and ecological resilience (Butler, 1998).

In Saudi Arabia, the sustainability agenda is firmly embedded within Vision 2030, which identifies tourism as a cornerstone of national transformation and post-oil economic diversification (Vision 2030, 2016). The policy framework integrates tourism expansion with cultural heritage preservation, infrastructure modernization, and environmental protection (Almalki, Tolkacheva, & Choi, 2022). Within this national vision, the Ha'il region, located in the northwestern part of the Kingdom, represents a compelling case for examining sustainable destination development, combining high tourism potential with persistent structural and institutional constraints.

Ha'il possesses a distinctive cultural and natural heritage reflecting its deep historical significance in northwestern Saudi Arabia. Among its most notable sites are the Jubbah and Shuwaymis rock-art areas, which together form the UNESCO-inscribed property Rock Art in the Hail Region of Saudi Arabia. These sites contain thousands of petroglyphs and inscriptions depicting human and animal figures that document more than ten millennia of human activity (UNESCO, 2015). Complementing this ancient artistic record are architectural landmarks such as A'arif Fort and Barzan Palace. A'arif Fort, constructed around 1840 CE, occupies a commanding hilltop position and has long served as one of the city's most treasured symbols (Rehman & Alnuzhah, 2022). Barzan Palace, first built in 1808 and expanded under the Rashidi Amirs, once functioned as a royal residence and administrative center, representing Ha'il's political and cultural prominence during the 19th century (Albaqawy, Alnaim, Bay, & Touahmia, 2023). In addition to its tangible heritage, Ha'il is also known for dynamic contemporary events such as the Ha'il International Rally, a major annual motorsport competition that attracts international participants and highlights the region's rugged desert landscape (Abdel Azim Ahmed, 2017). Collectively, these cultural landmarks and events underscore Ha'il's enduring role as a crossroads of heritage, art, and modern adventure in Saudi Arabia.

Despite these assets, tourism development in the region remains spatially uneven and institutionally fragmented. Ha'il City benefits from relatively advanced highways and airport facilities, whereas peripheral heritage areas continue to face inadequate road networks, weak public transport, and limited interpretive infrastructure (Alharbi, Aldosari, & Alanazi, 2023). These disparities concentrate tourism activities in the urban core and restrict the distribution of benefits to rural and heritage communities (Chaaben, Elleuch, Kahouli, & Zneidi, 2025).

Environmental challenges compound these issues. Ha'il's fragile desert ecosystems are increasingly threatened by unregulated visitation, off-road driving, and insufficient conservation planning (Albat, Alsaman, & Albakjaji, 2024). These pressures are intensified by socio-economic inequalities between the well-connected urban core and peripheral rural communities, where tourism's economic and social benefits are unevenly distributed. This situation exemplifies the "sustainability implementation gap," which captures the disparity between ambitious policy goals and limited institutional capacity in emerging destinations (Tosun, 2000).

Existing research on Saudi tourism has largely focused on flagship destinations such as AlUla, Riyadh, and Jeddah, leaving regions like Ha'il underexplored (Al Salah, 2023). Few empirical studies have examined how infrastructure, accessibility, and regional challenges interact to shape sustainability outcomes in semi-arid peripheral regions, highlighting an important theoretical and practical gap.

The sustainable tourism development framework provides an appropriate analytical lens for addressing this gap. It posits that tourism sustainability results from the interaction between enabling conditions such as infrastructure, accessibility, and human capital, and contextual constraints such as governance inefficiency and ecological fragility (Sofield, 2003).

Building on this foundation, the present study investigates how infrastructure and accessibility quality (IAQ) and regional challenges (RC) influence sustainable tourism development (STD) in Ha'il. Using Partial Least Squares Structural Equation Modelling (PLS-SEM), it empirically tests the direct relationships among these constructs to reveal how structural enablers and institutional barriers jointly shape sustainability outcomes. The study contributes to both theory and policy by demonstrating that infrastructure, while essential, yields sustainable benefits only when supported by effective governance and environmental stewardship. The findings provide evidence-based insights for advancing inclusive growth, heritage conservation, and ecological balance in Ha'il and similar arid-region destinations under Saudi Arabia's Vision 2030.

1.1. Conceptual Framework

This study is grounded in the sustainable tourism development framework, which posits that sustainability results from the balanced integration of economic viability, social equity, and environmental integrity (Elkington, 1998). Achieving sustainability requires the interaction of enabling conditions such as infrastructure, accessibility,

and human capital with contextual governance and ecological realities (Butler, 1998). Within this perspective, tourism development is viewed as a dynamic system shaped by both facilitating and constraining forces rather than as a linear process of continuous growth.

In the context of Ha'il, this framework provides an appropriate analytical lens to explore how infrastructure and accessibility quality (IAQ) function as key enablers of sustainable tourism, while regional challenges (RC) act as systemic constraints that limit sustainability outcomes. Infrastructure and accessibility refer to the adequacy, inclusiveness, and efficiency of transport, digital, and service systems that support mobility, enhance visitor experiences, and ensure equitable participation in tourism benefits (Abbas, Mamirkulova, Al-Sulaiti, Al-Sulaiti, & Dar, 2025). Regional challenges, in contrast, encompass governance inefficiency, institutional fragmentation, and ecological fragility, all of which can undermine destination sustainability (Chaaben et al., 2025).

Drawing on these theoretical foundations, the study tests two core hypotheses.

H₁: Infrastructure and accessibility quality (IAQ) are positively associated with sustainable tourism development (STD), reflecting the premise that well-developed and inclusive infrastructure enhances destination competitiveness and balanced growth.

H₂: Regional challenges (RC) are negatively associated with sustainable tourism development (STD), indicating that institutional and ecological constraints weaken sustainability performance.

Together, these relationships capture the central proposition of sustainable tourism theory: the sustainability of tourism systems depends on the interplay between enabling factors and contextual limitations. This framework aligns closely with the objectives of Saudi Arabia's Vision 2030, which emphasizes infrastructure development, governance reform, and environmental stewardship as foundations for sustainable regional transformation.
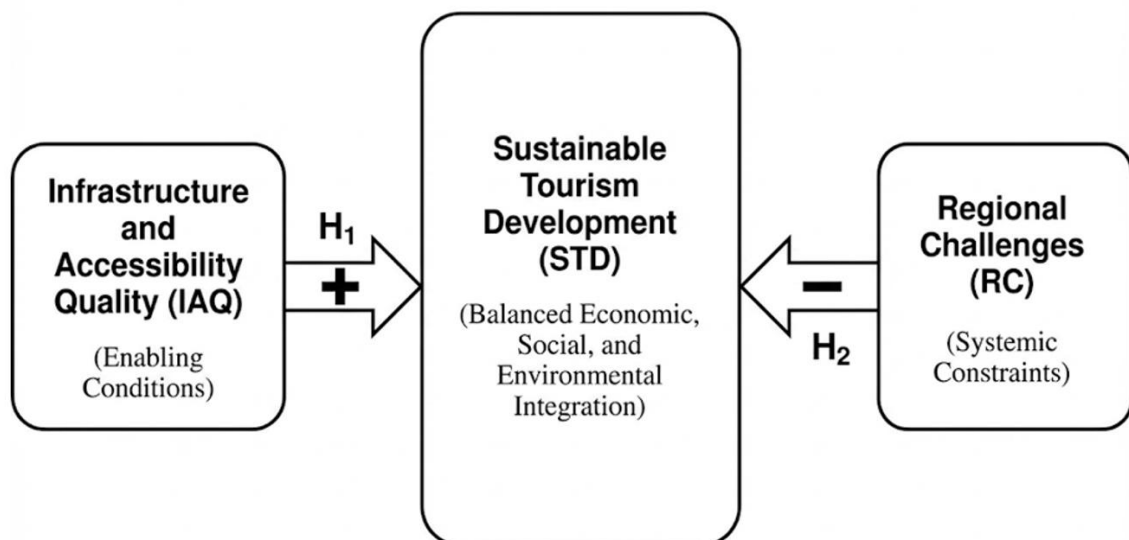

Figure 1. Conceptual framework.

Figure 1 illustrates the conceptual framework shows that Infrastructure and Accessibility Quality (IAQ) positively influence Sustainable Tourism Development (STD), while Regional Challenges (RC) negatively influence STD.

2. REVIEW OF LITERATURE AND HYPOTHESES

2.1. Infrastructure and Accessibility Quality (IAQ) and Sustainable Tourism Development (STD)

Infrastructure and accessibility form the structural foundation of sustainable tourism development (STD), influencing destination image, visitor satisfaction, and equitable participation in tourism benefits (Gössling & Hall, 2006). High-quality infrastructure facilitates mobility and connectivity while promoting environmental sustainability through improved resource efficiency and the dispersion of visitor flows (Bahou, Triki, Maâloul, & Tissaoui, 2024).

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Empirical evidence indicates that infrastructure investment functions as a catalyst for comprehensive destination sustainability rather than merely as a physical enabler. Abbas et al. (2025) found that large-scale infrastructure projects enhance community well-being and environmental sustainability, while Mamirkulova et al. (2020) observed that infrastructure development along the New Silk Road improved residents' quality of life by supporting sustainable tourism growth.

In the Saudi Arabian context, infrastructure assumes a multidimensional role that includes mobility enhancement, digital transformation, and institutional modernization. Bahou et al. (2024) emphasized the significance of digital transformation and human capital development for achieving tourism sustainability in Ha'il, while Al Salah (2023) confirmed that transport and information infrastructure investments positively influence tourism performance. Collectively, these studies suggest that infrastructure contributes to sustainability through economic, technological, and social pathways.

Nonetheless, critical scholarship warns that infrastructure-driven growth may generate unsustainable outcomes, including environmental degradation, resource depletion, and spatial inequality, when not accompanied by effective governance mechanisms (Mowforth & Munt, 2016). Hence, infrastructure should be considered a necessary but insufficient condition for sustainability.

Accessibility, as a complementary dimension of infrastructure, also embodies the principles of inclusion and social equity. Ginting et al. (2024) argue that accessible design removes physical and structural barriers to participation, while Aulet and Duda (2020) caution that uncontrolled accessibility in sacred or ecologically sensitive areas may threaten their cultural and environmental integrity.

In summary, the integration of transportation networks, digital connectivity, and inclusive design constitutes the backbone of sustainable tourism in emerging destinations. When equitably distributed and properly managed, these elements enhance competitiveness, strengthen environmental management, and broaden local participation in the tourism value chain (Byrd, 2007). Accordingly, the first hypothesis is formulated as follows:

H_1: *Infrastructure and accessibility quality (IAQ) are positively associated with sustainable tourism development (STD).*

2.2. Regional Challenges (RC) and Sustainable Tourism Development (STD)

Regional challenges (RC), encompassing governance inefficiencies, ecological vulnerability, and human capital limitations, are critical determinants of sustainability outcomes in peripheral destinations. Structural and institutional barriers often hinder the translation of tourism strategies into sustainable results, particularly in developing contexts. Tosun (2000) identified persistent constraints to community participation, while Sharpley (2020) emphasized that fragmented governance and limited coordination reduce tourism's contribution to sustainable development.

Recent studies reaffirm that governance quality, institutional capacity, and digital readiness are pivotal for implementing sustainability principles (Chaaben et al., 2025). In Saudi Arabia, inter-agency misalignment and regional disparities continue to constrain tourism's sustainable progression, particularly in Ha'il (Al-Ghamdi & Almuhrzi, 2024).

Empirical research across various contexts reveals that inadequate connectivity, insufficient infrastructure, and weak spatial planning diminish destination competitiveness (Albat et al., 2024). In Ha'il, geographical isolation and arid environmental conditions intensify these barriers, while unregulated visitation and off-road driving accelerate environmental degradation (Said, 2022).

Governance inefficiency further amplifies these challenges. Chaaben et al. (2025) note that fragmented policy frameworks and limited financial capacity undermine participatory governance and institutional performance. Bajrami, Radosavac, Cimbaljević, Tretiakova, and Syromiatnikova (2020) similarly report that community exclusion diminishes local support for sustainability initiatives. In Ha'il, weak digital marketing systems and shortages in tourism-related human capital further restrict competitiveness (Bahou et al., 2024).

Peripheral destinations such as Ha'il often experience limited investment and weaker linkages between tourism and local livelihoods (Alharbi et al., 2023). Even when infrastructure projects are implemented, their sustainable utilization is frequently constrained by poor coordination and inadequate technical expertise (Almalki et al., 2022). Collectively, governance fragmentation, ecological vulnerability, and socio-economic disparity represent systemic barriers to achieving sustainability in Ha'il.

Addressing these regional challenges requires the establishment of integrated governance frameworks, strengthened institutional capacity, and spatially balanced investment strategies that align with the objectives of Vision 2030. Accordingly, the second hypothesis is proposed as follows.

H_2: Regional challenges (RC) are negatively associated with sustainable tourism development (STD).

3. RESEARCH METHODOLOGY

3.1. Research Design and Approach

This study employed a quantitative, cross-sectional survey design to examine the factors influencing sustainable tourism development (STD) in the Ha'il region of Saudi Arabia, as perceived by tourists who visited between January and March 2024. This design enabled the empirical testing of hypothesized relationships between infrastructure and accessibility quality (IAQ), regional challenges (RC), and STD within a single time frame.

A quantitative approach was selected for its capacity to test theoretical relationships, ensure objectivity, and enable statistical generalization (Creswell & Clark, 2017). The cross-sectional nature of the data offers a contemporary snapshot of visitor perceptions and destination performance, consistent with studies that evaluate sustainability outcomes and policy implementation (Hair, Hult, Ringle, & Sarstedt, 2022). This approach is particularly relevant for Ha'il, where empirical research remains limited and data-driven insights are needed to inform regional policy under Vision 2030.

3.2. Instrumentation

Data were collected through a structured questionnaire designed to measure the determinants of sustainable tourism development in Ha'il. The instrument comprised two main sections. The first section captured demographic and travel characteristics, including gender, age, nationality, travel purpose, and frequency of visits. The second section measured the latent constructs, Infrastructure and Accessibility Quality (IAQ), Regional Challenges (RC), and Sustainable Tourism Development (STD), adapted from validated instruments in tourism and destination management research (Byrd, 2007; Sofield, 2003).

Respondents indicated their agreement using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree), ensuring comparability and reliability for parametric analysis. Construct operationalization followed established definitions and empirical models to maintain conceptual validity. The complete measurement items are provided in Appendix A.

To ensure linguistic and cultural equivalence, the survey was translated from English to Arabic using the forward–backward translation method (Brislin, 1970). Bilingual experts reviewed both versions for clarity and contextual appropriateness. A pilot test involving 60 tourists was conducted to evaluate item clarity, completion time, and reliability. Based on participant feedback, minor revisions were made, and redundant items were removed.

Reliability and content validity were assessed prior to full-scale administration. Cronbach's alpha values for all constructs exceeded 0.70, confirming internal consistency (Nunnally, 1978). Furthermore, six academic experts in sustainable tourism and governance reviewed the instrument to ensure content validity and contextual relevance. Their input enhanced the alignment between theoretical constructs and measurement indicators.

3.3. Survey Respondents and Sampling Procedure

The target population comprised all domestic and international tourists who visited Ha'il during the first quarter of 2024 (January–March). According to the Ministry of Tourism (2023), approximately 2.2 million tourists visited the Ha'il region in 2023, including 1.8 million domestic and 0.4 million international visitors. Given the seasonal consistency of tourism patterns, this figure was used as the population reference for sample size calculation.

The minimum required sample size was estimated using the formula of Krejcie and Morgan (1970) and verified through the Raosoft sample size calculator. A target sample of 385 respondents was determined as necessary to achieve a 95 percent confidence level and a 5 percent margin of error. Accordingly, 385 questionnaires were distributed between January and March 2024. After data screening, 282 complete and usable responses were obtained, yielding a response rate of 73.2%. This represents 282 valid responses from 385 distributed surveys, with 103 responses excluded due to incompleteness or inconsistent response patterns. This final sample size is acceptable for exploratory tourism research and sufficient for Partial Least Squares Structural Equation Modeling (PLS-SEM) analysis, as it meets and exceeds common heuristic and power requirements for the method (Hair et al., 2022).

Given the diversity and mobility of tourists, a non-probability purposive quota sampling technique was employed to ensure balanced representation across nationality, age, and travel purpose. Data collection was conducted through two complementary methods: (1) QR-coded online surveys distributed at key attractions and (2) in-person administration at hotels, transportation terminals, and major tourism venues. This hybrid strategy enhanced sample heterogeneity and mitigated location bias, consistent with best practices for tourism field studies (Kline, 2015).

The demographic composition of respondents was balanced across gender and age groups, with 53.2 percent male and 46.8 percent female participants. The largest age group was 46–60 years (38.3 percent), representing a mature and experience-oriented tourist segment that prioritizes environmental quality and heritage preservation. This demographic profile provides a suitable basis for assessing perceptions of sustainability in Ha'il.

3.4. Data Analysis

Data were coded and processed using SPSS version 29 before structural modeling. Missing values, which accounted for less than 5 percent of the total data, were addressed through the Expectation–Maximization (EM) algorithm, a more robust approach than simple mean substitution that better preserves relationships between variables (Tabachnick & Fidell, 2019). Outliers were identified using Mahalanobis D^2 statistics, and normality was assessed through skewness and kurtosis values, both within the acceptable ±2 range (Tabachnick & Fidell, 2019).

Data analysis was conducted using Partial Least Squares Structural Equation Modeling (PLS-SEM) with SmartPLS version 4. This approach is suitable for complex models containing latent constructs, non-normal data, and moderate sample sizes (Hair et al., 2022). The analysis proceeded in two main stages. First, the measurement model was assessed for indicator reliability, internal consistency, convergent validity, and discriminant validity, using the criteria of Average Variance Extracted (AVE > 0.50) and Heterotrait–Monotrait Ratio (HTMT < 0.90). Second, the structural model was evaluated to test the hypothesized relationships among the constructs. Bootstrapping with 5,000 resamples was performed to generate robust estimates of path coefficients, t-values, and p-values.

Model adequacy was examined using multiple goodness-of-fit indices, including the coefficient of determination (R^2), effect size (f^2), predictive relevance (Q^2), and collinearity diagnostics (VIF). Statistical significance was established at the 0.05 level. This procedure provided a rigorous empirical basis for examining the effects of infrastructure and accessibility quality and regional challenges on sustainable tourism development, and for quantifying their combined explanatory power in the context of Ha'il.

4. RESULTS

4.1. Assessment of the Measurement Model

Before testing the hypothesized structural relationships, the measurement model was examined to ensure that all constructs met the standards for reliability, convergent validity, and discriminant validity. The model included three latent constructs: Infrastructure and Accessibility Quality (IAQ), Regional Challenges (RC), and Sustainable Tourism Development (STD).

Convergent validity was assessed through standardized factor loadings and Average Variance Extracted (AVE), using a minimum threshold of 0.50. Construct reliability was evaluated using Cronbach's alpha and Composite Reliability (CR), with acceptable values set above 0.70. All retained items demonstrated loadings above 0.50, and all constructs achieved AVE and CR values exceeding the recommended thresholds, confirming internal consistency and convergent validity (Fornell & Larcker, 1981).
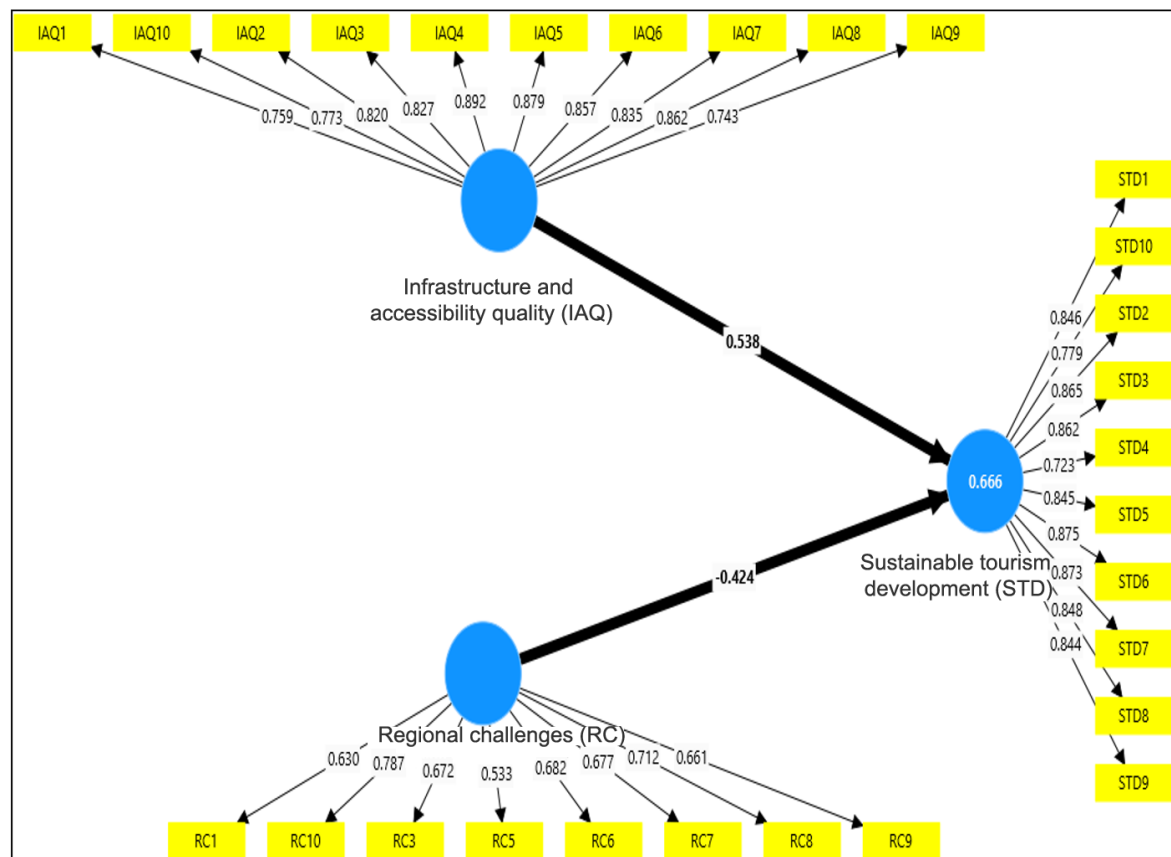

Figure 2. Outer model assessment.

Figure 2 illustrates the outer model assessment, displaying the standardized factor loadings of all retained measurement items for IAQ, RC, and STD constructs.

4.1.1. Assessment of Constructs' Reliability and Convergent Validity

During the assessment of the measurement model, several reflective items were excluded due to low standardized loadings below the 0.60 threshold, indicating insufficient contribution to their respective constructs. Specifically, items RC2 ("Limited inter-agency coordination"), RC4 ("Insufficient environmental monitoring systems"), and RC5 ("Weak enforcement of conservation regulations") were removed from the Regional Challenges (RC) construct because their factor loadings did not meet the minimum acceptable level for indicator reliability (Hair et al., 2022). The removal of these low-performing items improved the overall construct validity and internal consistency of the model.

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All constructs recorded average variance extracted (AVE) values greater than 0.50 and composite reliability (CR) values above 0.70 (see Table 1). After the removal of low-loading items, all standardized loadings exceeded 0.50, meeting the minimum acceptable standard for reflective indicators (Hair et al., 2022). Although ideal loadings exceeded 0.70, items within the 0.50–0.70 range were retained to preserve theoretical and content validity. Cronbach's alpha and CR values surpassed 0.70 for all constructs, demonstrating high internal consistency. It should be noted that the RC construct recorded an AVE of 0.506, which, while meeting the minimum threshold, is lower than the other constructs. This suggests that the RC construct captures somewhat more variance from measurement error than IAQ and STD, though the value remains within acceptable parameters. The AVE values indicated that each construct explained more than half of the variance of its associated indicators, confirming strong convergent validity (Fornell & Larcker, 1981). These results validate the robustness of the measurement model and confirm its suitability for subsequent structural analysis.

Table 1. Constructs' reliability and convergent validity.

Constructs	Items	Item loadings	Cronbach's alpha	Composite reliability	AVE
Infrastructure and accessibility quality (IAQ)	IAQ1	0.759	0.949	0.953	0.688
	IAQ2	0.825			
	IAQ3	0.828			
	IAQ4	0.890			
	IAQ5	0.882			
	IAQ6	0.857			
	IAQ7	0.837			
	IAQ8	0.868			
	IAQ9	0.750			
	IAQ10	0.784			
Regional challenges (RC)	RC1	0.616	0.838	0.900	0.506
	RC3	0.643			
	RC6	0.705			
	RC7	0.655			
	RC8	0.698			
	RC9	0.643			
	RC10	0.801			
Sustainable tourism development (STD)	STD1	0.849	0.952	0.955	0.701
	STD2	0.870			
	STD3	0.861			
	STD4	0.710			
	STD5	0.847			
	STD6	0.875			
	STD7	0.873			
	STD8	0.844			
	STD9	0.848			
	STD10	0.781			

Note: See Appendix A for complete item descriptions.

4.1.2. Discriminant Validity

Discriminant validity was examined using the Fornell–Larcker criterion and the Heterotrait–Monotrait (HTMT) ratio.

1. Fornell–Larcker Criterion

According to Fornell and Larcker (1981), the square root of the AVE for each construct should exceed its correlations with other constructs. As presented in Table 2, this condition was met for all constructs, confirming that

each latent variable was empirically distinct. Table 3 presents the HTMT ratios, confirming discriminant validity among constructs with all values below the 0.90 threshold.

Table 2. Discriminant validity: Fornell–Larcker criterion.

Construct	1	2	3
1. Sustainable tourism development (STD)	**0.837**		
2. Infrastructure and accessibility quality (IAQ)	0.728	**0.829**	
3. Regional challenges (RC)	-0.662	-0.451	**0.711**

Note: Bold diagonal values represent the square root of AVE.

2. Heterotrait–Monotrait Ratio (HTMT)

To supplement the Fornell–Larcker assessment, the HTMT ratio was used as a more stringent measure of discriminant validity (Henseler, Ringle, & Sarstedt, 2015). All HTMT values were below the 0.90 threshold, indicating satisfactory discriminant validity.

Table 3. Discriminant validity: HTMT ratios.

Construct	1	2	3
1. Sustainable tourism development (STD)			
2. Infrastructure and accessibility quality (IAQ)	0.760		
3. Regional challenges (RC)	0.582	0.359	

4.2. Estimation of the Hypothesized Structural Model

Following validation of the measurement model, the structural model was assessed to test the hypothesized relationships among the constructs. Bootstrapping procedures were performed using SmartPLS version 4, following the guidelines of Hair et al. (2022). A resampling of 5,000 iterations was used to generate robust estimates of path coefficients and significance levels. Figure 3 graphically represents the inner model after the bootstrapping procedure, illustrating the path coefficients between IAQ, RC, and STD with t-values and significance levels.
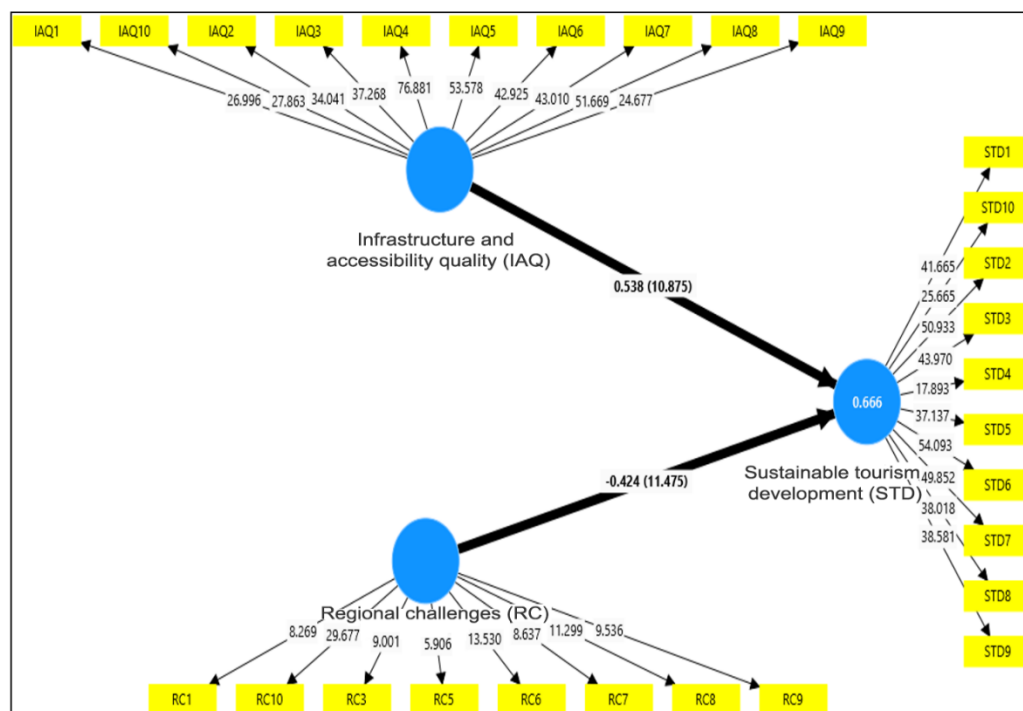

Figure 3. Graphical representation of the inner model after the bootstrapping procedure.

4.3. Hypotheses Testing

The results of the structural model evaluation are summarized in Table 4. The analysis revealed that Infrastructure and Accessibility Quality (IAQ) had a strong, positive, and statistically significant association with Sustainable Tourism Development (STD) ($\beta = 0.538$, t = 10.875, p < 0.001). This finding indicates that improvements in transport, digital, and service infrastructure substantially enhance sustainable tourism outcomes in the Ha'il region.

Conversely, Regional Challenges (RC) exhibited a significant negative association with STD ($\beta = -0.424$, t = 11.475, p < 0.001). This suggests that higher levels of governance inefficiency, environmental fragility, and logistical barriers constrain progress toward sustainability objectives. Both hypotheses (H_1 and H_2) were therefore supported, reinforcing the theoretical proposition that sustainability outcomes are jointly determined by enabling factors and contextual constraints.

Table 4. Hypothesis testing results.

Hypothesis	Relationship	β	t-value	p-value	Decision
H_1	IAQ → STD	0.538	10.875	0.000	Supported
H_2	RC → STD	−0.424	11.475	0.000	Supported

4.4. Coefficient of Determination and Effect Size

The coefficient of determination (R^2) measures the proportion of variance in the dependent construct explained by its predictors, while the effect size (f^2) quantifies each predictor's individual contribution. According to Cohen (1988), benchmarks, f^2 values of 0.02, 0.15, and 0.35 indicate small, medium, and large effects, respectively.

The model produced an R^2 value of 0.666, indicating that 66.6 percent of the variance in Sustainable Tourism Development was explained by IAQ and RC. This reflects substantial explanatory power within the model. The effect size results further showed that IAQ had a large positive effect ($f^2 = 0.652$) on STD, while RC had a substantial negative effect ($f^2 = 0.469$). These results underscore the central role of infrastructure and accessibility in fostering sustainability, while emphasizing the need to address regional constraints that limit Ha'il's sustainable tourism potential. Table 5 presents the coefficient of determination (R^2) and effect size (f^2) values, demonstrating the explanatory power of the model.

Table 5. Coefficient of determination and effect size.

Hypothesis	Structural path	f²	R²
H_1	IAQ → STD	0.652	0.666
H_2	RC → STD	0.469	

5. DISCUSSION AND CONCLUSION

5.1. Discussion of the Results

This study examined how infrastructure and accessibility quality (IAQ) and regional challenges (RC) influence sustainable tourism development (STD) in Ha'il. The findings from the PLS-SEM analysis offer a clear and theoretically coherent picture: IAQ exerts a positive and substantial effect on STD ($\beta = 0.538$, t = 10.875, p < 0.001), while RC has a significant negative effect ($\beta = -0.424$, t = 11.475, p < 0.001). Together, these variables explain 66.6 percent of the variance in STD ($R^2 = 0.666$), reflecting strong explanatory power. Both predictors demonstrate large effect sizes ($f^2 = 0.652$ for IAQ; $f^2 = 0.469$ for RC), underscoring their critical importance in shaping Ha'il's sustainability outcomes. The robust psychometric properties of the measurement model further reinforce the reliability of these results.

The positive IAQ–STD relationship confirms that investments in transport, digital, and service infrastructure enhance sustainability outcomes by improving mobility, dispersing visitor flows, and enhancing destination quality. This finding aligns with prior research emphasizing that infrastructure development strengthens competitiveness,

residents' quality of life, and environmental management while promoting equitable access (Abbas et al., 2025). In the Ha'il context, where peripheral heritage areas have historically lagged behind the urban core, the magnitude of this effect suggests that reducing spatial and digital inequalities, through road improvements, transit connectivity, and online services, can yield immediate sustainability gains through better visitor experiences, more balanced tourism distribution, and lower environmental pressure.

Conversely, the negative RC–STD association confirms that governance fragmentation, weak inter-agency coordination, and ecological vulnerability undermine sustainability progress (Chaaben et al., 2025). The large effect size indicates that these constraints are systemic and not peripheral. In practice, such challenges manifest in uneven regional investment, underdeveloped management structures, and pressures on fragile desert ecosystems (Albat et al., 2024). Even where physical infrastructure is in place, poor maintenance, limited community engagement, and institutional inefficiency can prevent its effective utilization, thereby diminishing the potential sustainability returns from infrastructural investments.

Overall, the findings empirically validate a key proposition of Sustainable Tourism Development Theory (STDT): sustainability emerges from the interaction between enabling conditions and contextual constraints (Butler, 1998). Infrastructure acts as a facilitating mechanism, while regional challenges operate as structural inhibitors. Although this study formally tested only direct relationships (H_1 and H_2), the results imply a contingent dynamic where the effectiveness of infrastructure depends on governance capacity and environmental stewardship. Future research incorporating mediation and moderation effects could better capture this interplay, thereby advancing causal understanding of how institutional quality amplifies or constrains infrastructure's contribution to sustainability.

5.2. Theoretical and Practical Implications

5.2.1. Theoretical Contribution

This study contributes to the theoretical discourse on sustainable tourism by challenging the assumption that infrastructure alone guarantees sustainability. The results demonstrate that while IAQ is a necessary condition for sustainability, it is not sufficient in the absence of institutional coherence, participatory governance, and ecological stewardship. This finding extends STDT by highlighting that sustainability is not a linear outcome of infrastructural improvement but a co-produced process shaped by both structural enablers and systemic constraints.

The findings move beyond the reductionist notion of "infrastructure determinism" that dominates some development-focused tourism studies. The strong yet opposing effects of IAQ and RC support a systems-oriented understanding of destination sustainability, in which physical assets, institutional arrangements, and socio-ecological processes are interdependent. The substantial explanatory power of the model ($R^2 = 0.666$) reinforces the argument that infrastructure cannot generate sustainable outcomes in isolation from governance and environmental capacity.

Moreover, by empirically demonstrating that governance fragmentation and institutional weakness act as countervailing forces to infrastructural modernization, this study strengthens the theoretical bridge between sustainable tourism and governance scholarship. The results corroborate the arguments of Tosun (2000) and Sharpley (2000) that participatory deficits and policy incoherence are persistent barriers to sustainability in developing contexts. Through an empirically validated model, the study advances a holistic conceptual framework that situates infrastructure within the broader governance–sustainability nexus, emphasizing that development outcomes depend on institutional quality as much as on physical investment.

In this respect, infrastructure is repositioned as a context-dependent catalyst rather than an autonomous driver of sustainable development. This perspective deepens the theoretical understanding of sustainability transitions in peripheral tourism systems, particularly in arid and institutionally fragmented regions such as Ha'il.

5.2.2. Policy and Managerial Implications

From a policy perspective, the findings highlight that infrastructural development must be embedded within coherent governance frameworks to produce lasting sustainability outcomes. Policymakers should prioritize connective and inclusive infrastructure that physically and digitally integrates urban cores with peripheral heritage and nature-based destinations. Such investments should be complemented by systematic maintenance, universal design, and environmental safeguards, including carrying capacity assessments, eco-sensitive construction practices, and visitor flow management.

Institutional coordination should also be strengthened through the creation of a dedicated Destination Management Organization (DMO) for Ha'il, empowered to align tourism, heritage, and environmental agendas. Establishing integrated performance metrics, such as visitor dispersion, conservation indicators, and resident satisfaction, would enhance accountability and ensure that development outcomes align with sustainability goals.

Furthermore, participatory governance should be institutionalized to ensure local ownership and legitimacy of tourism initiatives. Genuine stakeholder participation, beyond token consultation, can improve community support, preserve cultural authenticity, and facilitate equitable benefit-sharing (Byrd, 2007). Involving residents in monitoring, planning, and decision-making processes would narrow the "participation gap" long identified in developing tourism systems (Tosun, 2000).

Policy efforts should also embrace data-driven conservation and adaptive management. Deploying digital monitoring tools to track visitor movement, ecosystem conditions, and service quality can enable responsive management of fragile desert environments. Infrastructure expansion should therefore occur alongside spatial zoning, conservation planning, and environmental education initiatives.

Finally, investment in human capital and digital readiness is essential. Building local expertise in sustainable operations, interpretation, and digital marketing can transform physical assets into inclusive, high-quality tourism experiences consistent with Vision 2030's objectives of innovation and diversification (Bahou et al., 2024). Enhancing digital literacy and e-tourism capabilities will strengthen competitiveness and ensure that sustainability transitions are technologically supported rather than administratively constrained.

The managerial implication is clear: Ha'il's sustainability depends not only on modern infrastructure but also on institutional maturity and participatory governance. Infrastructure should function as a foundation for coordination, inclusion, and conservation rather than as a substitute for them.

5.3. Limitations and Directions for Future Research

While this study provides strong empirical support for the proposed model, several limitations warrant acknowledgment. The use of cross-sectional, self-reported data limits causal inference and may be susceptible to common method variance (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). Future research employing longitudinal or multi-source designs, including objective environmental, governance, or mobility indicators, would enhance temporal and causal validity.

The purposive sampling strategy, although suitable for exploratory purposes, restricts the generalizability of findings. Subsequent studies should adopt probability-based or stratified sampling techniques to capture more representative samples of tourists and residents (Kline, 2015). Comparative analyses across other Saudi regions or Gulf destinations could also clarify whether the IAQ–RC–STD dynamics observed in Ha'il are context-specific or generalizable. Methodologically, future research could extend the current model by testing moderating and mediating effects, for instance, examining how regional challenges attenuate the positive influence of infrastructure or how factors such as resident support, visitor satisfaction, and institutional trust mediate these pathways (Hair et al., 2022). Employing moderated PLS-SEM or multi-group analysis could help quantify how governance quality shapes infrastructure's contribution to sustainability outcomes. Spatially oriented methods, such as GIS-based or spatial econometric models, could further enrich analysis by capturing variations in accessibility, investment equity, and

ecological sensitivity across Ha'il's landscapes (Al Salah, 2023). Such approaches would support more granular and evidence-based planning for sustainable regional development.

Theoretically, future studies should continue to bridge sustainability transition theory with destination governance frameworks, exploring how digital transformation, institutional learning, and networked governance mediate the relationship between physical capital and sustainable outcomes.

In conclusion, this study demonstrates that Ha'il's sustainable tourism future depends not only on infrastructural development, roads, airports, and digital networks, but also on how these assets are governed, maintained, and integrated. Achieving Vision 2030's sustainability objectives, therefore, requires a dual investment strategy that simultaneously strengthens physical connectivity and institutional capacity. Infrastructure should serve as a vehicle for inclusion, resilience, and ecological stewardship rather than as an end in itself.

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Appendix A. Measurement Items.

Infrastructure and Accessibility Quality (IAQ)

- IAQ1: Ha'il has well-maintained road networks connecting major attractions.
- IAQ2: Public transportation options in Ha'il are accessible and reliable.
- IAQ3: Digital/online tourism services are easily available.
- IAQ4: Airport facilities meet international standards.
- IAQ5: Signage and wayfinding systems are clear and helpful.
- IAQ6: Accommodation facilities are of good quality.
- IAQ7: Tourist information centers are accessible and informative.
- IAQ8: Internet connectivity is reliable throughout tourism areas.
- IAQ9: Infrastructure accommodates visitors with special needs.
- IAQ10: Service quality at tourism sites meets expectations.

Regional Challenges (RC)

- RC1: Coordination between government agencies is limited.
- RC3: Tourism planning lacks community input.
- RC6: Environmental protection measures are insufficient.
- RC7: Remote heritage sites lack adequate infrastructure.
- RC8: Skilled tourism workforce is limited.
- RC9: Marketing and promotion of Ha'il tourism is inadequate.
- RC10: Investment in peripheral areas is insufficient.

Items RC2 ("Limited inter-agency coordination"), RC4 ("Insufficient environmental monitoring systems"), and RC5 ("Weak enforcement of conservation regulations") were removed due to low factor loadings (<0.60).

Sustainable Tourism Development (STD)

- STD1: Tourism development in Ha'il protects natural resources.
- STD2: Local communities benefit economically from tourism.
- STD3: Tourism preserves cultural heritage and traditions.
- STD4: Visitor management prevents environmental degradation.
- STD5: Tourism creates employment for local residents.
- STD6: Tourism development is planned for long-term viability.
- STD7: Tourism activities respect local culture and values.
- STD8: Tourism revenues support conservation efforts.
- STD9: Tourism facilities are designed with environmental sensitivity.
- STD10: Tourism contributes to regional development equity.