Geojournal of Tourism and Geosites
ISSN 2065-0817, E-ISSN 2065-1198

Year XVIII, vol. 58, no. 1, 2025, p.275-283
DOI 10.30892/gtg.58124-1409

THE IMPACT OF CLIMATE ON THE COMFORT OF TOURISTS IN THE ALGERIAN DESERT - THE CASE OF ADRAR STATE, ALGERIA

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Citation: Mokhtari, M., & Hattab, S. (2025). The impact of climate on the comfort of tourists in the Algerian desert - The case of Adrar state, Algeria. *Geojournal of Tourism and Geosites*, 58(1), 275–283. https://doi.org/10.30892/gtg.58124-1409

Abstract: In an effort to address the delays observed within the tourism sector in Algeria, the Algerian government is currently undertaking initiatives to enhance various tourist destinations, with particular emphasis on the desert tourism destination due to the vast area occupied by the desert, which is approximately 87% of the total area of the country, it has enormous and charming tourism potential. Furthermore, the planning necessary for the development of desert tourism necessitates the consideration of multiple factors, including the climatic conditions that influence the degree of comfort experienced by tourists while engaging in diverse tourism activities, this will inevitably determine the length or shortness of the tourist season. This research endeavors to investigate the situation in the state of Adrar Located in the far southwest of Algeria as a representative model for desert tourism in Algeria by measuring the temperature and humidity index (THI) devised by the scientist Thom in 1959 to assess comfort levels, which depends on temperature and relative humidity, alongside the Robaa index (RI) proposed by Robaa Mohamed Abdel Hamid in 1999, which quantifies the level of climatic comfort by integrating three climatic variables: dry heat temperature, wet temperature, and wind velocity, utilizing climate data collected over the period from 1996 to 2008, which was sourced from the National Meteorological Office, and given the vastness of the study area extending over an area of 427.968 km2 (representing 17.98% of the total area of the Algerian state), we used data from the three meteorological stations located there, which are distributed spatially from the north of the state to its south as follows: Timimoun station, Adrar station and Bordj Badji Mokhtar station, This will enable us to identify comfortable and uncomfortable periods, with the aim of planning the various tourist activities that tourists can practice in this state according to those periods. In the present study, the descriptive analytical method was employed. The findings derived from this analysis indicated that the integration of these two indicators facilitated the identification of three distinct levels of climatic comfort within the state: complete comfort, relative comfort, and discomfort. These levels exhibit temporal variations throughout the months of the year, as well as diurnal and nocturnal fluctuations, and they also demonstrate spatial differences across the four regions of the state that extend from north to south.

Keywords: comfort, climate, temperature and humidity index, Robaa index, tourism, Algerian Desert, Adrar State

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INTRODUCTION

In contemporary society, tourism has emerged as a paramount and rapidly expanding economic sector. In 2019, the World Tourism Organization counted nearly one billion tourists in the world, with revenues for that year reaching an impressive 1,700 billion dollars. Consequently, it is reasonable to observe the heightened interest exhibited by numerous nations in the tourism industry and the imperative to enhance its development. Tourism has evolved into a crucial sector that occupies a significant position within the diverse programs and developmental strategies of these nations, aimed at diversifying their revenue streams and economic income. Presently, tourism is recognized as one of the foremost economic activities globally and is acknowledged as a catalyst for advancement (Esparza-Huamanchumo et al., 2024). It has a role in the economic development of cities and in bringing several benefits to the locals. Economists believe that it is one of the most promising industries from which the Third World can benefit to substitute other industries (Yazdanpanah et al., 2016).

Desert tourism represents a specific category of (natural) ecotourism. Its domain encompasses arid regions, including: sand dunes, barren mountain ranges, arid valleys, natural oases, khabari, and depressions. The human dimensions of this tourism type encompass the lifestyle and cultural practices of desert inhabitants, which are deeply intertwined with the characteristics of the desert, thereby creating a unique paradigm of existence in both urban and rural contexts (Ghraiba, 2012), it is also defined as tourism dedicated to exploring the desert, in which oases are used as a point of departure and arrival (Benaissa et al., 2022). In this type of tourism, specific types of people enjoy visiting unusual places, which offer specific attractions or activities (Doreen, 2016). The Algerian state acknowledges the paramount significance of cultivating a multifaceted tourism sector that yields benefits across economic, social, cultural, and political dimensions. Considering its

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diverse natural and anthropogenic tourism assets, which have not yet aligned with prevailing tourism trends, Algeria is classified among the least attractive nations for international tourists. It accounts for a mere 1.1% of the market share in Africa, in stark contrast to 20.8% for South Africa, 19% for Tunisia, and 14.9% for Morocco (Ben Turki & Cherfi, 2019). Accordingly, Algeria is currently endeavoring to rectify the lag experienced in this sector to enhance its tourism image through various tourist destinations, of which desert tourism is a pivotal component.

Algeria's current emphasis on desert tourism is driven by the extensive area occupied by desert landscapes, which constitutes 87% of the country's total land area. This region possesses substantial and enchanting tourism potential. By investing in and developing these resources, Algeria has the capacity to transform its desert areas into appealing tourist destinations for global tourism traffic, especially amidst the current global momentum surrounding competition in attracting visitors. Furthermore, tourism in desert areas contributes effectively to the economic, social, cultural and environmental development of these areas (Bouaicha et al., 2019). In this context, a multitude of strategies and mechanisms have been employed to enhance the tourism sector, with the most significant being the Tourism Development Master Plan for Horizon 2025, which serves as a strategic reference framework for the formulation of tourism policy in Algeria within the paradigm of sustainable development. This plan constitutes an integral component of the National Territorial Planning Scheme for Horizon 2025. The Tourism Development Master Plan posits that the southern regions (specifically, the Sahara) represent a distinctive heritage of exceptional value for Algeria that warrants respect and should be emblematic of Algerian tourism. The Tourism Development Master Plan has categorized the national territory into seven tourism excellence poles, tasked with actualizing “showcases symbols” to foster the emergence of a unique and sustainable tourist destination capable of competition and innovation, thereby facilitating the proliferation of tourism across the national landscape. Notably, four of these poles are situated in the desert (Ministry of territorial Planning, Environment and Tourism, 2008).

In alignment with this endeavor, the planning process for the advancement of desert tourism must consider a plethora of factors, including climate as one of the main factors affecting development in the tourism sector (Goh, 2012), as it affects the timing and length of the tourism seasons (Mahmoud et al., 2019), and is an important consideration in tourists’ choice of destination (Lise & Tol, 2002). A number of studies have found this. According to a study by Lohmann & Kaim in 1999, the climate is the third most important factor influencing the choice of a holiday destination by German travelers. Kozak found in a study conducted in 2002 on German and British tourists in Mallorca and Turkey that “enjoying good weather” was the major factor for travel. Hamilton and Lau in 2005 confirmed that climate is at least the third most common characteristic in the decision-making process of tourists. A field survey conducted by Gossling, Bredberg, Randow, Svensson, and Swedlin in 2006 indicated that 53% of respondents rated climate as a very important factor in destination choice (Goh, 2012). Through the various climatic elements, the level of comfort experienced by tourists during their visits, their stays in desert locales, and their engagement in various tourism activities can be determined, which will inevitably dictate the length or brevity of the tourist season.

Climate comfort is defined as the comfort of a healthy person acting without any self-protection equipment in nature (Liu et al., 2020), it is the condition of thermal equilibrium between the human body and its environment, where The human body sustains a stable temperature (37 degrees Celsius) without resorting to increasing its temperature through shivering in response to cold or enhancing cooling through perspiration in reaction to heat, or by other means (Ammar & Sarah, 2019), which allows individuals to maximize their physical and intellectual capacity (Lucio & Gomes, 2023). Climate elements were used to calculate climatic comfort or environmental stress initially in the study of animal life and then their application gradually extended to sciences focused on the study of humans (Liu et al., 2020), and is affected by air temperature, wind speed, radiation, humidity, clothing and activities performed (Toy et al., 2007), in addition to sex, age, health status and nature of eating. Consequently, the extent of human interaction with climatic variations differs from individual to individual and over time. Achieving a standard of normal comfort for one individual under specified conditions at a particular time may not be attainable for another individual under identical circumstances (Nashwan, 2004). Therefore, the challenge of quantifying the level of climatic comfort through mathematical principles and disseminating those findings to the populace persists. Nevertheless, several initiatives have emerged aiming to assess human comfort levels in diverse environments by proposing various indicators, some of which are predicated on a singular climatic element, while others are based on two or more climatic elements. However, these indicators remain relative and provide estimates and information about human comfort in general (Ghanem, 2010).

The objective of this article is to evaluate the level of climatic comfort within the Algerian desert, utilizing the model of Adrar State, which possesses substantial and diverse tourism potential, both natural and anthropogenic. If optimally harnessed, this potential could significantly contribute to the flourishing of tourism activities and serve as a catalyst for local development within the region. We will employ the Temperature-Humidity Index (THI) devised by the scientist Thom in 1959 to assess comfort levels in the United States, which serves as a pertinent standard for characterizing individuals' perceptions of high temperatures, contingent upon temperature and relative humidity (Zakri, 2005), alongside the Robaa Index (RI) proposed by Robaa Mohamed Abdel Hamid in 1999, which quantifies the level of climatic comfort by integrating three climatic variables: dry heat temperature, wet temperature, and wind velocity (Robaa, 2003), This will enable us to identify comfortable and uncomfortable periods, with the aim of planning the various tourist activities that tourists can practice in this state according to those periods.

STUDY DATA, TOOLS, AND METHODOLOGY

In order to engage with the subject matter effectively, and given the vastness of the study area, we have utilized data from three meteorological stations located there, obtained from the National Meteorological Office, which are distributed

spatially from the north of the state to its south as follows: Timimoun station, Adrar station and Bordj Badji Mokhtar station, during the period (1996 - 2008), and the following table (Table 1) highlights the characteristics of these stations.

Table 1. Characteristics of Aerial Monitoring Stations Approved in the Study
(Source: Construction of Authors based on the data of the National Meteorological Office)

Station	Timimoun station	Adrar station	Bordj Badji Mokhtar station
Height (m)	312	279	397
Longitude	00°17′ E	00°11′ W	00°57′ E
Latitude	29°15′ N	27°49′ N	21°20′ N

Through the aforementioned stations, we acquired the subsequent climatic parameters: the mean temperature of the arid heat (°C), the relative humidity percentage (%), and the mean wind velocity (m/s). The data pertinent to the mean temperature of the moist environment (°C) were derived from a table that computes this temperature utilizing the dry temperature and relative humidity, which can be accessed online through the following hyperlink (https://www.thermexcel.com/french/tables/th.htm). The Temperature Humidity Index (THI) shall be computed using the following equation: THI = T - 0.55 (1 - H) (T - 14.5) (Moses, 2017).

In this equation, THI represents the comfort factor, T denotes the temperature in (°C), H signifies the relative humidity/100, and the constants 0.55, 1, and 14.5 are predetermined values. The values derived from this index are interpreted in accordance with the criteria presented in the subsequent table (Table 2) (Mazen, 2012).

Table 2. Temperature and Humidity Index and the corresponding human sensation

Result (numeric value without unit)	less than 10	10 - 15	15 - 18	18 - 21	21 - 24	24 - 27	27 -29	More than 29
Sensation	very cold discomfort	cold discomfort	Cool comfort	Complete comfort	Warm comfort	Hot discomfort	Extreme heat discomfort	High stress and dangerous to health
Symbol of every sensation	C^{--}	C	P^{-}	P	P^{+}	H	H^{+}	H^{++}

The Robaa Index (RI) shall be computed using the following equation:

$RI = 1.53T_d - 0.32\ T_w - 1.38V + 44.65$ (Robaa, 2003); Where: RI denotes the quarterly index /T_d represents dry temperature (°C) /T_w signifies wet temperature (°C) /V indicates wind velocity (m/s) 44.65 is a constant parameter.The resultant values derived from this index are elucidated as depicted in the subsequent tabulation (Table 3) (Robaa, 2003).

Table 3. The Robaa Index and the corresponding human sensation (source: The symbols in this table are proposed by Authors)

Result (numeric value without unit)	less than 60	60 to less than 65	65 to less than 75	75 to less than 80	80 to less than 85	greater than or equal to 85
Sensation	Everyone feels cold	50% of people feel cold	All people feel comfortable	50% of people feel hot	Everyone feels hot	Everyone feels very hot
Symbol of every sensation	C	P^{-}	P	P^{+}	H	H^{+}

Utilizing the two indicators established in this investigation, we shall ascertain the diurnal and nocturnal climatic comfort intervals pertinent to the diverse regions within the state. For the diurnal assessment, we have relied upon the mean maximum temperatures. Conversely, during the nocturnal phase, we employed the mean minimum temperatures.

Our evaluation of the overall climatic comfort level within the state will be derived from the integration of the outcomes of these two indicators. Moreover, it is imperative to consider that the outcomes obtained from each meteorological station will be applicable to the region in which it is situated or in proximity to it. Consequently, we will attribute the findings from the Timimoun station to the Gourara region (located in the northern part of the state). The results from the Adrar station will correspond to the Touat and Tidikelt regions (central part of the state), whereas the findings from the Bordj Badji Mokhtar station will pertain to the Tanzrouft region (southern part of the state). Regarding the methodological instruments employed in this study, we utilized the Geographic Information Systems (MapInfo Professional 8.0) software to construct cartographic representations. Data processing and graphical representation were conducted using Microsoft Excel (Microsoft Excel). As for the treatment method adopted in this study, it will be according to the descriptive analytical method.

STUDY AREA

The state of Adrar is situated in the extreme southwest of Algeria (Figure 1), approximately 1500 km from the capital city of Algiers, and is geographically positioned between 1 degree east and 3 degrees west longitude, as well as between 20 and 30 degrees north latitude. Consequently, the Greenwich Meridian, also known as the World Time Line, traverses this region.

In accordance with the administrative division of Algeria established in 1987, the state covers a vast area of 427.968 Km^2 (Directorate of Programming and Budgetary Monitoring of Adrar State, 2015), which constitutes 17.98% of Algeria's total landmass (2,381,000 Km^2). Considering the expanse of the Algerian desert, which measures 2,081,000 square kilometers (National Office of Statistics, 2011), the state of Adrar occupies 20.57% of this desert territory, equating to one-fifth of the total area. The state of Adrar shares its boundaries with five other states within the national framework, as well as with two foreign nations. To the north, it is bordered by the state of El Bayadh; to the northwest, by the state of Bechar; to the northeast, by the state of Ghardaia; to the west, by the state of Tindouf; and to the southeast, by the state of Tamanrasset. Additionally, it shares a southern border with the state of Mali, extending approximately 983 kilometers, and a southwestern border with the state of Mauritania, which stretches about 100 kilometers.

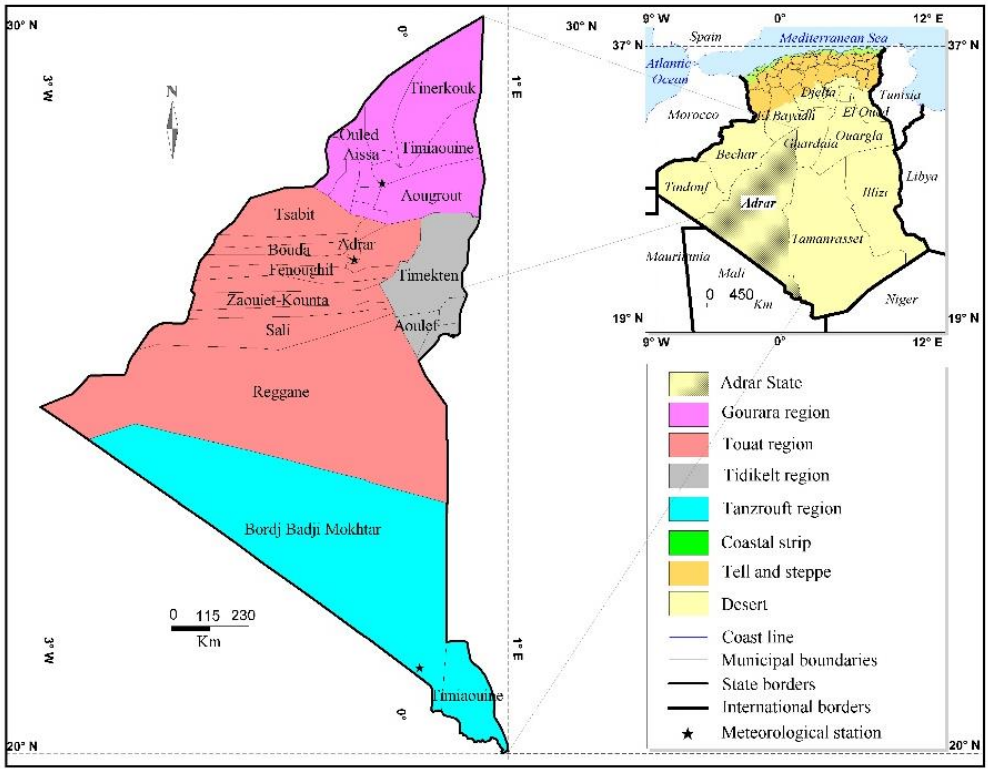

Figure 1. Location of Adrar State and its geographical regions (Source: Authors based on the administrative division of Algeria in 1984 and Statistical collections No. 163/2011, "Urban framework", ONS 2011)

Administratively, the state is composed of 28 municipalities. Geographically, it is subdivided into four principal regions:

a. The Gourara (Timimoun region): This region is situated in the northern part of the state and comprises 15.24% of its total area.

b. The Touat (Adrar region): Located in the central portion of the state, this region accounts for 48.05% of its overall area.

c. The Tidikelt (Aoulef region): Positioned on the eastern side of the state, this region constitutes 5.73% of its area.

d. The Tanzrouft (Bordj Badji Mokhtar region): This region is found in the southern part of the state and represents 30.98% of its total area.

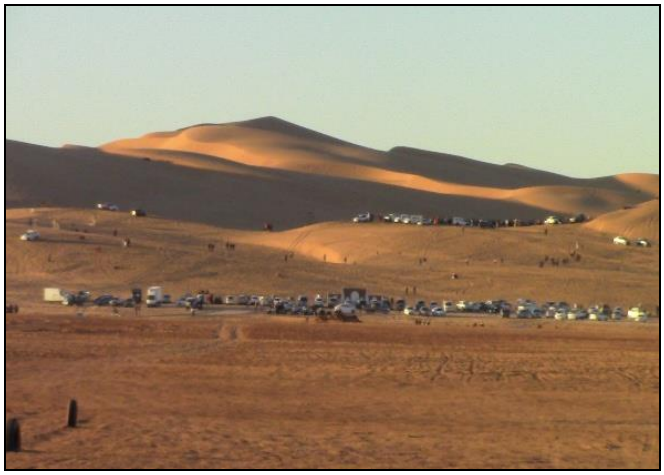

Figure 2. Sand dunes near Timimoun Kasar (Source: Authors, 2014)

Figure 3. Local architectural character - Adrar city center

According to the General Population and Housing Census conducted in 2008, the population of the state was recorded at 399,714 individuals, distributed across the aforementioned regions in the following proportions: 30.53% residing in the Gourara region, 50.50% in the Touat region, 13.74% in the Tidikelt region, and 5.23% in the Tanzrouft region. As per estimates from 2019, the total population has now surged to approximately 528,000 individuals (Ministry of Interior and Local Communities, 2019). The state of Adrar possesses a plethora of both natural and anthropogenic tourism resources (Figures 2 and 3). In terms of its natural attributes, the terrain is marked by a rich diversity. It is predominantly composed of four distinct morphological features: plateaus, plains, sand dunes, and Sabakhat, which collectively contribute to the state's varied landscapes, alongside numerous caves, the most notable being Ighzer in Ouled Saïd. On the anthropogenic front, the region is home to numerous desert palaces (Ksours) distinguished by their architectural uniqueness, constructed

using indigenous building materials such as clay and palm components. Furthermore, a significant portion of its palm oases employs the foggara irrigation system, which was designated as a UNESCO World Heritage Site in 2018.

The expertise and methodologies related to water management within this system were recognized as part of the intangible cultural heritage of humanity in the same year, in addition to the inclusion of Tamantit Oasis in the Ramsar List of Wetlands in 2001. The state also boasts a rich repository of folkloric and musical literature, prominently featuring the Ahelil character, which was classified as World Heritage by UNESCO in 2005, along with various religious events, the most notable being the Esboua El-moulid, celebrated on the 18th of Rabie Al-Awaal each year (the Hijri calendar), recognized as a World Heritage by UNESCO in 2015. Additionally, the state is abundant in traditional crafts such as pottery, particularly renowned in the Tamantit area. Complementing these attributes are ancient manuscripts discovered in Zaouias and Quranic schools that safeguard extensive knowledge across various disciplines, as well as sites of inscriptions and rock carvings that date back to ancient epochs. According to the Emberger Index, the climatic conditions of the state are classified as desert, exhibiting two variants of winter: a moderate climate in the northern and central regions (specifically Gourara, Touat, and Tidikelt), and a hot climate in the southern region (notably the Tanzrouft area).

As per the data provided by the Directorate of Tourism and Traditional Industry of Adrar State, the influx of tourism to the state during the period from 2000 to 2019 experienced various fluctuations around an average of 16,372 tourists. The peak tourist influx occurred in 2004, with a total of 26,161 visitors, while the lowest recorded number was 10,771 tourists at the commencement of this period in 2000. Consequently, the overarching trend in the evolution of tourism traffic indicates a slight decrease, approaching a state that can be characterized as stable, as illustrated by the following regression line equation (*y= -16.107x + 16541*), as demonstrated in Figure 4. Concerning the origins of tourism flows to the state during the aforementioned period, domestic tourism predominates, comprising over 86% of total flows across all years, as depicted in Figure 5.

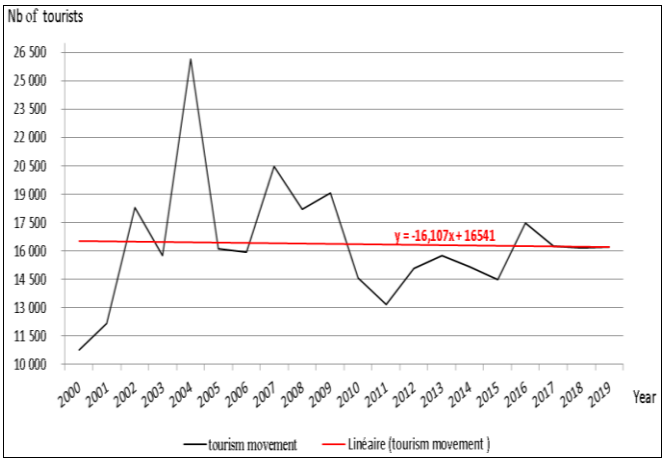

Figure 4. Development of tourism movement coming to Adrar State (2000 - 2019) (Source: Directorate of Tourism and Traditional Industry of Adrar State, 2019)

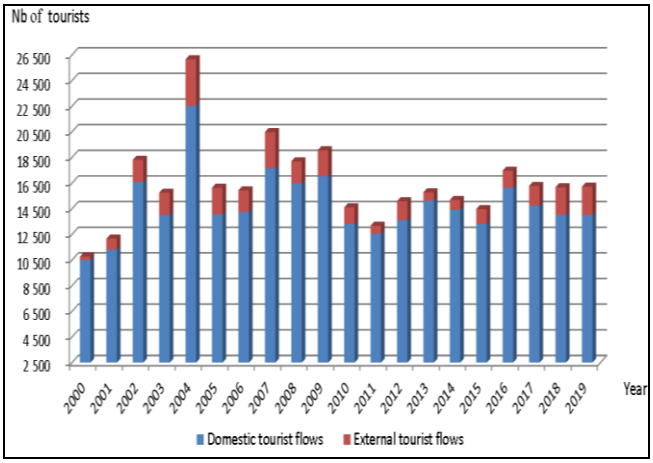

Figure 5. Tourist flows to Adrar State (2000 - 2019) (Source: Directorate of Tourism and Traditional Industry of Adrar State, 2019)

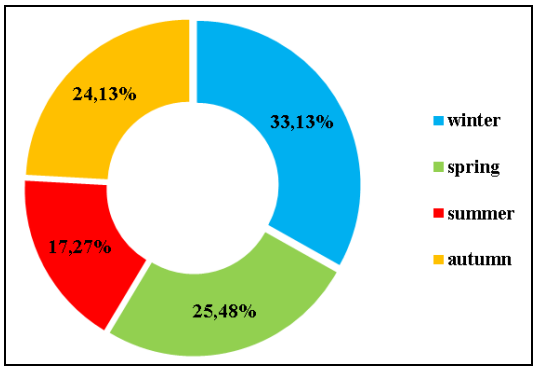

Figure 6. Distribution of tourist flows to Adrar by season in 2017(Source: Directorate of Tourism and Traditional Industry of Adrar State, 2019)

These tourist flows exhibit varying distributions across the seasons of the year. The summer season emerges as the most significant, accounting for 33.13% of all tourists, followed by the spring and autumn seasons, each representing approximately a quarter of the total tourist count, with figures of 25.48% and 24.13% respectively.

The winter season records the least number of tourists, comprising 17.27% of the total arrivals in the state. This distribution is illustrated in Figure 6 for the year 2017.

RESULTS AND DISCUSSION

1. Assessment of Climatic Comfort Utilizing the Temperature Humidity Index (THI)

This analytical indicator has facilitated the acquisition of results, which are detailed in the subsequent Table 4.

Table 4. Temporal Distribution of (THI) Across the Annual Cycle in Adrar State
(Source: Construction of Authors based on the data of the National Meteorological Office)

Months	Timimoun station				Adrar station				Bordj Badji Mokhtar station			
	Index of Diurnal Comfort	Classification	Index of Nocturnal Comfort	Classification	Index of Diurnal Comfort	Classification	Index of Nocturnal Comfort	Classification	Index of Diurnal Comfort	Classification	Index of Nocturnal Comfort	Classification
January	17.80	P^-	8.05	C^-	19.05	P	8.37	C^-	21.00	P^+	11.11	C
February	19.32	P	10.07	C	20.46		10.28	C	22.33		12.33	
March	22.14	P^+	12.91		22.93	P^+	13.14		24.46	H	14.66	
April	24.34	H	15.46	P^-	25.20	H	15.72	P^-	26.81		17.52	P^-
May	26.63	H^+	18.01	P	27.38	H^+	18.20	P	28.43	H^+	19.92	P
June	29.20	H^{++}	20.36		29.57	H^{++}	20.45		30.00	H^{++}	21.85	P^+
July	30.77		21.91	P^+	30.84		21.85	P^+	30.80		22.51	
August	30.37		21.74		30.63		21.83		31.32		22.70	
September	28.86	H^+	20.16	P	29.71		20.49	P	30.15		21.64	
October	26.06		16.96	P^-	27.05	H^+	17.33	P^-	27.40	H^+	18.40	P
November	21.34	P^+	11.97	C	22.27	P^+	12.33	C	23.96	P^+	14.55	C
December	18.16	P	8.52	C^-	19.36	P	8.83	C^-	21.72		12.04	

1.1. The Index of Diurnal Comfort

For the north and center of the state (the regions of Gourara, Touat and Tidikelt), the comfort period generally extends for five months of the year, starting from November until March, but the level of this comfort varies between complete, cool and hot, as follows: - The climate of Touat and Tidikelt regions is characterized by a period of complete comfort during the three months (December, January and February), where we recorded in this area a comfort index between 19.05 and 20.46, while in November and March the comfort index reached 22.27 and 22.93 respectively, and thus it is a period of comfort but it tends somewhat towards heat.

- The climatic characteristics of the Gourara region reveal a complete comfort duration during December and February, with comfort indices of 18.16 and 19.32, respectively. Based on the recorded comfort index of 17.80, January can be categorized as a month of comfort, although it inclines towards cooler conditions. In November and March, the indices were noted at 22.14 and 21.34, respectively, indicating a comfort phase that also trends towards warmer conditions.

- In the southern region of the state (Tanzrouft), the four-month interval from November to February represents an optimal timeframe for diverse diurnal Tourist activities. During this period, we have documented a limited comfort range between 21 and 23.96, which attributes the climate with characteristics of warm comfort.

1.2. The Index of Nocturnal Comfort

This comfort period lasts for seven months of the year in the north and center of the state (the regions of Gourara, Touat and Tidikelt), starting from April until October, where the two ends of this period represent a climatic comfort that tends to be cold, as we recorded comfort indexes between 15.46 and 16.96 in the region of Gourara, and between 15.72 and 17.33 in the regions of Touat and Tidikelt. As for the months (May, June and September), they represent a complete comfort period with a comfort index between 18.01 (corresponding to May in the region of Gourara) and 20.49 (corresponding to September in the regions of Touat and Tidikelt). As for the months of July and August, they are comfort months that tend to be hot with a recorded comfort index of 21.91 and 21.91 respectively for the region of Gourara, and almost the same recorded comfort index during these two months for the regions of Touat and Tidikelt. In the southern part of the state, specifically the Tanzrouft region, this period of comfort similarly extends over seven months, initiating in April and concluding in October. The onset of this timeframe signifies a cold climatic comfort, as evidenced by the recorded comfort value in April, which is estimated at 17.52. The months of May and October represent a phase of complete climatic comfort, with recorded comfort values of 18.40 and 19.92, respectively. The remaining four months, spanning June to September, are characterized by a cold comfort period, with recorded comfort values confined to between 21.94 and 22.71.

2. Assessment of Climatic Comfort Utilizing the Robaa Index (RI):

It is imperative to emphasize that among the climatic variables incorporated in the computation of this index are wind patterns, which either amplify the perception of cold during the cooler months or contribute to the alleviation of warmth during the hotter months, particularly when ambient temperatures fall below the human skin temperature, estimated at 33 °C on average. Conversely, during excessively hot months that surpass this threshold, wind conditions exacerbate the sensation of heat (Raad et al., 2016) . This phenomenon will manifest in the propensity for climatic comfort to oscillate between cold and heat during certain months, and our findings, derived from the calculation of this indicator, are delineated in the subsequent table (Table 5).

2.1. The daytime comfort period

The recorded daytime climatic comfort period, as assessed by the Robaa Index (RI), exhibits a decreasing trend from the northern to the southern regions of the state. This phenomenon can be elaborated as follows: - In the northern sector of the state, specifically within the Gourara region, this climatic comfort period extends over six months (half of the annual cycle), commencing in November and concluding in April. The index values during this interval fluctuated between 62.32 and 78.62. Notably, the months of November, February, and March are characterized as a complete climatic comfort period. Conversely,

December and January are identified as a phase of cold weather, during which approximately 50% of the population perceives cold conditions. In April, the climatic comfort level transitions to hot, with around 50% of individuals experiencing heat.

Table 5. Distribution of the Robaa Index (RI) Across the Annual Months in Adrar State (Source: Construction of Authors based on the data of the National Meteorological Office and the website: https://www.thermexcel.com/french/tables/th.htm)

Months	Timimoun station				Adrar station				Bordj Badji Mokhtar station			
	Index of Diurnal Comfort	Classification	Index of Nocturnal Comfort	Classification	Index of Diurnal Comfort	Classification	Index of Nocturnal Comfort	Classification	Index of Diurnal Comfort	Classification	Index of Nocturnal Comfort	Classification
January	62.32	P^-	44.11	C	65.53	P	44.27	C	72.06	P	49.13	C
February	65.53	P	46.77		68.29		46.92		75.19	P^+	51.05	
March	73.32		52.46		75.82	P^+	52.92		81.70	H	56.82	
April	78.62	P^+	57.91		82.03	H	58.46		87.92	H^+	63.87	P^-
May	84.80	H	64.04	P^-	88.07	H^+	64.66	P^-	92.62		70.14	P
June	94.06	H^+	71.59	P	95.88		72.02	P	96.02		74.62	
July	98.63		75.50	P^+	99.85		75.81	P^+	94.50		74.90	
August	97.23		75.18		98.29		75.64		92.76		73.92	
September	90.34		70.03	P	92.44		70.75	P	93.00		73.24	
October	80.87	H	61.64	P^-	82.86	H	62.33	P^-	87.84		66.01	
November	69.52	P	51.43	C	72.55	P	52.37	C	78.51	P^+	57.20	C
December	62.50	P^-	45.25		65.52		45.66		74.27	P	51.41	

- In the central of the state, encompassing the Touat and Tidikelt regions, the duration of this climatic comfort is five months annually. This period spans from November to March, with index values ranging from 65.52 to 75.82. The first four months of this span are classified as a complete climatic comfort period. The final month is distinguished by a hot climatic comfort, where 50% of the populace reports feeling hot.

- In the southern of the state (Tanzrouft region), the climatic comfort period is recorded as four months, commencing in November and concluding in February, during which index values range from 72.06 to 78.51. This climatic comfort is delineated into two distinct phases. The months of December and January are associated with a complete climate comfort, whereas February is characterized by warmer conditions, with 50% of the population experiencing heat.

2.2. The period of night comfort

- In the northern and central regions of the state (Gourara, Touat, and Tidikelt), the timeframe from May to October (six months) constitutes a climatic comfort period. This interval includes two months marked by cold climatic conditions, during which approximately 50% of individuals perceive cold, with index values ranging from 61.64 to 64.66. June and September are characterized by a complete climate comfort, with index values between 70.03 and 72.02. The index values during July and August range from 75.18 to 75.81, indicating a period of warm climate comfort, wherein 50% of individuals feel hot.

- In the southern region of the state (Tanzrouft), the recorded climatic comfort period is notably extended, encompassing seven full months (exceeding half of the year), commencing in April and concluding in October. Excluding the initial month of this duration, which is marked by cold climatic conditions (where 50% of the population feels cold), the remaining months represent a complete climate comfort period, with index values fluctuating between 66.01 and 74.90.

3. Evaluating the level of climatic comfort across the state's regions through the integration of the two indices (THI and RI)

Table 6. The level of climatic comfort in the state according to the indicators of (THI) and (RI) (Source: Construction of Authors based on the results of Tables 04 and 05)

Months	Gourara region						Touat and Tidikelt regions						Tanzrouft region					
	Daytime comfort level			Night comfort level			Daytime comfort level			Night comfort level			Daytime comfort level			Night comfort level		
	THI	RI	Classification	THI	RI	Classification	THI	RI	Classification	THI	RI	Classification	THI	RI	Classification	THI	RI	Classification
January	P^-	P^-		C^-			P	P		C^-			P^+	P				
February	P	P		C	C					C	C			P^+		C	C	
March	P^+						P^+	P^+					H	H				
April	H	P^+		P^-			H	H		P^-				H^+		P^-	P^-	
May	H^+	H		P	P^-		H^+	H^+		P	P^-		H^+			P	P	
June	H^{++}	H^+			P		H^{++}				P		H^{++}			P		
July				P^+	P^+					P^+	P^+					P^+	P	
August																		
September	H^+			P	P					P	P							
October		H		P^-	P^-		H^+	H		P^-	P^-		H^+			P		
November	P^+	P		C	C		P^+	P		C	C		P^+	P^+		C	C	
December	P	P^-		C^-			P			C^-				P				
	Complete comfort						Relative comfort						Discomfort					

The findings acquired in this domain are encapsulated in the subsequent Table 6. By integrating the values derived from the two indicators, one can categorize the levels of climatic comfort that tourists may experience during their sojourn in the state into three distinct classifications: complete comfort, relative comfort, and discomfort. This categorization can be elaborated upon as follows:

3.1. The duration of complete climatic comfort within the state

At this level, the state's climate comfort is complete for all tourists during their visit to the state. The differentiation in this level is observable in its temporal distribution between day and night across the four regions as follows:

- The duration of climatic comfort during daylight hours in the Gourara region spans three months, specifically November, February, and March. In contrast, the regions of Touat and Tidikelt exhibit a four-month period, confined to the months of November through February, aligning with the conclusion of autumn and the winter season. In the case of the Tanzrouft region, this period is comfort restricted solely to December and January.

- The duration of complete climatic comfort during nocturnal hours is uniform across the regions of Gourara, Touat, and Tidikelt, occurring in the months of June and September. The Tanzrouft region is distinguished by an extended duration of this period, which persists for a comprehensive six months, from May to October, thereby encompassing the transition from late spring to mid-autumn. All forms of tourism-related activities are feasible during the aforementioned periods within these regions. It is recommended that tourism-related activities, particularly those involving guided tours, be scheduled to maximize enjoyment and engagement with the diverse array of tourist sites available within the state, as the remaining months are less conducive to such practices and may only accommodate a limited segment of tourists.

3.2. The duration of relative climatic comfort within the state

At this level, the climatic conditions in the state exhibit tendencies towards either cold or hot extremes, thereby resulting in a scenario where tourists do not experience complete comfort during their visit, particularly while engaging in various tourism activities, especially those involving excursions between differing tourist sites. The months classified within this period are delineated as follows:

- During the daytime, the months of December and January for the Gourara region, March for the Touat and Tidikelt regions, and February and November for the Tanzrouft region, are characterized by relative climate comfort. With the exception of March, in which comfort tends to be hot, all the other months mentioned tend to be cold.

- During the night, the months of May, June, July and August (corresponding to summer and the beginning of autumn) for the regions of Gourara, Touat and Tidikelt, and April for the region of Tanzrouft, are relatively comfortable for tourists, as they tend to be hot.

3.3. The duration of climatic discomfort within the state

At this level, the climatic conditions throughout the state become entirely uncomfortable for all tourists. The periods characterized by climatic discomfort are distributed across the regions of the state as follows:

- The two periods extending from mid-spring to mid-autumn for the regions of Gourara, Touat, and Tidikelt, and from spring to mid-autumn for the Tanzrouft region, constitute periods of daytime climatic discomfort, attributable to the state's classification as a desert climate. This classification is associated with a significant escalation in maximum temperatures during these intervals, which range from 27.5 °C to 46.5 °C. Consequently, during the aforementioned periods, the execution of tourism-related activities involving excursions amongst natural sites and various locales within the state is rendered infeasible due to the associated risks posed to tourists' health.

The intervals spanning from mid-autumn to mid-spring in the regions of Gourara, Touat, and Tidikelt, as well as from mid-autumn to the spring season in the Tanzrouft region, represent two distinct periods characterized by nocturnal climatic discomfort attributable to the significantly low minimum temperatures prevailing during these intervals, which fluctuate between 5.1°C and 14.8°C. Consequently, during these specified periods, it becomes imperative to organize tourism-related activities within enclosed environments, such as those associated with folkloric celebrations or exhibitions pertaining to traditional industries, for examples. As for tourist activities related to tourist tours, they require tourists to wear winter clothes that protect them from the cold weather and provide them with the required comfort.

CONCLUSION AND RECOMMENDATIONS

In the present study, we endeavored to examine the Impact of Climate on the comfort levels of tourists within the Algerian desert, utilizing the state of Adrar as a representative case study. This state possesses substantial natural and anthropogenic tourism potential across its four geographical regions, thereby facilitating the development of a diverse array of tourist activities. To quantify the degree of comfort experienced by tourists, we employed the Temperature and Humidity Index (THI) alongside the Robaa Index (RI), which we categorized into daytime and nighttime comfort levels.

The findings derived from this study indicate that the values of the two indices exhibit temporal variability throughout the calendar year, as well as spatial discrepancies across the various regions of the state. This variability is manifested in the differing levels of climatic comfort experienced by tourists, which can range from complete comfort to relative comfort and ultimately to discomfort during their visits to distinct tourist locales.

Consequently, in light of the observed climatic impact on tourism activities within the state, it is imperative that any strategic planning for the enhancement of this sector takes into account the full climate comfort periods for scheduling outdoor tourism activities, such as excursions among the various tourist attractions within the state, or organize sports events held in nature, such as running or four-wheel drive car racing in the sand dunes. Simultaneously, it is advisable to

organize tourist events in enclosed or sheltered venues during periods of discomfort to safeguard the health of Tourists. Furthermore, this approach will aid in mitigating the challenges associated with seasonal tourism dictated by climatic conditions. The discomfort period can also be used to maintain the tourist facilities in the state.

Author Contributions: Conceptualization, M.M. and S.H; methodology, M.M. and S.H.; software, M.M. and S.H; validation, M.M. and S.H.; formal analysis, M.M. and S.H.; investigation, M.M. and S.H.; data curation, M.M. and S.H.; writing - original draft preparation, M.M. and S.H.; writing - review and editing, M.M. and S.H.; visualization, M.M. and S.H.; supervision, M.M. and S.H.; project administration, M.M. and S.H. All authors have read and agreed to the published version of the manuscript.

Funding: Not applicable.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study may be obtained on request from the corresponding author.

Acknowledgements: The research undertaken was made possible by the equal scientific involvement of all the authors concerned.

Conflicts of Interest: The authors declare no conflict of interest.

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Article history: Received: 17.10.2024 Revised: 06.01.2025 Accepted: 29.01.2025 Available online: 05.03.2025