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Climate and Tourist Location in Saudi Arabia: A Spatial and Econometric Analysis of the Climatic Determinants of Tourist Area Selection

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ABSTRACT

The objective of this research is to empirically analyze how climatic factors influence the choice and spatial distribution of tourist areas in Saudi Arabia over the period 2005–2024. This study adopts a multidimensional perspective linking climatology, spatial economics, and tourist behavior. Methodologically, the work employs a spatial panel model and a discrete choice model to assess the direct and indirect effects of climatic variables—including average temperature, number of extreme days, humidity, rainfall, and sandstorms—on regional and seasonal tourist flows. The data used come from the Saudi Tourism Authority, the ERA5 and WorldClim climate databases, and environmental statistics from the Ministry of Environment. Preliminary empirical results indicate a non-linear relationship between climatic conditions and tourist activity. Coastal and mountainous areas exhibit a positive elasticity to thermal comfort, particularly during the cooler season (November–March), while desert areas experience a significant drop in visitor numbers during the months of extreme heat. Simulations under future climate scenarios (RCP 4.5 and 8.5) suggest a gradual shift in demand towards higher-altitude regions and a shortening of the summer tourist season. Furthermore, the spatial dependence observed in the SAR and SDM models confirms the presence of neighborhood effects: the dynamics of a tourist region influence those of its neighbors, especially during periods of extreme conditions.

Keywords: Tourism; Destination Choice; Thermal Comfort; Climate Change; Regional Attractiveness; Tourism Sustainability

INTRODUCTION

Saudi Arabia (Kingdom of Saudi Arabia) is at a turning point in its economic development through tourism: through the "Vision 2030" program, tourism is now identified as a strategic pillar of diversification, and investment efforts are increasing to make the country a destination of choice. In this context, the study of the role of climate in the attractiveness of tourist areas is of growing importance. Climate—particularly temperature, humidity, rainfall, and extreme weather events—shapes not only the tourist experience but also the timing, seasonality, and destination preferences of visitors.

From an empirical perspective, numerous studies have demonstrated that climatic conditions are a significant determinant of tourism demand, for example, through thermal comfort indices or the "optimal climate window" (European Commission, 2023). However, the majority of these studies focus on temperate or coastal contexts (e.g., Europe or Southeast Asia), and few studies concentrate on arid or desert areas such as Saudi Arabia. Recently, a study conducted in the AlUla region assessed the suitability of the climate for tourism using the Tourism Climate Index (TCI) and found that, during certain seasons, conditions are "very good" to "ideal" (Almushayt, 2025). The fact that some regions benefit from a relative climatic advantage (e.g., higher altitudes or coastal exposure) suggests that the climatic factor could play a substantial role in differentiating tourist areas within a country.

Furthermore, Saudi Arabia already faces significant climatic constraints: extreme summer temperatures exceeding 45-50°C, episodes of dust and sandstorms, and highly variable weather conditions depending on the region and season. In this context, the question of the extent and manner in which climate influences the choice of tourist areas becomes central to land-use planning, infrastructure development, and the sustainability of tourism. Even though the tourism sector is experiencing strong growth—for example, tourism's share of Saudi GDP exceeded 6% in 2023 according to some reports (Al-Barakati, 2023)—the climatic dimension remains largely unexplored. The link between climatic conditions, regional attractiveness, and the decision to visit a tourist area therefore warrants increased attention.

This study aims to empirically analyze how climatic factors influence the location and visitor numbers of tourist areas in Saudi Arabia between 2005 and 2024. Three guiding research questions inform the analysis: (1) To what extent do climatic conditions (temperature, humidity, extreme weather days) explain the spatial and seasonal variation in tourist flows? (2) Can climatic comfort thresholds be identified beyond which visitor numbers decline? (3) Do climatic effects vary according to destination type (coast, mountains, desert)? To answer these questions, we adopt a mixed-methods approach: firstly, a discrete choice model (conditional logit) to capture how tourists "select" an area based on its climatic and structural attributes; secondly, a spatial panel model (areas × months) to quantify the impact of climatic variables on visitor numbers, while controlling for accessibility, hotel availability, and seasonality.

The originality of this study lies in its integration of a spatial and climatic econometric approach applied to the Saudi context, a field still relatively unexplored in the literature on Middle Eastern tourism. It proposes an operational measure of arid tourism comfort and offers a prospective assessment of the impacts of climate change on the geography of tourism demand. On a practical level, the results provide useful guidance for regional diversification, seasonal management of tourist flows, and the development of climate-resilient infrastructure, thus contributing to the sustainable implementation of Vision 2030.

This study makes a twofold contribution. First, it enriches the literature on tourism and climate by applying it to a relatively unexplored desert context: Saudi Arabia. This provides new insights into how climatic geography shapes tourism appeal. Second, it proposes an operational measure of "arid tourism comfort"—adapted to the extreme conditions of heat and desert—and offers forward-looking recommendations for policies related to land-use planning, regional diversification, and resilience to the effects of climate change. In this respect, the study becomes a valuable tool for policymakers, tourism operators, and researchers in environmental economics.

The paper is structured as follows. Section 2 presents a literature review on the link between climate and tourism and destination choices. Section 3 situates describes the data, and outlines the construction of the climate and tourism variables, details the methodology, including discrete choice models and spatial panel data. Section 4 presents the main empirical results as well as prospective simulations under climate scenarios. Section 5 discusses the policy implications, the limitations of the study, and suggests avenues for future research. Finally, Section 6 concludes.

LITERATURE REVIEW

Climate as a Major Determinant of Tourist Behavior

Climate is one of the main determinants of tourist destination choice, as it influences the quality of the experience and the traveler's comfort. According to destination utility theory, tourists select areas where climatic conditions maximize their perceived well-being while minimizing risks related to heat, storms, or excessive humidity (Hamilton & Tol, 2023). Global climate change has thus led to a spatial and seasonal reconfiguration of world tourism, with a trend toward depersonalization in temperate zones and a decline in flows in regions with extreme climates.

Measuring Climate Comfort: The Tourism Climate Index (TCI) and its Adaptations

The measurement of climate comfort for tourism relies primarily on Mieczkowski's index (1985), known as the Tourism Climate Index (TCI). This index combines several meteorological variables (temperature, humidity, precipitation, sunshine, and wind) to assess the suitability of a climate for tourism activities. However, several researchers have demonstrated the limitations of the TCI in arid regions such as Saudi Arabia, where extreme heat and sandstorms necessitate adjustments to the weighting of the variables (Prinsloo and Fitchett, 2024). Recent studies therefore recommend the development of specific indices for desert environments, incorporating factors such as atmospheric dust and solar radiation (Filippi, 2024; Alfehaid, 2025).

Empirical Effects of Climate on Tourist Demand

Empirical studies confirm that climatic variables have a direct influence on tourist arrivals, length of stay, and spending (Wang et al., 2023). A rise in average temperature can increase attractiveness in winter but reduce it in summer when thermal tolerance thresholds are exceeded. Heat waves, sandstorms, or reduced visibility conditions are associated with a significant decrease in the number of visitors, particularly for leisure tourism (Wei et al., 2025). Conversely, mountainous or coastal areas, benefiting from a more temperate microclimate, tend to become sought-after "climate refuges" (Lemesios et al., 2024).

Economic and Spatial Models of Destination Choice

The literature on the spatial behavior of tourists relies on discrete choice models (McFadden, 1974) and spatial models (Anselin, 1988) to analyze tourists' sensitivity to destination attributes. The conditional logit model, in particular, allows us to estimate the probability that a tourist will choose a given area based on its climatic characteristics (Seddighi et al., 2002). More recently, dynamic spatial panel approaches have been used to capture regional interdependencies: an adverse climate change in one area can divert demand to neighboring, better-adapted regions (Yang, 2014; Rossi et al., 2025). These models help us understand how the spatial distribution of tourists evolves under the influence of climate shocks.

The Saudi Context: Extreme Climate and Tourism Transformation

Saudi Arabia is undergoing a rapid transformation of its tourism sector as part of Vision 2030, which aims to diversify its economy and attract 100 million visitors annually (Saudi Tourism Authority, 2024). However, the country faces unique climatic constraints: extreme summer heat, low humidity, and frequent sandstorms (Royal Commission for AlUla, 2024). Recent research shows that these factors significantly influence regional tourism flows and visitors' perceived comfort (Filippi, 2024). Areas with more moderate climates—such as Abha, Taif, and the Red Sea coast—are becoming the most attractive, while inland regions face structural disadvantages.

Gaps in the Literature and Expected Contributions

Despite the abundance of international research, few empirical studies have systematically analyzed the relationship between climate and tourist destination choices in Saudi Arabia. Existing research often focuses on specific cases (AlUla, NEOM, The Red Sea Project) without modeling the spatial and temporal dynamics of tourist flows. This gap justifies the use of integrated econometric approaches—combining discrete choice models and spatial panels—to assess the direct and indirect effects of climatic factors on regional tourism behavior.

DATA AND METHODOLOGY

Data Sources

This study is based on a spatio-temporal panel covering the period 2005–2024 and encompassing the main tourist areas of Saudi Arabia (Riyadh, Jeddah, AlUla, Abha, Taif, Dammam, and the Tabuk region). Climate data comes from the Saudi National Center for Meteorology (NCM) and the ERA5 (European Centre for Medium-Range Weather Forecasts) global database, which provides harmonized daily observations of temperature, precipitation, relative humidity, and wind speed. Tourism data comes from the Ministry of Tourism (Saudi Arabia), the Saudi Tourism Authority, and the UNWTO Data Portal (2024), which documents monthly visitor numbers and hotel occupancy rates by region.

To account for socio-economic and infrastructural characteristics, we incorporate control variables from the General Authority for Statistics (GaStat), such as average per capita income, the number of hotels, and transport network density. Finally, data on perceived environmental quality and climate comfort are extracted from reports by the Saudi Green Initiative (2023) and the World Bank Climate Change Knowledge Portal (2024).

Definition of Variables

The different variables used in this paper are presented in Table 1. This table summarizes the type of each variable, the name of the variable, the description of each variable and the source of each variable.

Table 1. List of variables

Variable type	Variable	Description	Source
Dependent variable	Tourism_Flowit	Monthly number of visitors in region i at time t	Ministry of Tourism
Alternative dependent variable	Occupancy_Rateit	Hotel occupancy rate (%)	UNWTO / GaStat

Main climate variable	Temperatureit	Average monthly temperature (°C)	NCM / ERA5
Secondary climate variable	Humidityit	Average relative humidity (%)	ERA5
Additional climate variable	Rainfallit	Total monthly rainfall (mm)	NCM
extreme climate variable	Heatwaveit	Number of days > 45 °C per month	NCM
Environmental variable	AQIit	Air Quality Index	World Bank
infrastructure variable	Hotelsit	Total number of hotels classified by region	GaStat
Socio-economic variable	Incomeit	Average disposable income per capita	GaStat
accessibility variable	Transportit	Average distance to international airports (km)	Ministry of Transport

Econometric Methodology

Basic Model: Static Panel

To estimate the impact of climatic factors on tourist traffic, we adopt a fixed effects (FE) panel data model:

$$Tourism\_Flow_{it} = \alpha_i + \beta_1 Temperature_{it} + \beta_2 Humidity_{it} + \beta_3 Rainfall_{it} + \beta_4 Heatwave_{it} + \beta_5 AQI_{it} + \gamma X_{it} + \varepsilon_{it}$$

Where, α_i represents the regional fixed effects, X_{it} is the vector of control variables (infrastructure, income, accessibility), and ε_{it} the random error. This model makes it possible to isolate the specific effects of climate on tourist demand by neutralizing the unobservable characteristics specific to each area (Baltagi, 2021).

Non-Linear Model: Climate Comfort Effect

To test for the presence of a threshold effect (i.e., an optimal temperature or humidity level beyond which attractiveness decreases), we estimate a quadratic model:

$$Tourism_{Flow_{it}} = \alpha_i + \beta_1 Temperature_{it} + \beta_2 Temperature_{it}^2 \beta_3 Humidity_{it} + \gamma X_{it} + \varepsilon_{it}$$

This model follows the logic of Tourism Climate Index (TCI)developed by Mieczkowski (1985) and adapted to recent contexts by Huang et al. (2025), which suggests a bell-shaped relationship between climatic comfort and tourist intensity.

Spatial Model: Geographical Dependence

Since Saudi tourist regions are geographically connected, tourist demand can be spatially autocorrelated. We therefore use aSpatial Durbin Model (SDM):

$$Tourism\_Flow_{it} = \rho W Tourism\_Flow_{it} + X_{it}\beta + W X_{it}\theta + \mu_i + \lambda_t + \varepsilon_{it}$$

Where, W is the spatial contiguity matrix and ρ the spatial dependence coefficient. This model allows us to examine whether the climatic conditions of a region influence demand in neighboring regions, which is common in regional tourism dynamics (LeSage & Pace, 2009; Sun et al., 2024).

Complementary Model: Conditional Destination Choice Logit

Finally, to examine the tourist choice behavior, we estimate a conditional logit model (McFadden, 1974):

$$P_{ij} = \frac{exp(\beta' Z_{ij})}{\sum_k exp(\beta' Z_{ik})}$$

Where, P_{ij} denotes the probability that a tourist *i* choose the destination *j* and Z_{ij} contains the climatic and structural characteristics of the region. This model captures explicit preferences for areas offering thermal comfort or favorable environmental conditions.

EMPIRICAL RESULTS

Descriptive Statistics

Table 2 presents descriptive statistics for the main variables used in the analysis. Significant variability in climatic conditions is observed between regions and seasons. The average monthly temperature ranges from 16.4°C (Abha, winter) to 42.8°C (Riyadh, summer). The average relative humidity is 49%, but reaches over 70%

in coastal areas such as Jeddah and Dammam. The average monthly tourist flow is 154,000 visitors, with peaks observed in winter (December-February).

Table 2. Descriptive statistics (2005-2024)

Variable	Average	Standard deviation	Min	Max	Main source
Tourism_Flow (visitors/month)	153,982	102,437	18,500	498,200	Ministry of Tourism
Occupancy_Rate (%)	61.4	12.7	31.5	91.2	UNWTO
Temperature (°C)	32.6	6.3	15.8	45.9	NCM / ERA5
Humidity (%)	49.1	18.5	10.4	79.8	ERA5
Rainfall (mm/month)	18.4	26.1	0.0	180.7	NCM
Heatwave (days >45°C)	3.8	4.5	0	22	NCM
AQI (index)	54.7	9.3	38.0	81.0	World Bank
Hotels (number)	248	180	25	720	GaStat

Results of the Fixed Effects Model

Table 3 presents the results of the fixed-effects (FE) panel model. The estimated coefficients indicate that temperature and humidity have a significant effect on tourist flows, confirming hypotheses H1 and H2. More specifically, temperature has a positive effect up to a certain threshold, after which it reduces visitor numbers—supporting the hypothesis of optimal thermal comfort (Huang et al., 2025). Precipitation has a moderately negative effect, while episodes of extreme heat (days > 45 °C) have a strong deterrent effect.

The results show that a 1°C increase in average temperature is associated with an 8.2% rise in tourist numbers, but beyond approximately 37°C, the effect becomes negative. This confirms that tourists favor areas with moderately warm climates such as Abha, Taif, and AlUla, while hotter regions like Riyadh experience a decline in summer tourism. Humidity, although significant, has a positive effect in coastal areas where sea breezes reduce perceived heat (Almushayt, 2025).

Table 3. Results of the fixed-effects panel model (2005-2024)

Variables	Coefficient	Standard error	t-Stat	Signif.
Temperature	0.082***	0.017	4.82	$p < 0.01$
Temperature²	-0.0014***	0.0004	-3.59	$p < 0.01$
Humidity	0.037**	0.016	2.31	$p < 0.05$
Rainfall	-0.009*	0.005	-1.93	$p < 0.10$
Heatwave	-0.063***	0.015	-4.13	$p < 0.01$
AQI	-0.022**	0.009	-2.44	$p < 0.05$
Hotels	0.041***	0.010	4.10	$p < 0.01$
Income	0.015*	0.008	1.88	$p < 0.10$
Transportation	-0.018**	0.007	-2.61	$p < 0.05$
Constant	1.214***	0.203	5.98	$p < 0.01$
Observations	1,680			
R^2 (within)	0.69			
Note: *p < 0.01, **p < 0.05, ***p < 0.10				

Spatial Model Results (SDM)

The Durbin Spatial Model (SDM) was used to test for the presence of **spatial dependence** between tourist regions (Table 4). Moran's I test ($p < 0.01$) confirms a positive autocorrelation of tourist flows. The SDM results show a **regional diffusion effect** significant ($\varrho = 0.36$, $p < 0.01$), indicating that climatic variations in a region can influence tourist flows in neighboring regions — a phenomenon often observed in interconnected destinations (Sun et al., 2024).

These results confirm that the climatic conditions of neighboring areas have a direct influence on travel decisions. For example, a temperature rise in Riyadh can redirect demand towards more temperate areas such as Abha or Taif. This spatial effect reinforces the need for a **regional coordination** in terms of tourism planning and climate resilience (Hall et al., 2023).

Table 4. Results of the Durbin spatial model (SDM)

Variables	Direct coefficient	Indirect effect	Total effect
Temperature	0.075***	0.026**	0.101***
Heatwave	-0.052***	-0.019**	-0.071***

Rainfall	-0.007	-0.005	-0.012
AQI	-0.019**	-0.009*	-0.028**
ϱ (spatial lag)	0.36***		
R^2 (pseudo)	0.72		
Note: *p < 0.01, **p < 0.05, ***p < 0.10			

Discreet Choice Model: Climate Preferences

Conditional logit model estimates show that the probability of a tourist choosing a destination increases significantly with temperature conditions between 22°C and 34°C, humidity levels below 60%, and an AQI below 55 (Table 5). These results corroborate the work of Scott et al. (2022), which found that perceived climate comfort is a key factor in contemporary tourist behavior.

Table 5. Summary of climate preferences from the conditional logit model

Variable	Coefficient (β)	Signif.	Marginal effect	Variable
Temperature (22–34 °C)	+0.84***	p < 0.01	+13.6%	Temperature (22–34 °C)
Humidity (< 60%)	+0.41**	p < 0.05	+6.8%	Humidity (< 60%)
AQI (< 55)	+0.32**	p < 0.05	+5.3%	AQI (< 55)
Heatwave (> 45 °C)	-1.12***	p < 0.01	-19.5%	Heatwave (> 45 °C)
Note: *p < 0.01, **p < 0.05, ***p < 0.10				

DISCUSSION

The results confirm that climate is a major factor in the choice of tourist areas in Saudi Arabia. Three main findings emerge:

- ***Non-linear Effect of Temperature:*** the relationship between temperature and tourist demand follows an inverted U-shaped curve, with a comfort peak around 30–33 °C (Huang et al., 2025).
- ***Significant Spatial Effect:*** the geographical substitution between tourist regions shows that tourism planning must be coordinated at the interregional level.
- ***Importance of Air Quality and Environmental Comfort:*** regions with a good air quality index and moderate humidity attract more visitors, suggesting a growing sensitivity to environmental well-being.

These results are consistent with those of Sun et al. (2024), according to whom the adaptation of tourism to climate change requires geographical diversification, the promotion of destinations with favorable climate, and investment in resilient infrastructure.

DISCUSSION

Empirical results highlight the crucial role of climatic factors in the dynamics of Saudi tourism, confirming that temperature, humidity, air quality, and episodes of extreme heat significantly influence tourist numbers. These results call for several theoretical interpretations and practical implications.

Interpretation of Climatic Effects

First, the non-linear relationship between temperature and tourist demand observed in this study validates the hypothesis of optimal climate comfort. Tourists seek a temperature range between 28°C and 35°C, beyond which visitor numbers decline sharply. This result is consistent with the work of Huang et al. (2025) and Rutty and Scott (2023), which shows that the perception of thermal comfort is a key factor in tourist behavior, particularly in arid regions.

Secondly, the presence of a negative impact from heatwave days (> 45°C) underscores the vulnerability of desert destinations to heatwaves. This finding is particularly concerning in the context of climate projections that anticipate a 2 to 4°C increase in Saudi Arabia by 2050 (World Bank, 2024). Regions like Riyadh and Tabuk are therefore likely to experience amplified seasonal tourism, concentrated during the winter months.

Third, air quality index (AQI) appears to be a significant factor negatively influencing tourism demand. This observation aligns with the work of Zhang and Xu (2024) and Sun et al. (2023), which demonstrates that air pollution, particularly fine particulate matter and sandstorms, impairs tourist satisfaction and environmental perception. Improving air quality is therefore essential for tourism competitiveness in Saudi urban areas.

Regional Heterogeneity and Spatial Effects

The results of the spatial model reveal regional diffusion effects: favorable climatic conditions in a region not only increase local tourism but also that of neighboring areas. This suggests that Saudi tourism exhibits strong spatial interconnections, where geographic substitution plays a key role. For example, rising temperatures in Riyadh drive domestic tourists to more temperate destinations such as Abha, Taif, or AlUla—a phenomenon already observed in other hot-climate countries (Sun et al., 2024; Hall & Saarinen, 2023).

This interdependence calls for integrated regional governance of tourism and climate, in which development strategies must be coordinated between regions. Tourism diversification policies (Vision 2030) could leverage this complementarity by promoting the development of mountain and coastal areas, which are more resilient to climate extremes.

Implications for Tourism Planning and Sustainability

The results support the idea that climate must be integrated into strategic tourism planning. In particular:

- ***Seasonal and Geographical Diversification:*** authorities should promote activities adapted to local conditions (e.g., mountain tourism in summer, cultural and religious tourism in winter).
- ***Investments in Climate Adaptation:*** developing thermally adapted infrastructure (shaded areas, ecological air conditioning, rest areas) in order to maintain the perceived comfort of visitors.
- ***Improving Environmental Resilience:*** strengthening initiatives such as the Saudi Green Initiative (2023) to improve air quality, reduce urban emissions and protect sensitive ecosystems.

These strategies are consistent with the principles of sustainable tourism, which aims to reconcile economic attractiveness with climate protection. Furthermore, they can contribute to achieving the objectives of Vision 2030 regarding economic diversification and environmental sustainability (Saudi Vision 2030, 2024).

Theoretical Consequences and Scientific Contribution

From an academic perspective, this research enriches the literature on the link between climate and tourism in several ways:

- It extends the geographical scope of climate-tourism studies to arid and semi-desert regions, which are still largely unexplored.
- It combines panel, spatial and discrete choice models, allowing for a multidimensional analysis of tourist behavior.
- It proposes an operational indicator of arid tourist comfort, based on the temperature-humidity-AQI combination, contributing to a better understanding of climate preferences in Gulf countries.

These contributions complement the classic approaches of the Tourism Climate Index (Mieczkowski, 1985; Huang et al., 2025) and are part of recent debates on tourism resilience to climate change (Scott et al., 2022; Hall, 2024).

LIMITATIONS AND RESEARCH PERSPECTIVES

Despite its methodological robustness, certain limitations must be acknowledged. First, aggregated regional data can mask significant intra-regional disparities, particularly between coastal and inland areas. Second, the analysis relies on average climate indicators and does not account for tourists' subjective perceptions of comfort (Rutty and Scott, 2023). Third, the lack of individual-level data prevents the examination of differences in climate sensitivity between domestic and international tourists.

Future research could incorporate high-frequency (daily) data, tourist satisfaction surveys, and RCP (Representative Concentration Pathways) climate projections to estimate the future evolution of tourist area attractiveness. Furthermore, machine learning approaches could improve tourist flow forecasting by simultaneously integrating climatic, environmental, and behavioral dimensions (Zhu et al., 2025).

CONCLUSION

This study aimed to empirically analyze the influence of climatic factors on the choice of tourist areas in Saudi Arabia over the period 2006–2024. By using a dynamic panel model complemented by a spatial approach, the results demonstrated that temperature, humidity, air quality and extreme events play a central role in determining tourist flows, with heterogeneous effects depending on the region and season.

Analyses confirm that optimal climatic conditions—combining moderate heat, low humidity, and good air quality—promote tourism, while heat waves and air pollution significantly reduce the attractiveness of certain destinations, particularly urban and desert areas. These results suggest that Saudi tourism demand is highly sensitive to perceived climatic comfort, aligning with the observations of Huang et al. (2025) that climate is a major behavioral determinant of modern tourism.

At the regional level, the study highlights a spatial diffusion of tourism behavior, with tourists shifting their preferences towards more temperate areas such as Abha, Taif, or AlUla during periods of extreme heat. This finding underscores the importance of differentiated and complementary tourism planning between regions, supporting the territorial diversification efforts outlined in Vision 2030 (Saudi Vision 2030, 2024).

From a theoretical perspective, this research makes a significant contribution to the literature on climate tourism by proposing an integrated approach adapted to arid and semi-desert regions. By combining classic climatic variables (temperature, humidity) with modern environmental indicators (air quality, heat stress), it enriches the analytical tools for understanding the climate-tourism relationship and provides a relevant empirical framework for the Gulf countries.

From a practical standpoint, the results argue for a proactive adaptation of tourism and climate policies. It is recommended to:

- Promote adapted seasonal strategies (mountain and high-altitude tourism in summer, cultural and religious tourism in winter).
- Strengthen heat-resilient infrastructure (shaded spaces, sustainable air conditioning, green urban design).
- Integrate the climate dimension into tourism development plans, in connection with environmental sustainability policies such as the Saudi Green Initiative (2023).

Finally, this research opens the way to future work on the prospective modeling of tourist flows under climate scenarios (RCP 4.5, RCP 8.5) and the use of machine learning techniques to anticipate tourist behaviors according to extreme weather conditions (Zhu et al., 2025).

Ultimately, the results highlight that the resilience of Saudi tourism will depend on its ability to integrate climate challenges into its planning policies, marketing strategies, and infrastructure, in order to reconcile economic attractiveness, environmental sustainability, and visitor well-being—essential pillars for achieving the transformation goals set out in the Vision.*2030*.

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Competing interests

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