CLIMATE CHANGE AND ITS IMPACT ON THE BIOCLIMATIC MAP OF IRAQ

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Abstract
The study aims to determine the extent of change in the boundaries of bioclimatic regions, which are of great importance for human comfort, as they are factors that affect their health and activities. The research included analyzing the changes in climate characteristics that are closely related to human comfort. Climate data from the period of 1988-2020 were used, covering nineteen stations, with one station per province and two stations for Anbar province to cover its large area. The Oliver's quotient was applied for each month and each cycle to accurately determine the bioclimatic regions. The results were then represented cartographically for the bioclimatic regions of each month and each cycle, and a comparison was made among the three cycles to determine the changes in the boundaries of the bioclimatic regions. Statistical parameters were also used to determine the differences and their trends for the bioclimatic regions, based on standard deviation, difference magnitude, direction, annual and overall rate of change.
One of the important results obtained from the study is the presence of periodic differences in climate elements, especially temperature, which showed a relative increase, particularly in the third cycle compared to the first and second cycles. The study also revealed remarkable changes in the boundaries of the bioclimatic map of Iraq as a result of climate change. Thus, the study fully achieved its hypothesis in a scientific and statistically accurate manner. Tables were created to present the results, using color variations and maps to illustrate the regions and their changes.

Keywords*: Bioclimatic map, Human comfort, Health, Activities, Climate characteristics, Oliver's quotient, Color variations*

INTRODUCTION

In the late 19th century, the field of applied climatology emerged as one of the modern geographical sciences, providing a method to understand the relationship between climate and human activities. Bioclimatology, a branch of applied climatology, focuses on studying the impact of the environment on living organisms, particularly humans, especially in areas of pollution, human health, and well-being [1].
Most studies have primarily addressed the direct effects of climate on humans. However, the content of most Arab and local studies and research has been limited to interpreting climatic phenomena as separate cases from humans. Arab libraries lack studies that explore the relationship between climate and humans, their impact on human comfort, and their influence on daily life.
This study aims to delineate the boundaries of bioclimatic regions in the study area, encompassing the provinces of Iraq. Nineteen stations were selected, and climatic data from 1988 to 2020 were divided into three smaller climatic cycles. The main objective of this study is to determine the changes in the boundaries of bioclimatic regions in Iraq during the three recent climatic cycles, comparing and identifying the changes and differences in these

boundaries resulting from global climate change observed in the study area. The results will be represented cartographically and will employ a set of equations, mathematical and statistical methods, implemented using the Excel program [2]. Additionally, the ArcGIS 10.5 program was used to assess the changes in the bioclimatic map of Iraq.

PROBLEM OF THE STUDY:

The problem of the study represents an unanswered question and serves as the first step in the scientific research process. The problem of this study is manifested in the following question: Are there any changes in the boundaries of bioclimatic regions in Iraq? This can branch into several sub-questions:

What are the characteristics of Iraq's climate and its spatial and temporal variations?
What is the periodic bioclimatic map of Iraq like?
How do the periodic climate variations affect the bioclimatic map of Iraq?
Research Hypothesis:
The hypothesis is a preliminary assumption based on the researcher's experience and knowledge of the study subject. This study aims to provide scientific solutions to the problem by stating the following hypothesis:

There are changes in the boundaries of bioclimatic regions in Iraq. The secondary hypotheses of the study are as follows:

There are spatial and temporal periodic variations in the characteristics of Iraq's climate.
The periodic bioclimatic map can be determined by applying comfort criteria and using quantitative and statistical methods.
The periodic climate variations have an impact on the bioclimatic map of Iraq.
Characteristics of Mean Maximum Temperatures in Iraq and Their Variations:
Table (1) demonstrates an increase in the mean maximum temperature rates as we move from northern stations towards the central and southern regions of Iraq. This is attributed to the difference in latitude. As known, solar radiation intensity decreases with an increase in latitude, resulting in a decrease in the angle of solar elevation, an increase in reflection coefficients, and consequently, temperature differences. The southern region, being closer to the Tropic of Cancer, experiences higher maximum temperatures, while the opposite is true for the northern region. Additionally, factors related to elevation above sea level also affect temperature rates. The northern region, being at a higher elevation compared to the central and southern regions, experiences lower temperatures. It is known that the temperature decreases by about 0.6 °C for every 100-meter increase in elevation above sea level.

Clear temporal variations are evident from the recording of July as the highest monthly average temperature in all stations, while January records the lowest average maximum temperatures, aligning with the alignment of sun rays in summer and their tilt in winter, in addition to the clear skies in summer and increased cloud cover in winter [3]. These factors affect the delineation of bioclimatic regions in Iraq. The significant variations can be identified as follows:

July clearly recorded the highest monthly average maximum temperature in Basra Station during the third cycle (2010-2020) at around 48.0 °C. This can be attributed to factors such as clear weather and longer daylight, confirming that temperatures tend to increase, especially in the third cycle (2010-2020). This change will impact the spatial and temporal distribution of bioclimatic regions in Iraq [4]. On the other hand, January recorded the lowest average maximum temperatures across all stations and cycles, reaching as low as 8.8 °C in Erbil Station during the first cycle (1988-1998).

Table (1): Monthly Mean Maximum Temperatures (°C) in Iraq for the period (1988-2020).

Dec.	Nov.	Oct.	Sep.	Aug.	July	Jun	May	Apr.	Mar.	Feb.	Jan.	Duration	Location
15.4	18.4	30.6	35.0	39.5	39.6	35.2	29.0	22.9	17.4	14.8	12.8	1988-1998	Zakho
14.6	20.5	29.5	35.9	40.9	41.3	37.7	31.2	21.1	19.0	13.4	12.4	1999-2009	
15.1	20.5	29.5	37.7	42.1	42.4	38.2	31.3	24.7	19.0	15.0	12.5	2010-2020	
11.5	17.4	26.4	33.1	37.7	37.9	33.1	27.7	20.7	15.2	10.2	8.8	1988-1998	Erbil
10.9	16.9	26.2	32.1	37.1	36.9	33.1	27.1	20.5	15.6	10.2	9.1	1999-2009	
14.7	21.0	29.8	36.5	41.4	42.2	38.9	32.7	26.6	19.7	15.7	13.9	2010-2020	
14.3	21.3	30.7	37.8	42.5	42.3	39.1	32.6	24.8	18.4	14.1	11.9	1988-1998	Mosul
15.1	21.4	31.5	38.2	43.4	43.6	40.1	33.7	26.2	20.9	15.8	13.0	1999-2009	
16.0	22.0	32.6	39.5	44.1	43.9	39.9	33.7	26.7	20.5	16.5	14.1	2010-2020	
13.5	19.4	29.4	31.9	37.2	38.4	32.9	30.5	21.7	16.7	15.7	12.1	1988-1998	Sulaymaniyah
12.9	18.1	28.3	34.3	39.3	39.1	35.8	29.4	22.5	18.3	12.4	10.2	1999-2009	
14.0	19.3	28.6	36.0	40.2	40.6	36.9	30.2	23.7	17.7	12.8	11.9	2010-2020	
15.9	22.5	31.8	38.3	42.7	43.4	40.1	34.0	26.4	19.2	15.0	13.3	1988-1998	Kirkuk
16.5	23.0	31.0	37.2	43.3	43.5	40.4	34.4	27.1	22.1	16.9	14.1	1999-2009	
17.8	23.5	33.6	39.4	44.6	44.7	41.7	35.6	28.8	22.6	17.9	15.6	2010-2020	
16.6	23.4	32.5	39.2	43.1	43.7	40.3	35.1	28.4	21.2	16.5	13.9	1988-1998	Baiji
17.0	23.7	33.2	39.6	43.9	44.0	40.9	36.3	29.1	24.7	18.4	15.3	1999-2009	

17.0	23.8	32.4	40.1	44.3	44.3	41.2	35.1	29.7	23.4	18.3	15.8	2010-2020	
17.8	24.3	33.8	40.1	44.4	44.5	41.8	36.6	28.5	21.2	17.3	15.2	1988-1998	Khanaqin
17.9	24.4	34.6	40.8	45.4	45.0	42.8	37.1	29.9	24.2	18.4	15.3	1999-2009	
20.0	25.6	35.2	42.7	46.9	46.8	43.8	37.8	30.7	24.4	19.9	18.7	2010-2020	
17.6	23.8	33.4	39.9	43.3	43.9	41.5	36.7	30.1	22.5	17.8	14.9	1988-1998	Baghdad
17.9	23.7	34.5	40.3	44.7	44.8	42.2	37.3	30.6	25.9	19.9	15.9	1999-2009	
18.4	24.3	34.0	40.7	45.1	45.3	42.4	37.2	30.8	24.8	19.7	17.1	2010-2020	
15.2	21.1	29.6	35.6	38.7	38.7	36.4	32.0	26.4	18.9	14.7	12.7	1988-1998	Rutba
16.6	21.4	30.3	36.2	40.2	39.7	37.0	32.4	27.0	21.3	16.8	14.0	1999-2009	
16.4	22.4	30.6	37.1	40.0	40.0	37.6	32.7	27.4	21.3	16.4	14.5	2010-2020	
17.0	23.2	32.2	38.2	41.5	41.7	39.3	34.9	28.9	21.7	17.2	14.5	1988-1998	Ramadi
17.5	23.1	32.9	38.9	43.0	43.2	40.4	36.1	29.8	24.6	19.1	15.8	1999-2009	
17.8	24.6	33.7	40.8	44.2	44.4	41.8	36.2	30.3	25.3	18.9	16.9	2010-2020	
19.0	25.7	34.9	41.4	44.1	44.3	42.9	38.2	31.0	23.5	18.9	16.2	1988-1998	Hayy
19.3	25.9	36.5	42.2	46.5	45.9	44.2	39.5	32.7	27.0	21.2	17.3	1999-2009	
19.6	25.2	35.5	42.4	46.1	46.1	43.5	38.5	32.2	25.9	20.6	17.7	2010-2020	
18.4	24.6	33.5	39.5	42.7	43.1	41.1	36.9	30.6	23.2	18.5	15.9	1988-1998	Hilla
17.9	24.7	34.2	39.9	43.9	42.7	41.5	37.5	31.2	26.4	20.7	16.7	1999-2009	
19.2	25.3	34.2	40.9	44.3	44.4	41.9	37.3	31.4	26.1	20.7	17.9	2010-2020	
17.8	23.9	33.4	39.8	43.5	44.0	41.6	37.0	30.4	22.6	18.0	15.8	1988-1998	Karbala
18.1	24.1	34.4	40.3	44.9	44.7	42.5	37.9	31.6	24.9	19.7	16.0	1999-2009	
19.0	24.4	34.6	42.1	45.6	45.7	42.8	37.8	31.6	25.7	20.4	17.8	2010-2020	
18.3	24.4	33.5	39.9	43.4	44.1	42.0	37.6	30.7	23.1	18.3	16.4	1988-1998	Najaf

18.5	**24.7**	**34.8**	**41.4**	**45.6**	**45.6**	**43.4**	**38.8**	**31.8**	**26.6**	**20.5**	**16.8**	**1999-2009**	
19.3	**24.9**	**35.9**	**42.4**	**45.9**	**46.2**	**43.6**	**38.7**	**32.0**	**26.3**	**20.8**	**18.0**	**2010-2020**	
18.8	**25.1**	**34.2**	**40.1**	**43.3**	**44.0**	**42.2**	**37.7**	**31.0**	**23.5**	**18.8**	**16.2**	**1988-1998**	Diwaniyah
18.8	**24.6**	**35.3**	**41.0**	**45.1**	**44.6**	**42.7**	**38.5**	**32.0**	**27.2**	**20.8**	**17.2**	**1999-2009**	
20.0	**25.6**	**35.7**	**42.9**	**45.3**	**47.1**	**43.3**	**38.8**	**32.9**	**26.7**	**22.4**	**19.1**	**2010-2020**	
19.4	**26.1**	**35.1**	**40.9**	**43.8**	**44.2**	**42.6**	**38.4**	**31.8**	**24.3**	**19.3**	**16.8**	**1988-1998**	Samawah
19.4	**27.0**	**35.1**	**41.6**	**45.5**	**45.2**	**43.5**	**39.1**	**32.2**	**27.4**	**21.2**	**16.5**	**1999-2009**	
19.9	**25.1**	**35.4**	**42.3**	**46.0**	**45.5**	**43.7**	**39.2**	**32.1**	**26.9**	**21.4**	**18.5**	**2010-2020**	
19.4	**26.4**	**35.4**	**41.6**	**44.7**	**44.8**	**43.0**	**38.5**	**30.7**	**24.6**	**19.4**	**16.8**	**1988-1998**	Nasiriyah
20.0	**26.0**	**36.7**	**42.6**	**47.0**	**46.4**	**44.2**	**40.2**	**33.6**	**27.7**	**21.4**	**17.6**	**1999-2009**	
20.6	**26.5**	**37.0**	**44.5**	**47.4**	**47.1**	**44.8**	**40.0**	**33.1**	**27.7**	**22.1**	**19.5**	**2010-2020**	
19.1	**26.2**	**34.8**	**41.8**	**44.8**	**45.4**	**43.5**	**35.4**	**28.9**	**22.5**	**18.7**	**16.5**	**1988-1998**	Imarah
19.2	**25.8**	**36.5**	**42.7**	**47.0**	**46.6**	**44.7**	**39.8**	**32.7**	**27.2**	**20.9**	**16.7**	**1999-2009**	
19.6	**25.2**	**36.0**	**43.5**	**46.9**	**46.8**	**44.7**	**39.4**	**32.0**	**26.6**	**21.3**	**18.4**	**2010-2020**	
20.4	**27.3**	**36.1**	**42.7**	**46.0**	**45.8**	**43.9**	**39.2**	**32.5**	**24.7**	**20.3**	**17.4**	**1988-1998**	Basra
19.9	**26.8**	**37.6**	**42.6**	**47.5**	**47.2**	**45.5**	**41.3**	**34.0**	**27.7**	**21.8**	**18.2**	**1999-2009**	
21.1	**27.0**	**37.6**	**44.3**	**47.7**	**48.0**	**45.3**	**40.6**	**30.6**	**25.4**	**22.5**	**20.0**	**2010-2020**	

The information in the table is based on the following sources:

1.General Directorate of Meteorology and Seismic Monitoring in Iraq, Climate Department, unpublished data, Baghdad, 2021.

2.General Directorate of Meteorology and Seismic Monitoring in the Kurdistan Region, Climate Department, unpublished data, Erbil, 2021.

CHARACTERISTICS OF THE VARIATION IN MINIMUM RELATIVE HUMIDITY IN IRAQ:

The term "minimum relative humidity" refers to the lowest humidity values recorded during hot times, especially during the daytime. It is inversely proportional to temperature rates. Table (2) indicates spatial and temporal variations in the values of minimum relative humidity. The monthly averages of minimum relative humidity exhibited clear variations. For example, January recorded the highest averages, particularly in Mosul station, reaching 68.6% during the third period (2010-2020). On the other hand, the lowest monthly

average of minimum relative humidity was recorded in Nasiriyah station in July and August, with a value of 5.5% during the third period (2010-2020).

Table (2): Average minimum relative humidity (%) in Iraq for the period (1988-2020).

Dec.	Nov.	Oct.	Sep.	Aug.	July	Jun	May	Apr.	Mar.	Feb.	Jan.	Duration	Location
63.0	48.1	336.	16.9	16.4	15.0	19.7	35.4	34.8	36.3	39.0	38.1	**1988-1998**	Zakho
41.7	37.6	29.2	15.6	11.3	8.0	14.0	24.0	35.0	35.4	35.0	34.9	**1999-2009**	
37.4	33.1	22.6	9.6	6.8	7.0	8.0	23.1	35.6	36.6	39.4	41.3	**2010-2020**	
59.8	42.2	25.4	14.2	10.4	10.8	13.2	24.3	34.0	40.0	47.1	41.6	**1988-1998**	Erbil
44.8	35.4	27.2	17.0	12.0	9.0	8.3	19.2	35.6	35.9	40.8	46.0	**-1999 2009**	
53.3	44.0	27.8	18.0	15.1	14.2	16.9	27.4	38.5	45.1	51.0	53.8	**2010-2020**	
62.5	50.8	22.2	14.8	11.8	10.3	13.6	31.4	49.3	54.8	58.7	64.7	**1988-1998**	Mosul
61.0	45.7	19.6	15.1	12.4	14.4	14.8	25.5	48.5	45.5	53.7	61.6	**1999-2009**	
61.6	51.7	29.0	15.2	12.7	14.8	15.6	25.3	45.6	55.9	58.3	68.6	**-2010 2020**	
41.8	47.4	23.7	13.0	7.3	7.2	7.3	27.5	39.5	40.9	41.0	50.8	**1988-1998**	Sulaymaniyah
49.0	36.5	25.6	17.1	9.5	8.8	10.1	20.6	34.6	35.7	44.7	50.2	**1999-2009**	
50.8	48.4	25.5	15.0	10.5	9.6	10.4	34.3	35.2	46.4	51.2	56.7	**2010-2020**	
56.6	40.8	11.3	12.3	10.1	8.7	10.6	20.5	39.1	45.3	52.7	54.7	**-1988 1998**	Kirkuk
52.1	37.0	25.4	13.7	11.0	8.4	9.5	18.8	33.1	37.1	52.3	58.6	**1999-2009**	
53.6	35.8	23.5	12.3	9.2	7.4	9.7	20.3	30.4	40.8	50.4	51.4	**2010-2020**	
62.1	48.8	26.8	19.3	12.6	12.0	12.2	23.8	30.7	44.2	54.7	63.7	**1988-1998**	Baiji
50.8	34.5	27.4	15.7	9.7	9.9	9.1	15.5	30.9	41.2	48.3	51.3	**-1999 2009**	
45.6	40.2	25.1	19.3	12.1	11.4	12.4	20.4	32.2	35.8	50.3	59.4	**2010-2020**	
58.1	43.8	20.8	15.1	13.4	12.8	14.0	19.4	38.6	45.9	52.3	62.2	**1988-1998**	Khanaqin

59.8	45.2	23.4	18.1	11.5	8.5	12.1	20.7	35.2	39.3	55.3	62.0	**1999-2009**	
45.8	39.2	20.8	12.0	7.5	7.9	8.7	18.1	25.8	41.5	52.7	59.2	**-2010 2020**	
51.2	35.7	25.6	18.5	10.9	10.3	10.5	17.9	28.8	35.8	45.3	60.2	**1988-1998**	Baghdad
45.8	41.5	25.6	18.2	10.4	9.9	9.9	15.6	23.8	28.1	41.5	51.5	**1999-2009**	
42.2	26.6	23.8	12.4	8.3	5.8	7.2	14.7	24.2	22.7	33.8	42.0	**2010-2020**	
55.6	44.5	25.7	16.5	14.6	13.5	14.5	19.6	27.5	35.0	45.5	55.3	**-1988 1998**	Rutba
53.5	40.0	25.6	18.3	13.1	10.8	11.4	16.9	27.2	32.3	42.5	51.4	**1999-2009**	
56.5	38.6	20.4	12.3	10.3	11.5	12.7	19.6	22.4	31.9	40.7	48.0	**2010-2020**	
61.2	52.7	37.4	20.3	20.6	16.8	19.3	27.0	35.3	40.3	45.9	62.5	**1988-1998**	Ramadi
64.3	45.7	35.1	20.9	20.2	15.0	19.7	15.5	25.6	37.4	50.5	55.4	**-1999 2009**	
54.1	43.5	33.5	20.8	15.1	14.4	16.1	24.8	33.5	37.9	49.9	55.1	**2010-2020**	
59.9	47.3	35.3	20.7	18.6	15.4	18.4	22.4	31.5	38.5	48.8	57.7	**المعدل**	
51.5	35.3	24.1	14.0	9.2	9.9	11.0	17.6	25.0	43.6	49.4	56.6	**1988-1998**	Hayy
45.5	35.3	15.8	12.3	10.2	8.5	9.5	17.4	29.4	35.3	40.4	52.2	**-1999 2009**	
52.5	44.5	24.0	13.4	10.4	8.5	10.2	18.2	28.3	39.0	45.8	57.7	**2010-2020**	
53.0	46.7	29.3	23.2	19.2	15.6	16.9	22.2	32.5	40.6	49.9	59.3	**1988-1998**	Hilla
59.6	50.4	34.5	25.0	20.5	18.6	17.5	21.6	32.3	36.4	45.5	57.6	**1999-2009**	
51.5	47.0	29.5	19.5	15.5	12.5	13.0	19.2	27.7	34.2	43.8	51.7	**-2010 2020**	
58.5	46.8	30.5	19.0	14.9	12.2	13.2	19.0	28.6	39.5	48.5	60.5	**1988-1998**	Karbala
57.6	46.3	33.0	27.7	21.5	21.4	16.0	19.6	27.1	32.9	37.3	62.7	**1999-2009**	
51.0	47.6	25.7	14.2	10.8	8.5	11.5	16.8	24.6	30.0	45.0	51.9	**2010-2020**	
51.3	41.0	25.8	13.7	9.1	7.2	9.6	15.0	29.0	36.4	44.2	55.0	**-1988 1998**	Najaf
50.2	39.5	24.2	14.7	8.2	7.8	9.6	17.8	27.6	31.4	42.5	51.7	**1999-2009**	

48.4	44.4	23.7	13.0	8.4	6.7	9.1	15.0	24.0	30.1	40.9	49.1	**2010-2020**	
43.4	24.5	10.5	8.6	10.6	12.9	12.5	7.0	17.8	18.9	28.5	56.4	**1988-1998**	Diwaniyah
43.8	26.2	16.6	9.6	10.6	8.0	11.3	14.8	16.0	20.7	22.8	41.5	**-1999 2009**	
39.4	36.9	17.0	9.8	14.0	13.0	13.5	9.7	19.4	26.1	36.3	44.3	**2010-2020**	
34.2	28.5	13.1	13.8	10.0	8.2	9.5	16.0	16.2	27.3	32.1	44.0	**1988-1998**	Samawah
28.4	15.8	12.3	12.4	7.1	6.3	6.7	11.7	10.9	17.6	20.1	33.4	**1999-2009**	
23.8	24.5	10.5	7.9	8.1	6.3	6.0	11.0	12.9	10.1	17.0	40.0	**-2010 2020**	
41.3	19.8	15.4	13.5	9.1	7.6	10.0	13.0	15.0	20.0	29.5	48.3	**1988-1998**	Nasiriyah
41.8	27.6	20.0	10.0	7.0	8.0	8.4	13.5	15.7	31.3	33.8	43.4	**1999-2009**	
28.3	28.5	13.4	6.6	5.5	5.7	5.5	9.9	9.7	10.8	17.3	25.3	**2010-2020**	
43.6	25.3	15.1	14.9	11.3	9.5	11.7	15.6	22.3	23.9	35.3	50.6	**-1988 1998**	Imarah
51.8	33.0	15.5	14.0	9.0	9.5	13.6	10.0	20.4	25.1	31.0	49.4	**1999-2009**	
40.5	27.4	19.9	11.5	8.2	7.5	8.2	11.4	18.2	25.7	31.5	43.5	**2010-2020**	
35.7	20.5	14.3	11.3	7.6	7.9	7.6	11.5	15.4	16.5	29.6	42.7	**1988-1998**	Basra
50.0	27.5	18.0	12.9	9.5	6.6	5.6	10.2	20.6	20.2	29.9	43.3	**-1999 2009**	
39.0	20.4	19.4	12.0	8.5	6.5	8.7	10.9	15.6	17.7	30.7	31.1	**2010-2020**	

1.General Authority for Meteorology and Seismology in Iraq, Climate Department, unpublished data, Baghdad, 2021.
2.General Directorate of Meteorology and Seismology in the Kurdistan Region, Climate Department, unpublished data, Erbil, 2021.

Oliver's Index is a formula that was first introduced in 1981 by climate scientist Oliver. It is based on the relationship between temperature and relative humidity, as these two factors have the most significant impact on human comfort. The formula used in Oliver's Index is as follows:

T - (0.55 - 0.55 * Rh / 100) * (T - 58) = THI

Where:
T = Temperature (in degrees Fahrenheit)
Rh = Relative humidity (in percentage)

Table (3) Oliver's Criteria

THI Values	Comfort Level
Less than 60	Uncomfortably Cold
60 - 65	Comfortable
65 - 75	Moderately Comfortable
75 - 85	Uncomfortably Hot

The source is based on: Atef Ahrez, "External Thermal Comfort: Concepts and Theories," Ay-Kutab Publishing House, London, 2018, p. 54.

The results of applying Oliver's comfort index for the daytime climate in Iraq during the study period (1988-2020) are shown in Table (4). The table reveals clear spatial and temporal variations in the values of the bio-climatic boundaries based on Oliver's index in Iraq during the studied cycles [5]. The following points can be noted:

Cold Discomfort Region: This region is observed in the months of January, February, and December, rarely appearing in March. January is the month with the highest occurrence of this region, particularly in stations such as Zakho, Erbil, Mosul, Sulaymaniyah, Kirkuk, and Rutba. In the first and second cycles, it appeared in stations like Baiji and Khanqin. In the first cycle, it was observed in stations like Baghdad, Ramadi, Karbala, and Najaf. In March, it only appeared in the first and second cycles in the Erbil station. The important spatial and temporal variations in the boundary values of this region are as follows:

First Cycle (1988-1998): The highest value for this region's boundaries was recorded in the Sulaymaniyah station, reaching approximately 59.9 in February, while the lowest value was observed in the Erbil station, around 49.7 in January.

Second Cycle (1999-2009): The highest boundaries for this region were recorded in the Baiji and Khanqin stations, with a value of 59.3 in January, while the lowest value in the same month was observed in the Erbil station, around 50.0.

Third Cycle (2010-2020): In this cycle, the Erbil station recorded the highest boundaries for this region, reaching 59.9 in February, while the lowest boundaries were recorded by the Sulaymaniyah station in January, at around 54.1.

Comfortable Region: This region appears in five months (January, February, March, November, December), with January being the most frequent month. It appears in most of the studied stations except for Zakho, Erbil, Mosul, Sulaymaniyah, Kirkuk, and Rutba. In Baiji and Diwaniyah stations, it appears in all cycles except the third one. It does not appear in the first and second cycles in the Khanqin station, nor in the first cycle in stations like Baghdad, Ramadi, Karbala, and Najaf. In the third cycle, it does not appear in the Diwaniyah and Basra stations. November has the lowest frequency, with it being present only in the Erbil station except in the third cycle and the second cycle in the Sulaymaniyah station [6]. The important spatial and temporal variations in the boundary values of this region are as follows:

First Cycle (1988-1998): The highest boundaries for comfort were observed in Kirkuk and Amara stations in consecutive months, March and December, with a value of approximately 64.9. Karbala recorded the lowest value, around 60.0, in January.

Second Cycle (1999-2009): The highest boundaries for comfort were recorded in the Ramadi station in February, with a value of 64.8, while Mosul had the lowest value, around 60.0, during the same month.

Third Cycle (2010-2020): The highest boundaries for comfort were recorded in the Ramadi station in February, with a value of 64.5, while the Baiji station recorded the lowest value, around 60.1, in January.

Table (4): Results of applying Oliver's index for the daytime climate in Iraq according to the cycles

Dec.	Nov.	Oct.	Sep.	Aug.	July	Jun	May	Apr.	Mar.	Feb.	Jan.	Duration	Location
59.5	65.0	79.6	81.1	86.2	85.6	81.6	77.1	69.5	62.2	58.5	55.6	1988-1998	Zakho
58.2	66.4	76.9	81.9	86.1	85.6	83.3	78.1	66.7	64.1	56.5	55.1	1999-2009	
58.9	66.1	75.9	82.5	85.9	85.8	82.6	77.9	71.4	64.2	58.8	55.2	2010-2020	
53.4	62.3	72.3	78.3	82.9	83.0	78.3	74.4	66.7	59.1	51.7	49.7	1988-1998	Erbil
52.8	61.3	72.4	77.9	82.4	81.5	77.8	72.5	65.9	59.6	51.9	50.0	1999-2009	
58.4	67.3	77.5	83.2	87.8	88.3	85.8	80.7	74.7	65.6	59.9	57.2	2010-2020	
57.8	67.9	78.2	84.0	88.2	87.5	85.0	81.0	72.9	63.9	57.5	53.9	1988-1998	Mosul
59.0	67.8	79.2	84.8	89.3	89.1	85.6	81.3	74.5	67.2	60.0	55.7	1999-2009	
60.4	69.1	80.6	86.5	90.2	89.5	86.6	82.3	75.3	66.9	61.2	57.5	2010-2020	
56.6	65.1	75.8	77.0	80.6	82.7	77.1	77.8	68.1	61.2	59.9	54.6	1988-1998	Sulaymaniyah
55.8	62.8	75.1	80.4	84.1	83.3	80.6	75.4	68.6	63.3	55.0	51.9	1999-2009	
57.3	65.0	75.7	81.9	85.0	85.6	82.3	77.4	70.7	62.7	55.6	54.1	2010-2020	
60.2	69.3	78.7	83.8	87.9	88.2	85.3	80.7	74.1	64.9	58.8	56.2	1988-1998	Kirkuk
61.0	69.7	78.0	83.4	88.9	88.5	85.3	80.8	74.3	68.2	61.6	57.5	1999-2009	
63.0	70.6	81.4	85.2	89.7	89.3	86.8	82.6	76.8	69.4	63.0	59.8	2010-2020	
61.4	70.9	80.8	86.5	89.7	89.7	86.4	82.6	76.2	67.7	61.1	57.1	1988-1998	Baiji
61.8	70.8	81.1	86.3	89.4	89.2	86.0	82.7	76.5	71.6	63.7	59.3	1999-2009	

61.7	**71.1**	**80.7**	**87.7**	**90.5**	**90.0**	**87.5**	**82.9**	**77.8**	**70.2**	**63.6**	**60.1**	**2010-2020**	
63.2	**72.0**	**81.3**	**86.7**	**91.0**	**90.6**	**88.0**	**84.6**	**76.9**	**67.8**	**62.2**	**59.2**	**1988-1998**	Khanaqin
63.4	**72.2**	**82.6**	**88.0**	**91.3**	**90.5**	**88.6**	**84.4**	**78.3**	**71.6**	**63.9**	**59.3**	**1999-2009**	
66.3	**73.6**	**82.6**	**88.4**	**91.5**	**91.5**	**88.9**	**84.5**	**78.6**	**71.6**	**66.1**	**64.6**	**2010-2020**	
62.8	**71.0**	**81.5**	**87.1**	**89.5**	**89.5**	**87.0**	**83.3**	**77.5**	**69.0**	**62.7**	**58.7**	**1988-1998**	Baghdad
63.2	**70.7**	**82.7**	**87.2**	**90.1**	**90.0**	**87.3**	**83.4**	**77.4**	**72.2**	**65.5**	**60.1**	**1999-2009**	
63.8	**71.6**	**81.4**	**86.4**	**89.9**	**89.3**	**86.8**	**83.1**	**77.6**	**71.2**	**65.3**	**61.9**	**2010-2020**	
59.1	**67.3**	**77.1**	**81.7**	**84.8**	**84.5**	**82.2**	**78.2**	**72.7**	**64.1**	**58.4**	**55.4**	**1988-1998**	Rutba
61.2	**67.4**	**77.2**	**82.8**	**86.0**	**84.9**	**82.2**	**78.2**	**73.4**	**66.7**	**61.2**	**57.3**	**1999-2009**	
60.8	**72.3**	**77.2**	**83.4**	**85.9**	**85.4**	**83.1**	**79.0**	**73.3**	**66.7**	**60.6**	**58.1**	**2010-2020**	
62.0	**71.0**	**81.6**	**87.0**	**89.5**	**88.7**	**86.5**	**83.1**	**77.2**	**68.2**	**62.1**	**58.1**	**1988-1998**	Ramadi
62.9	**70.7**	**82.5**	**87.5**	**91.1**	**90.7**	**87.9**	**84.0**	**77.6**	**71.5**	**64.8**	**60.1**	**1999-2009**	
63.0	**65,3**	**82.8**	**89.5**	**91.9**	**91.0**	**88.6**	**84.2**	**78.4**	**72.4**	**64.5**	**61.7**	**2010-2020**	
64.7	**73.4**	**82.5**	**87.6**	**89.4**	**89.5**	**88.4**	**84.9**	**79.1**	**70.6**	**64.4**	**60.7**	**1988-1998**	Hayy
65.0	**73.2**	**83.9**	**88.0**	**92.0**	**90.8**	**89.3**	**86.3**	**80.8**	**74.4**	**67.4**	**62.2**	**1999-2009**	
65.6	**73.1**	**83.2**	**88.5**	**91.6**	**91.0**	**88.8**	**85.4**	**80.0**	**73.4**	**66.7**	**63.0**	**2010-2020**	
64.1	**72.4**	**82.5**	**87.8**	**90.5**	**89.9**	**88.0**	**84.4**	**78.7**	**70.1**	**63.9**	**60.2**	**1988-1998**	Hilla
63.4	**72.9**	**83.7**	**88.7**	**92.2**	**90.3**	**88.6**	**85.0**	**79.4**	**73.8**	**67.0**	**61.5**	**1999-2009**	
65.0	**73.4**	**82.7**	**88.5**	**91.2**	**90.4**	**87.8**	**84.2**	**78.9**	**73.1**	**66.7**	**63.1**	**2010-2020**	
63.2	**71.4**	**81.9**	**87.1**	**90.1**	**89.9**	**87.6**	**83.9**	**77.8**	**69.0**	**63.1**	**60.0**	**1988-1998**	Karbala
62.1	**67.6**	**78.9**	**87.7**	**94.8**	**93.4**	**89.2**	**85.0**	**79.1**	**71.4**	**65.2**	**60.4**	**1999-2009**	
63.1	**67.9**	**79.2**	**89.9**	**96.2**	**90.6**	**88.4**	**84.2**	**78.6**	**72.5**	**66.3**	**62.9**	**2010-2020**	
62.3	**67.9**	**78.0**	**87.1**	**92.9**	**88.6**	**87.0**	**83.7**	**78.0**	**69.4**	**63.4**	**61.0**	**1988-1998**	Najaf

62.6	**68.2**	**79.5**	**89.1**	**96.0**	**90.3**	**88.5**	**85.6**	**79.4**	**73.4**	**66.4**	**61.4**	**1999-2009**	
63.5	**68.5**	**80.7**	**90.6**	**96.7**	**90.6**	**88.6**	**84.9**	**79.0**	**72.9**	**66.6**	**63.1**	**2010-2020**	
64.5	**72.9**	**82.3**	**87.3**	**90.1**	**90.1**	**88.1**	**84.2**	**78.4**	**70.2**	**64.1**	**60.7**	**1988-1998**	Diwaniyah
64.5	**71.9**	**83.5**	**88.4**	**91.8**	**90.5**	**88.3**	**84.6**	**79.3**	**74.1**	**66.8**	**62.1**	**1999-2009**	
66.1	**73.8**	**84.2**	**90.0**	**91.9**	**93.5**	**89.5**	**86.1**	**81.1**	**74.2**	**69.3**	**65.0**	**2010-2020**	
65.2	**73.7**	**82.5**	**87.0**	**89.0**	**89.0**	**87.6**	**84.6**	**79.1**	**71.1**	**64.7**	**61.4**	**1988-1998**	Samawah
65.0	**74.5**	**81.9**	**87.4**	**89.9**	**89.4**	**87.8**	**84.5**	**78.7**	**73.9**	**67.2**	**61.0**	**1999-2009**	
65.6	**72.4**	**82.3**	**87.4**	**90.8**	**89.6**	**87.7**	**84.4**	**78.2**	**73.0**	**67.2**	**63.7**	**2010-2020**	
65.3	**74.2**	**83.4**	**87.7**	**89.7**	**89.4**	**88.1**	**85.1**	**78.3**	**71.6**	**65.0**	**61.5**	**1988-1998**	Nasiriyah
66.2	**73.4**	**84.2**	**88.3**	**91.5**	**90.3**	**88.4**	**86.2**	**81.2**	**74.8**	**67.7**	**62.7**	**1999-2009**	
66.7	**74.2**	**83.4**	**88.8**	**90.7**	**89.9**	**87.8**	**85.0**	**79.5**	**74.1**	**68.1**	**65.1**	**2010-2020**	
64.9	**74.2**	**83.0**	**88.3**	**62.6**	**90.6**	**89.2**	**82.2**	**76.6**	**69.2**	**64.2**	**61.1**	**1988-1998**	Imarah
65.3	**73.5**	**84.5**	**89.1**	**64.8**	**91.2**	**89.9**	**87.1**	**81.0**	**74.8**	**67.2**	**61.4**	**1999-2009**	
65.6	**73.0**	**83.5**	**89.2**	**65.1**	**91.1**	**89.5**	**86.2**	**79.4**	**73.9**	**67.7**	**63.8**	**2010-2020**	
66.6	**75.1**	**84.0**	**88.2**	**90.6**	**90.2**	**88.4**	**85.1**	**79.8**	**71.6**	**66.1**	**62.4**	**1988-1998**	Basra
66.2	**74.4**	**85.5**	**88.6**	**92.8**	**91.6**	**89.4**	**86.4**	**81.2**	**74.7**	**68.1**	**63.6**	**1999-2009**	
67.6	**75.1**	**85.6**	**90.2**	**92.7**	**92.2**	**88.7**	**85.9**	**76.3**	**71.2**	**69.0**	**65.9**	**2010-2020**	

3 - Relative Comfort Region: This region appears with varying intensity in most months except June, July, August, and September. The month of November, in particular, had the highest frequency of occurrence, with most stations included except for the third cycle in Erbil station and the second cycle in Sulaymaniyah station. This region did not appear in the third cycle in the Ratawah and Ramadi stations, as well as the first and third cycles in the Basra station. The month of May had the lowest frequency, limited only to the first cycle in Erbil station. In terms of the annual average, we notice that this region was limited to the appearance in Zaho and Sulaymaniyah stations, and Erbil and Ratawah stations, except for the third cycle.

The spatial and temporal variations within this region are as follows:

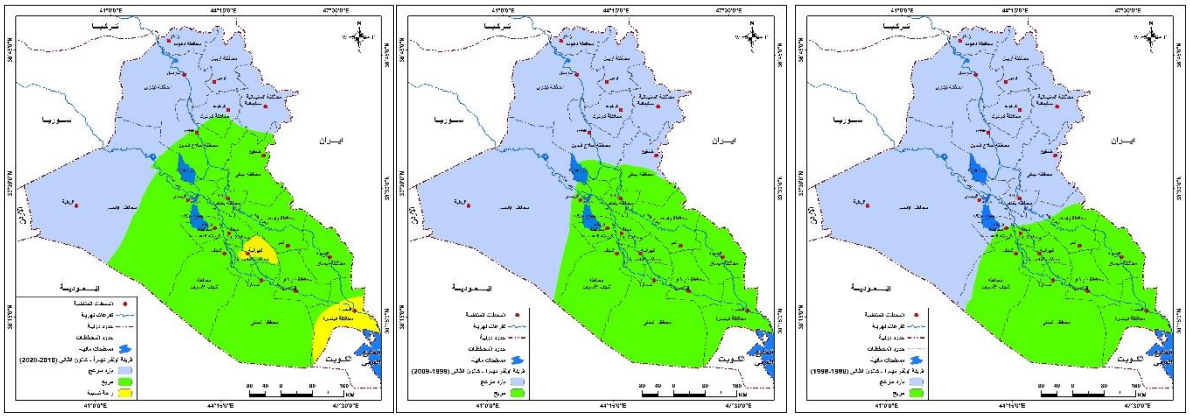
First cycle (1988-1998): Erbil station recorded the highest value of the relative comfort boundaries, reaching approximately 74.4 in the month of May, while Zaho and Nasiriyah stations had the lowest value of 65.0 for both November and February.
Second cycle (1999-2009): In this cycle, Samawah station had the highest relative comfort boundaries with approximately 74.5 in November, while Hay station had the lowest value of 65.0 in December.
Third cycle (2010-2020): Nasiriyah station had the highest boundaries for this region at 74.2 in November, while the lowest boundaries were recorded in Sulaymaniyah and Diwaniyah stations at 65.0 in December and January.
Region 4 - Annoying Hot Region: This region is concentrated in the hot summer months, prevailing in most of them, as well as in some transitional months. It did not appear in January, February, March, and December. The month of November had the lowest frequency for this region, limited only to the third cycle in the Ratawah and Ramadi stations. This region also prevailed in the annual average in all stations except for Zaho and Sulaymaniyah stations, and the third cycle in Erbil and Ratawah stations.

The significant spatial and temporal variations in the bioclimatic boundaries of the annoying hot region are as follows:

First cycle (1988-1998): Najaf station recorded the highest value of the region's boundaries in August at approximately 92.1, while Basra station had the lowest value at 75.1 in November.
Second cycle (1999-2009): Najaf station recorded the highest value for the boundaries of this region in August at 96.0, while Sulaymaniyah station had the lowest boundaries at 75.1 in October.
Third cycle (2010-2020): Najaf station recorded the highest boundaries for this region in August at 96.7, while Basra station had the lowest boundaries at around 75.1 in November.
Cartographic representation of bioclimatic regions:
The results of Oliver's quotient will be represented on maps using the ArcGIS 10.5 software. Groups of maps will be drawn, with each group representing a month or combining several months if they have identical values. Each group consists of three maps representing the three cycles: the first cycle (1988-1998), the second cycle (1999-2009), and the third cycle (2010-2020). The purpose is to illustrate the bioclimatic regions and the extent of their changes caused by climate change. The following is provided:

1.Bioclimatic regions during daytime in January according to Oliver's quotient in Iraq for the period (1988-2020):
From the set of maps (1), it is evident that there are two regions that are most extensive. The cold region appears in all stations in the northern region, in addition to the stations of Baghdad, Al-Rutba, and Al-Ramadi. The remaining stations belong to the comfortable region. In the second cycle, the two regions differed in their extent, as the comfortable region expanded at the expense of the annoying cold region, including the stations of Baghdad and Al-Ramadi. Due to the relative increase in temperature rates, the relative temperature increase continued in the third cycle compared to the first and second cycles, leading to the expansion of the comfort region at the expense of the annoying cold region, especially in the stations of Baiji and Khanqin. A new region, the relative comfort region, appeared in the stations of Diwaniya and Basra at the expense of the comfortable region [7].

Group of maps (1): Bioclimatic regions during daytime in January according to Oliver's quotient in Iraq for the three cycles.



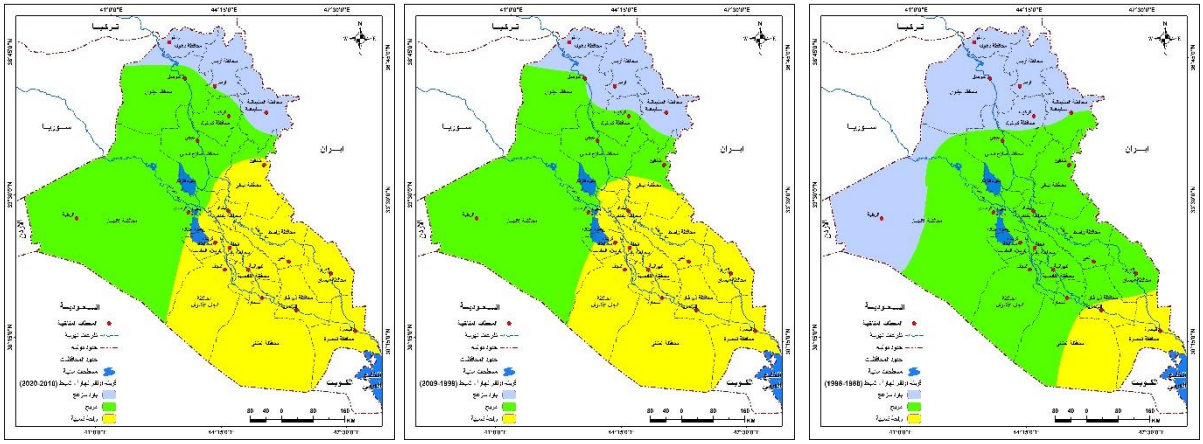
2.The bio-climatic regions during the daytime in the month of February, according to the Oliver index in Iraq for the period (1988-2020), are as follows:

In the first cycle, the largest region in terms of area is the Comfortable region, which dominates the central region. It is followed by the Cold and Annoying region, which includes stations such as Zakho, Erbil, Mosul, Sulaymaniyah, Kirkuk, and Rutba. The Relative Comfort region ranks third and appears in the stations of Nasiriyah and Basra [8].

In the second cycle, there was a change in the spatial extent of the bio-climatic regions. The Relative Comfort region took the lead and encompassed the stations that were previously within the boundaries of the Comfortable region, such as Baghdad, Al Hayy, Al Hillah, Karbala, Najaf, Diwaniyah, Samawah, and Amarah. The Cold and Annoying region, with the smallest area, lost some stations to the Comfortable region, especially Mosul and Kirkuk.

The spatial distribution of the bio-climatic regions continued to change in the third cycle, as seen in the station of Khanqin, which became part of the Relative Comfort region after being within the boundaries of the Comfortable region in the previous two cycles. This change in the distribution is a result of the higher temperatures in this cycle compared to the previous ones, due to climate change [9]. This information is presented in Map 2.

Map 2 represents the bio-climatic regions during the daytime in the month of February, according to the Oliver index in Iraq for the three cycles.



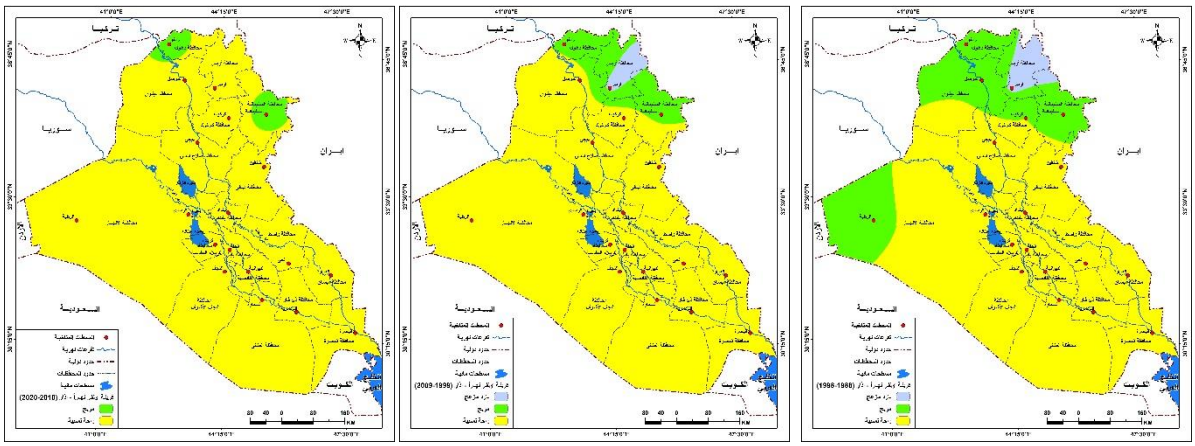
3. the bio-climatic regions during the daytime in the month of March, according to the Oliver index in Iraq for the duration of 1988 to 2020.

In March, during the first cycle, we observe that the bio-climatic map consists of three distinct regions in terms of spatial extension and area. The Relative Comfort region occupies the first rank in terms of area, encompassing all stations in the central and southern regions. The Comfort region ranks second and extends to stations such as Zakho, Mosul, Sulaymaniyah, Kirkuk, and Rutba. On the other hand, the Annoying Cold region is limited to the Erbil station only [10].

During the second cycle, we notice the expansion of the Relative Comfort region to include stations such as Mosul, Kirkuk, and Rutba, which were previously within the boundaries of the Comfort region. The expansion of the Relative Comfort region continues in the third cycle, as it takes over the Erbil station, which was previously part of the Annoying Cold region.

The gradual increase in maximum temperature during the third cycle is the reason behind these changes in the boundaries of the bio-climatic regions. Map 3 illustrates these changes.

Map 3 Represents the bio-climatic regions during the daytime in the month of March, according to the Oliver index in Iraq for the three cycles.

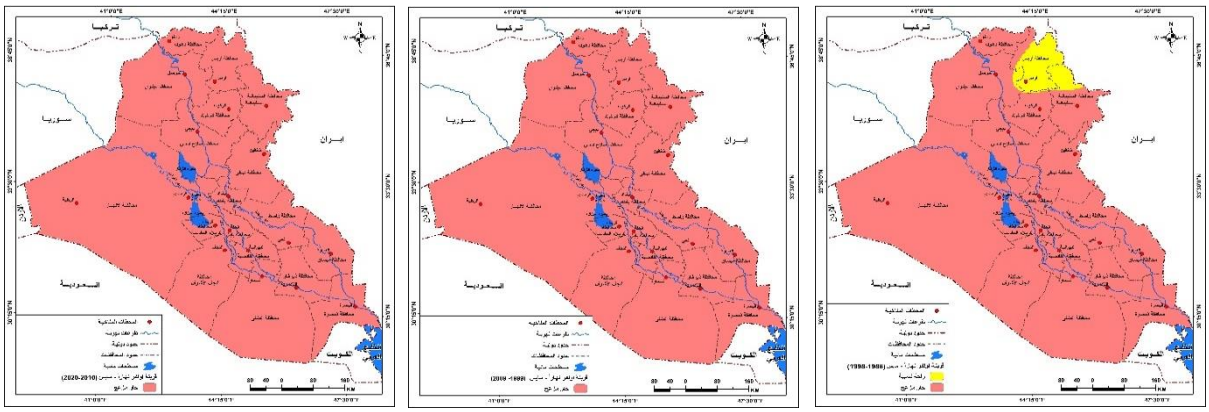


4.The diurnal bioclimatic regions for the month of April, according to Oliver's reference in Iraq for the period (1988-2020).

Between the results in the month of April during the first and second cycles in the study area, two major regions emerged. The larger region was the Hot Disturbing region, which included most of the stations in the central and southern regions. The second region, which had a smaller area, was the Relative Comfort region, observed in stations such as Zaku, Erbil, Mosul, Sulaymaniyah, Kirkuk, and Rutbah. This was due to the lower temperatures in the northern region, as it is farther from the Tropic of Cancer and at a higher elevation compared to other areas in the study area.

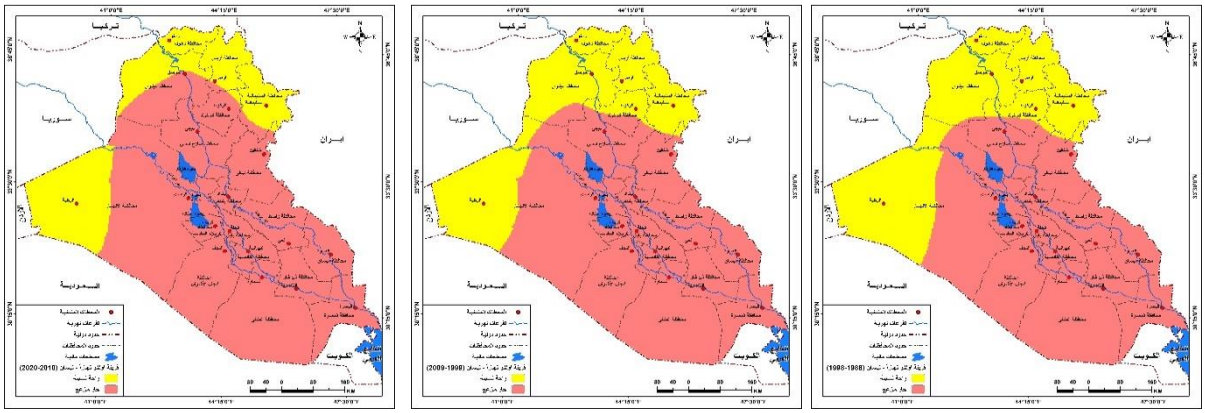
In the third cycle, there is a noticeable change in the bio-climatic regions map, particularly in the stations of Mosul and Kirkuk, which have now become part of the Hot Disturbing region after being part of the Relative Comfort region in the first and second cycles. This change is attributed to the relatively higher maximum temperature averages in the third cycle

compared to the previous two cycles, resulting from the climate change occurring globally



and in the study area.

Map 4 represents the bio-climatic regions during the daytime in the month of April, according to the Oliver index in Iraq for the three cycles.



5. Diurnal bioclimatic regions for the month of May according to Oliver's reference in Iraq for the period (1988-2020):
From the application of Oliver's reference during the daytime in May, we notice the appearance of two regions in the first cycle in the stations under study. The widest region in terms of spatial and areal extent is the "Hot Annoying" region, due to the relatively high maximum temperature values in May. This led to the dominance of this region in all the stations under study, except for the Erbil station, which was within the boundaries of the "Relative Comfort" region.

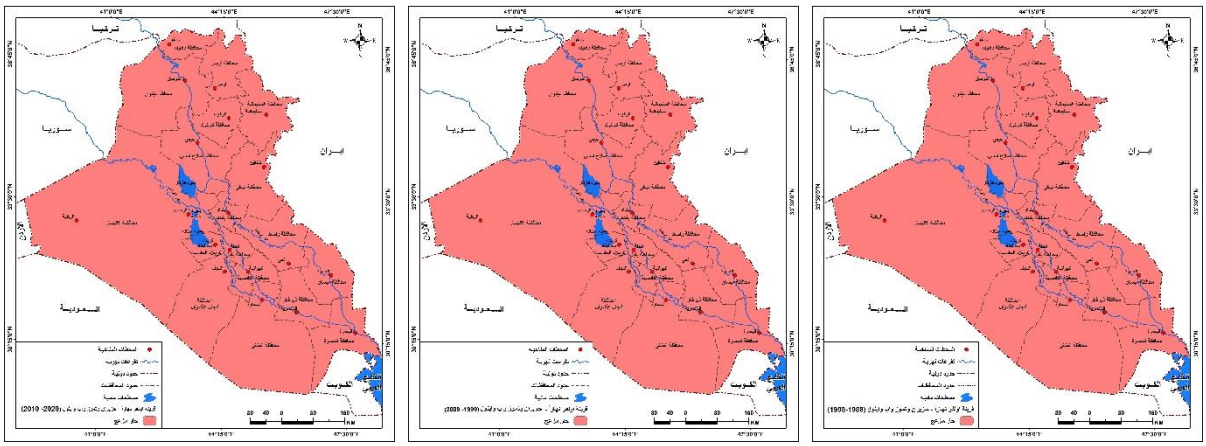
In the second and third cycles, which recorded higher maximum temperature values, there was a change in the bioclimatic regions, especially in the Erbil station. The transitional warm region disappeared from Erbil, replaced by the "Hot Annoying" region. Therefore, in the second and third cycles in May, we were within the range of the "Hot Annoying" region. This confirms the main objective of the study, which is the presence of a change in the boundaries of the bioclimatic regions in the stations of the study area, resulting from the climate change witnessed by the world and the study area in recent decades. (Map Collection 5).

Map Collection (5) - Diurnal bioclimatic regions for the month of May according to Oliver's reference in Iraq for the three cycles.

6. Diurnal bioclimatic regions for the months of June, July, August, and September according to Oliver's reference in Iraq for the period (1988-2020).

When applying Oliver's reference for the months of June, July, August, and September during the three cycles: the first cycle (1988-1998), the second cycle (1999-2009), and the third cycle (2010-2020), the results showed the dominance of the "Hot Irritating" region, which prevailed in all studied stations without exception throughout the three cycles. The reason behind this is that these months usually have high monthly averages of maximum temperatures due to factors such as clear skies, fewer clouds, longer daylight hours, and higher actual brightness. These factors contribute significantly to the increase in maximum temperatures during the daytime in those months. Additionally, the sun's rays are closer to being perpendicular during these months due to the apparent movement of the sun. Map Collection (6).

Map Collection (6): Diurnal bioclimatic regions for the months of June, July, August, and September according to Oliver's reference in Iraq for the three cycles.

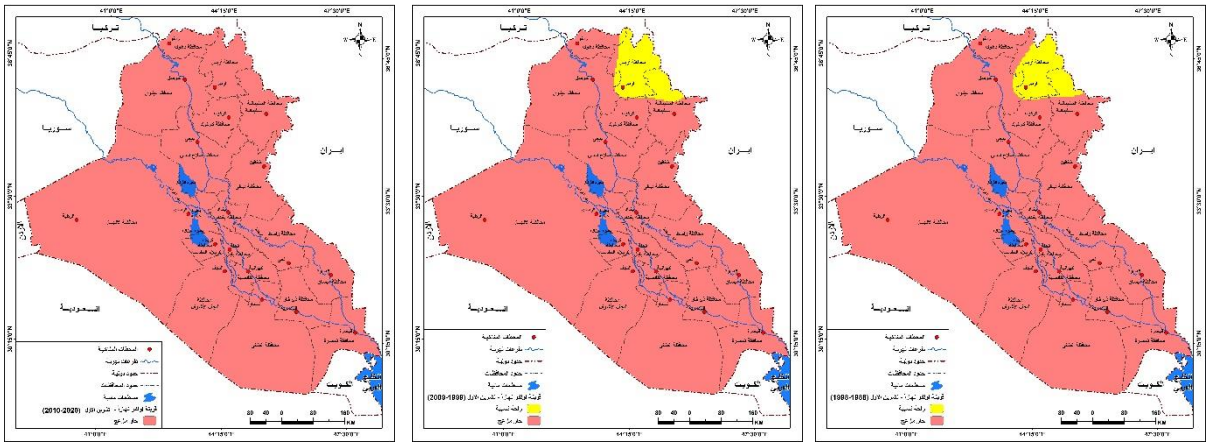


7.The diurnal bioclimatic regions in October according to Oliver's algorithm in Iraq for the period (1988-2020)

From Map Set (7), it becomes evident that when applying Oliver's algorithm during the month of October in daylight hours for the two cycles, the first cycle (1988-1998) and the second cycle (1999-2009) resulted in the emergence of two distinct regions in terms of spatial and geographical extent. The first region is the Hot Disturbing region, which is the largest in terms of area and covers all the studied stations except for the Erbil station, where the region of Relative Comfort appeared. This is due to Erbil station recording relatively lower temperature rates compared to other stations, as it is located in the northern region of Iraq, relatively far from the tropical region and at a higher elevation above sea level.

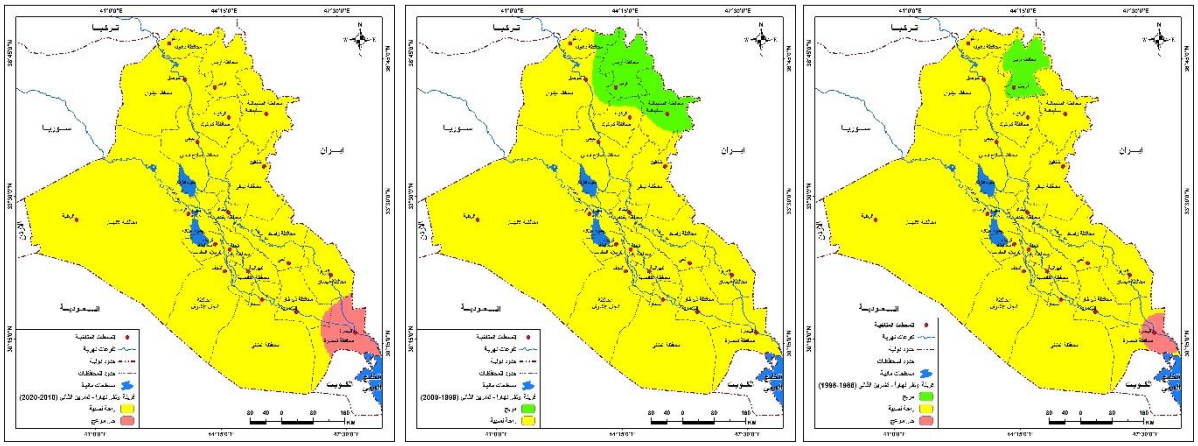
In the third cycle (2010-2020), we observe the disappearance of the region of Relative Comfort from the Erbil station, replaced by the Hot Disturbing region, which became the dominant region in all the studied stations without exception. The reason for this is the relatively higher temperature rates during the third cycle compared to the previous cycles, which is a result of the impact of climate change.

Map Set (7) displays the daytime bioclimatic regions in Iraq during the month of October according to Oliver's algorithm for the three cycles.



8.The region of relative comfort dominates most of the studied stations during the month of November in the first cycle, appearing in most stations except for Erbil, where the comfortable region prevailed, and Basra, which fell within the boundaries of the hot and annoying region. Additionally, we observe the continued dominance of the region of relative comfort in most of the studied stations in the second cycle, with some changes in certain regions. The comfortable region appeared in the Sulaymaniyah station instead of the region of relative comfort, and the hot and annoying region disappeared in the Basra station, replaced by the region of relative comfort. As for the third cycle, we notice a difference in the bioclimatic region only in the northern area, where the comfortable region was absent in the Erbil and Sulaymaniyah stations, replaced by the region of relative comfort. Additionally, the hot and annoying region returned to the Basra station after being absent in the second cycle, due to the relative increase in temperature in the third cycle. This confirms the presence of climate change, which has led to an increase in temperatures, especially in the third cycle. Map Set (8).

Map Set (8) - The Diurnal Bioclimatic Regions in the month of November according to Oliver's index in Iraq for the period (1988-2020).

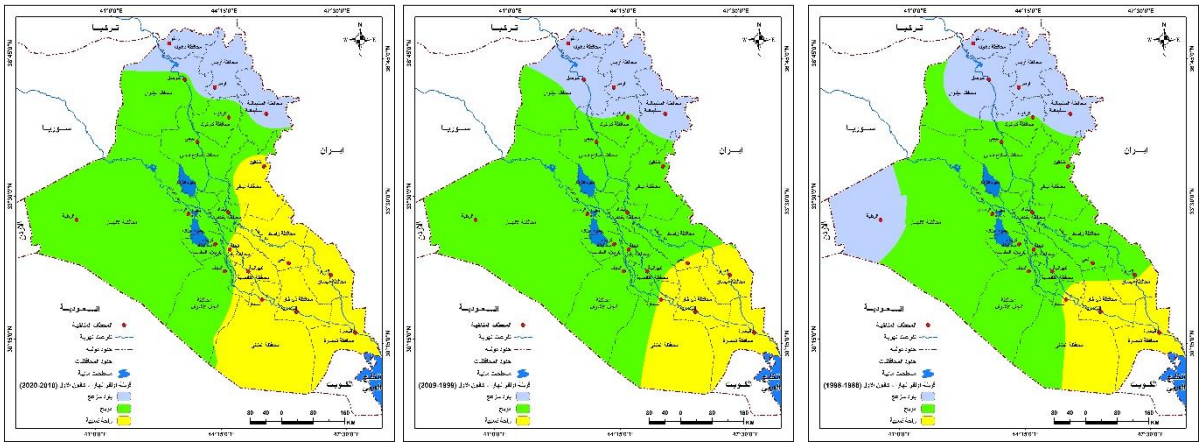


9.The Diurnal Bioclimatic Regions in the month of December according to Oliver's index in Iraq for the period (1988-2020).

In the first cycle, the month of December during the daytime exhibited the presence of three bioclimatic regions in the studied stations. The largest region was the Comfort region, concentrated in the central stations, including Kirkuk in the north and Amara in the south. The Annoying Cold region followed in terms of area, dominating the northern stations and the Rutba station. Subsequently, the Relative Comfort region appeared in the stations of Samawah, Nasiriyah, and Basra.

In the second cycle, the Annoying Cold region disappeared from the Rutba station, replaced by the Comfort region. Additionally, the Comfort region disappeared from the Hayy and Amara stations, replaced by the Relative Comfort region [11]. The boundaries of the diurnal bioclimatic regions continued to change in the stations of the study area during the third cycle, at a certain pace.

Map Set (9) - Diurnal Bioclimatic Regions in the month of December according to Oliver's index in Iraq for the three cycles.



RESULTS

It was found that the highest average maximum temperature was recorded in the months of June, July, and August. The city of Basra recorded the highest average maximum temperature of 48.0°C in July during the third cycle. The largest temperature difference was observed in Erbil station, with a difference of about 4.0°C in the month of April during the third cycle.

CONCLUSIONS

It became clear that the lowest average minimum humidity was recorded in the Nasiriyah station in the months of July and August, reaching around 5.5% in the third cycle. On the other hand, the highest average humidity was recorded in the Mosul station, reaching about 68.6% in January during the third cycle. The highest differences were recorded in the Zakho station, with a difference of 15.6% during the first cycle in December. The highest reverse differences reached -7.8% and were recorded in the Erbil station in December during the third cycle.

The study proved that the largest diurnal bioclimatic region according to Oliver's index during the daytime was the "Hot Irritating" region, as it covered most of the stations in the months of May, June, July, September, and October. The smallest region was the "Cold Irritating" region in January, February, and December.

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