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Impact of Climate on Ecotourism in the Muthanna Desert

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Abstract

This research addresses the measurement and statistical analysis of thermal comfort in the desert of Al Muthanna, aiming to identify the most influential climatic elements on human comfort in the study area. Additionally, it seeks to determine the most suitable climatic criteria that align with the climate and reality of the study area. The research has led to the following key conclusions: 1. The months (June, July, August, September) recorded values of (H-) indicating extreme discomfort according to the Thermal Comfort Index (THI), whereas the months of December and February experienced values of (C-) denoting discomfort. Extreme discomfort (H) was recorded in October and April, while relative comfort was noted in November and March, with THI values between 17 and 18. 2. The months (June, July, August) were recorded as (H+) indicating very hot conditions, while the months (May, September, October) recorded a value of (H), and ideal comfort was observed in December and January. The values of (P) indicating ideal warmth were recorded during the months (February, March, April, November.

Keywords: *Muthanna Desert, Climate, Ecotourism.*

INTRODUCTION

The spatial variability of climatic elements is one of the attractions for tourism in various domestic regions within a single country or between countries worldwide. Climate itself is a fundamental element in any tourist activity, being a primary factor in tourist attraction. Hence, most countries exploit the variability in climatic elements to develop tourism in its various forms. Moreover, it serves as a determinant factor for the potential utilization of resources to attract populations, significantly influencing their transformation into a tourism industry as a source of economic development for their countries. Furthermore, climate is among the most influential natural environmental elements and factors affecting the development of tourist resources.

THEORETICAL FRAMEWORK

Firstly: Study Problem

The research problem can be formulated as follows:

What is the impact of climate on environmental tourism in the desert of Al Muthanna Governorate?

What are the most important global standards or laws for measuring bioclimatic comfort in the study area?

Secondly: Study Hypothesis

The research hypothesis is summarized as follows:

The climate has a direct impact on environmental tourism in the desert of Al Muthanna.

The application of bioclimatic comfort standards will help us identify the most suitable criteria that align with the climate and reality of the study area.

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Thirdly: Research Objectives

The main objective of the research is to identify the most influential climatic elements on the comfort of tourists in the study area, as well as to determine the most suitable climatic criteria that align with the climate and reality of the study area.

Fourthly: Research Methodology

The research relied on descriptive and analytical methods to analyze and interpret the data.

3- Spatial and Temporal Boundaries of the Study Area:

The spatial boundaries are represented by Al Muthanna Governorate, which is geographically located in the southwestern part of Iraq. It shares international and administrative geographical borders with the Kingdom of Saudi Arabia, representing the southern boundary of the governorate. It also has administrative boundaries with four governorates: Al-Qadisiyyah to the north and northwest, Al-Najaf to the west, Dhi Qar to the east and northeast, and finally, Basra to the east, Astronomically, Al Muthanna Governorate is located between latitudes 29°32'N to 30°16'N and longitudes 44°E to 46°30'E, see Map (1). The temporal boundary of the study is represented by the year 2022.

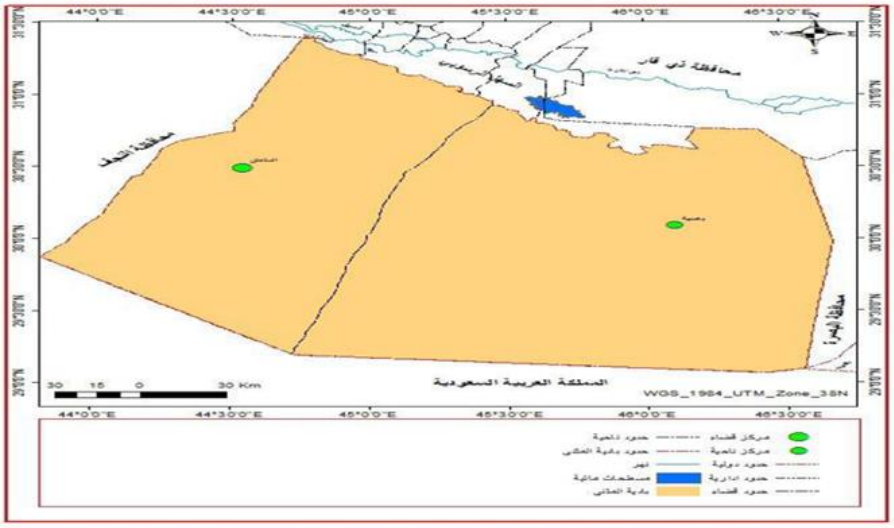

Figure 1. Location of Al-Muthanna desert.

CHAPTER ONE

The Impact of Climate on Tourism

Climate has both direct and indirect effects on environmental tourism. The direct impact lies in the suitable tourist climate that allows for the exploitation of other tourist potentials in the natural and human environment. Although there is no specific climate that suits all tourist activities, the climate suitable for general tourist movement is characterized as moderate, not too hot or too cold during the tourist season, and without significant weather fluctuations over a short period. It is also characterized by a large number of sunny days without a significant increase in temperature. This excludes winter tourist activities associated with snowfall and accumulation.

The presence of a large number of sunny hours during the tourist season in some regions is a tourist attraction for people from colder regions suffering from a lack of solar radiation reaching the Earth's surface. Additionally, low relative humidity during the hot season, high humidity during the cold season, and the blowing of gentle winds in the form of a breeze are desirable tourist phenomena. In contrast, strong winds, dust storms, and high relative humidity coupled with high temperatures are considered undesirable tourist phenomena.

The Relationship Between Climate and Environmental Tourism

Suitable Temperature

Temperature is the most important climatic element for tourism due to its significant impact on human comfort and activity, making it a crucial tourist attraction and driver for tourists in their tourism sphere. Hence, regions with extreme cold or heat are unattractive to tourists, who are repelled to areas with thermal moderation where they can experience physical and psychological comfort. The optimal temperature for human comfort and activity is between 18°C and 25°C, a range not available year-round except in the highlands of tropical regions between elevations of 500 to 2000 meters. In contrast, the lower parts of tropical regions, especially the equatorial zone, are thermally unsuitable as the average daily temperature consistently exceeds 25°C. The impact of temperature on comfort levels and the sensation of heat depends on the ability to absorb moisture, as high heat combined with high humidity creates an unsuitable climate for any tourist activities.

Winds and Their Tourist Effects

Wind characteristics are among the climatic elements that affect tourism. Wind speeds not exceeding 5 m/s are considered tourist attractions because they reduce the sensation of high heat. Winds affect temperature, humidity, precipitation, and evaporation, thereby determining tourist activity through:

a- Rapid changes in temperature are associated with the type of air masses affecting the area and changes in cloud cover.

b- The formation of frontal low-pressure systems represents the most significant changes accompanying temperature changes, leading to noticeable disturbances in the weather.

c- Atmospheric disturbances are associated with variations in atmospheric pressure and an increase in horizontal or vertical air movement, accompanied by cloudiness or active dust phenomena, as well as the movement of air masses.

d- Wind speeds exceeding 17 m/s hinder any tourist activity, while winds with speeds ranging from 10 to 17 m/s reduce tourist movement as storms of various types act as limiting factors for tourist movement.

Atmospheric Humidity

Relative humidity is one of the climatic elements of significant importance in tourism due to its effective role in human comfort and activities. Its impact is prominently observed in determining the actual value of temperature, as the relationship between them is very strong, making it difficult to separate them in terms of their vital impact on humans.

Studies in this area indicate that the suitable atmospheric humidity level, ranging between 40-60%, is most conducive for human body efficiency, providing a temperature level that is uncomfortable for the human body. Conversely, if it exceeds 70% during the cold or hot season, humans will feel cold in winter, especially if the temperature is near freezing (0 - 5°C), and their sensation of warmth increases in summer with rising temperature and humidity affecting their body. This is because high absolute humidity increases water vapor pressure, reducing sweating rates firstly, and secondly, decreasing the cooling of the body surface. However, when relative humidity drops below 40%, which can happen in dry areas in summer to below 10% with high temperatures, the weather becomes hot and dry. Yet, this is less bothersome than extremely hot and humid conditions. However, the combination of low relative humidity with decreasing temperature, reaching less than 5°C, will make the climatic conditions feel cold and uncomfortable.

Tourism activities vary in their reliance on climate; some directly depend on it, such as beach tourism and water-based activities, which are linked to sunlight and temperature. Meanwhile, there are other activities that do not directly depend on climate.

SECTION TWO

Climate of the Desert and its Relationship with Environmental Tourism

Climate constitutes a fundamental attribute of a tourist destination, serving as one of the main motivations for visiting a location. Indeed, it acts as a strong driver of impulse and satisfaction. Climate also has a significant impact on the environmental conditions that may deter tourists from traveling. It is considered a primary resource for tourism as it determines the suitability of certain attractions for a wide range of tourist activities and is the main driver of the seasonality of high demand for tourism. Climate changes can control the length and quality of tourist seasons.

The climate of the study area falls within the dry regions according to the most recognized climatic classifications. It is characterized by high temperatures in summer, which limits human activity during midday hours, and by a mild winter with a large daily and annual temperature range and low rainfall, giving the region's climate a dry characteristic. Given the importance of climate as a factor influencing the tourism industry, we will study the most important climatic elements in the province that affect tourism:

Temperature

Temperature is one of the most important climatic elements, and temperatures around the world vary significantly. Temperature is the main climatic element upon which all other climatic elements depend for tourist attraction, as it is the climatic element most felt by humans and has a clear impact on human comfort and activity.

Due to the location of the western desert plateau of Iraq within the dry region, its thermal characteristics are marked by the traits of this region. The area experiences two main seasons: summer and winter (the hot and the cold parts), with the summer lasting eight months from March to the end of October, while winter continues for four months from November to the end of February. The study area enjoys high temperatures as shown in Table (1) , with an annual average temperature in the province of 25.2°C. Temperatures gradually increase after January, reaching 25.4°C in April, coinciding with the apparent movement of the sun and its perpendicular position over the equatorial latitude. The heat continues to rise, reaching 35.8°C in June when the sun is perpendicular over the Tropic of Cancer in this month. The highest average temperature is recorded in August (37.1°C), as the sun is still near the perpendicular angle, recording the highest average maximum and minimum temperatures of 45.4°C and 28.6°C, respectively. Temperatures gradually decrease after July and August, reaching 27.3°C in October and continue to decrease until recording the lowest average in January (11.7°C), which is the month that records the lowest average maximum and minimum temperatures in the province, reaching 17.7°C and 6.5°C, respectively.

Table 1. Monthly and Annual Averages of Maximum and Minimum Temperatures for the Samawah Climatic Station (1993-2022).

Months	Maximum temperatures (°C)	Minimum temperatures (°C)	Average
January	17.7	6.5	11.7
February	20.9	8.4	14.4
March	26.1	12.6	19.4
April	32.2	18.3	25.4
May	39.1	24.2	32
June	43.5	27	35.8
July	45.1	28.6	37.4
August	45.4	28.1	37.2
September	41.8	24.5	33.3
October	35.4	19.9	27.3
November	25.8	12.8	18.4
December	19.6	8.2	13.6
Annual total	392.6	219.1	306.4
annual rate	32.7	18.3	25.2

Winds

Winds refer to the horizontal movement of air parallel to the earth's surface. Winds play a significant role in human activity in general and in tourism activity in particular. Winds are one of the climatic elements that can have a positive effect at times, as they help mitigate the impact of humidity in the hot season and prevent frost in the cold season. However, winds can have a clear negative role at other times, especially when blowing at very high speeds accompanied by dust storms.

Winds have an effect in cooling the atmosphere, with the preference given to winds reaching speeds of (0.3 – 1.5 m/s), known as "gentle breeze." If their speed is between (1.8 – 3.3 m/s), they are called "light breeze," and if the speed is between (3.4 – 5.5 m/s), they are referred to as "pleasant breeze".

Different types of winds blow in the study area throughout the year, and the prevailing winds in the province are the (northwestern), characterized by their light speed, which relatively increases in the summer season. In winter, their temperature is low. In addition to this, the (southeastern) winds, locally known as (the Sharqi), blow over the study area in summer, characterized by being warm and humid.

The highest wind speed averages in the province were recorded in the hot summer months, with speeds of (4.3, 4.1, 3.7 m/s) for the months of (June, July, August) respectively. In contrast, the average speeds decrease with the drop in temperatures in the winter months, recording (3.4, 2.9, 3.3 m/s) for the months of (December, January, February) respectively. Overall, the annual average wind speed in the study area is (3.4 m/s) (pleasant breeze), making it moderate in speed, as shown in Table (2) . This feature can be utilized for generating electricity, with the area between Dhi Qar and Al Muthanna provinces being the best location for installing wind turbines, where the average wind speed reaches 12 km/h throughout the year, a rate calculated using remote sensing technology that relies on satellites. This energy can be invested in environmental tourism development as it is clean, renewable, and environmentally friendly.

Table 2. Monthly and Annual Average Wind Speed in meters per second for the Samawah Climatic Station 1993-2023.

Months	wind speed Average (m/s)
January	2.9
February	3.3
March	3.6
April	3.7
May	3.8
June	4.3
July	4.1
August	3.7
September	3.3
October	2.9
November	2.6
December	2.7
Annual total	40.8
annual rate	3.4

Humidity

Atmospheric water vapor is one of the most important components of the lower atmosphere, despite only constituting about 2% of the total mass of the air and about 4% of its volume. It is the source of all forms of condensation and precipitation. Relative humidity is the third most important climatic element after solar radiation and temperature in terms of its significance for tourism activity, due to its effective role in human comfort and activity by determining the effectiveness of heat. It is difficult to separate the elements of heat and humidity from each other in terms of their vital impact on humans.

The humidity rates in Al Muthanna Governorate increase from the summer months to the winter months, with December and January representing the highest average relative humidity, reaching 62% and 63.1% respectively. Then, it gradually decreases to reach its lowest rate in the months of June, July, and August (21.7%, 21.4%, and 23.1% respectively), as shown in Table (3). The latter months reduce the opportunities for tourism and

recreational activities for individuals due to the significant increase in temperatures despite the decrease in relative humidity.

Table 3. Average Relative Humidity (%) for the Samawah Climatic Station 1993-2023.

Months	Relative humidity rate %
January	63.1
February	54.5
March	43.3
April	36.2
May	26.3
June	21.7
July	21.4
August	23.1
September	26.4
October	35.3
November	53.0
December	62
Annual total	404.8
annual rate	38.9

SECTION THREE

The Relationship Between Climate and Tourist Comfort

Thermal comfort for the human body is defined as a physiological state in which a person feels satisfied with the surrounding weather conditions. Each climatic element has its impact on humans, and the two most important elements that effectively and directly affect tourist comfort and the tourist activities they engage in are temperature and relative humidity, due to the strong relationship between them. Tourists generally prefer a moderate temperature range of 1-25 degrees Celsius. Humidity is considered an important climatic element for tourism activity due to its effective role in human comfort and activity and as a climatic healing element for many diseases. Many doctors advise some patients to travel to places with clean air and somewhat low humidity. There are several bioclimatic indices for measuring the degree of thermal comfort, including those based on temperature and humidity standards. Among these indices is Thom's index for determining the heat and humidity index and its effect on climatic comfort, which is as follows:

Heat-Humidity Index

The elements of heat and relative humidity are among the most important climatic elements affecting human health and comfort. The effectiveness of heat is determined by the air's humidity level. Therefore, Thom formulated the Relative Heat-Humidity Index (THI), also known as the discomfort index, to determine the optimal climate for human comfort. The Thom comfort index (THI) is calculated using the following equation:

$$THI = T - (0.55 - 0.55RH)(T-14)$$

Where:

THI refers to the Heat-Humidity Index or the discomfort index.

T is the air temperature (in Celsius).

RH is the relative humidity (as a decimal fraction).

Thom classifies temperatures according to the results of the equation in a table

Table 4. Thom's Index Classification Limits for Determining Human Comfort.

THI	Code	Comfort type
Less than 11.9	C	Severe discomfort (very cold)
12-13.9	C+	Moderate discomfort (cold)
14-14.9	C-	inconvenient
15-16	P	Complete rest
16.1-18	P^+	Relative comfort (10%-50%) of people feel comfortable

18.1-20	P^-	comfort
20.1-23	H	Severe discomfort (extreme heat)
23.1-25	H+	Great stress and dangerous to health (hot)
or more25	H-	Very annoying

Table 5. Monthly Thermal Comfort Index (Discomfort Index) for the Study Area.

Months	Code	Comfort type
January	C+	Moderate discomfort (cold)
February	C-	inconvenient
March	P+	Relative comfort (10%-50%) of people feel comfortable
April	H	Severe discomfort (extreme heat(
May	H+	Great stress and dangerous to health (hot)
June	H-	Very annoying
July	H-	Very annoying
August	H-	Very annoying
September	H-	Very annoying
October	H	Severe discomfort (extreme heat)
November	P+	Relative comfort (10%-50%) of people feel comfortable
December	C-	inconvenient

From the results of Table (5), we observe that the months (June, July, August, September) recorded values of (H-) indicating extreme discomfort according to the Thermal Comfort Index (THI). In contrast, the months of December and February experienced values of (C-) indicating discomfort according to Thom's index. Extreme discomfort (H) was recorded in October and April, while relative comfort was noted in November and March, with THI values between 17 and 18.

Wind Chill Index

Estimating the effect of wind on the elements of heat and humidity is insufficient for assessing comfort. Therefore, comfort limits should not be separated from the wind's cooling capacity because the feeling of comfort at a certain temperature and humidity level can differ significantly with changes in wind speed at the location.

In light of this, the division of comfort regions will be based on the heat and humidity index alongside the wind's cooling capacity, as introduced by Possel Siple in 1954, which uses the following equation:

$$K=100v+10.45-V(33-Ta)$$

Where:

- K represents the wind's cooling capacity, measured in kilocalories per square meter per hour.
- V is the wind speed, measured in meters per second.
- Ta is the air temperature in degrees Celsius.
- 3333 represents the normal body temperature (of exposed parts) upon which the cooling rate is based.

Table 6. Wind Chill Factor Values (k).

The values	code	Climate sensation
Less than zero	H^-	Extremely hot
Zero-50	H^+	Very hot
50-100	H	Warm
101-200	P	Ideal comfort (thermal comfort)
201-300	P^+	Perfect Comfort (Perfect Comfort)
301-400	P^-	Optimal comfort (cool comfort)
401-500	C	Cold
501-600	C^+	very cold
More than 600	C^-	too cold

Table 7. Wind Chill Index.

Months	Code	Comfort type
January	P+	Perfect Comfort (Perfect Comfort)
February	P	Ideal comfort (Thermal comfort)
March	P	Ideal comfort (Thermal comfort)
April	P	Ideal comfort (Thermal comfort)
May	H	Warm
June	H+	Very hot
July	H+	Very hot
August	H+	Very hot
September	H	Warm
October	H	Warm
November	P	Ideal comfort (Thermal comfort)
December	P+	Perfect Comfort (Perfect Comfort)

From Table (7), we observe that the months (June, July, August) were recorded as (H+) indicating very hot, while the months (May, September, October) recorded a value of (H), and ideal comfort was observed in December and January. The values of (P) indicating ideal warmth were recorded during the months (February, March, April, November)

CONCLUSIONS

The study concluded that there is a variation in values in the study area according to the months of the year:

The months (June, July, August, September) recorded values of (H-) indicating extreme discomfort according to the Thermal Comfort Index (THI), whereas the months of December and February experienced values of (C-) denoting discomfort. Extreme discomfort (H) was recorded in October and April, while relative comfort was noted in November and March, with THI values between 17 and 18.

The months (June, July, August) were recorded as (H+) indicating very hot conditions, while the months (May, September, October) recorded a value of (H), and ideal comfort was observed in December and January. The values of (P) indicating ideal warmth were recorded during the months (February, March, April, November.

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