THE CHANGE IN BIOCLIMATIC REGIONS IN IRAQ FOR THE PERIOD (1988-2020) BASED ON THE WIND COOLING INDEX

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Abstract
The study aims to demonstrate the changes in the boundaries of bioclimatic regions in Iraq, which are of great importance to human comfort and 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 nineteen stations for the period (1988-2020) were used, and the wind cooling index was applied for each month during the day and for each cycle to determine the bioclimatic regions clearly and accurately. The results were then represented cartographically for the bioclimatic regions for each month and each cycle, and a comparison was made between the three cycles to determine the changes in the boundaries of the bioclimatic regions. Statistical techniques were also used to determine differences in the bioclimatic regions based on standard deviation, difference magnitude, direction, and annual and overall rate of change.
One of the notable results of the study is the periodic differences in the rates of climate elements, particularly in temperature rates, which showed a relative increase in the third cycle compared to the first and second cycles. The study found remarkable results in the changes in the boundaries of the bioclimatic regions in Iraq as a result of climate change. The study achieved a high percentage of its hypothesis through an accurate statistical scientific approach. Tables were also created to present the results using color variations, and maps were used to illustrate the regions and their changes.
Keywords: *Bioclimatic regions, Human health, Climate characteristics, Wind cooling index, Difference magnitude, Rate of change*

INTRODUCTION

At the beginning of the 20th century, the field of applied climatology emerged as a modern branch of geography that aimed to understand the relationship between climate and human activities. Vital climate is considered one of the important branches of applied climatology, focusing on studying the impact of the environment on living organisms, particularly humans, especially in the areas of pollution, human health, and well-being [1].

Many studies have focused on the direct effects of climate on humans, but most of the studies, especially in the Arab and local contexts, have limited their content to interpreting climatic phenomena as separate from humans. Arab libraries lack studies that explore the relationship between climate and humans, their impact on human well-being, and their impact on practical life [2].

This study delineated the boundaries of bioclimatic regions in the study area, represented by the general provinces of Iraq, through the adoption of nineteen stations and the climatic period (1988-2020), divided into three minor climatic cycles. The aim of this study is to identify the changes in the boundaries of bioclimatic regions in Iraq during the last three climatic cycles, in order to illustrate the changes and differences in the boundaries of bioclimatic regions in Iraq between one cycle and another, represented by mapping and using a set of mathematical and statistical equations and methods applied using Excel software. ArcGIS 10.5 was also used to determine the changes in the bioclimatic map of Iraq [3].

Problem of the study:

The problem of this study is embodied in the following question: Is there a change in the boundaries of bioclimatic regions in Iraq? This can lead to several questions:

1- What are the characteristics of maximum temperatures and wind speed in Iraq and their periodic spatial and temporal variations?
2- What is the shape of the periodic bioclimatic regions in Iraq?

Study hypothesis:
This study came to provide scientific solutions to the problem of the study as follows:
There is a change in the boundaries of bioclimatic regions in Iraq. The secondary hypotheses are as follows:
1- There are periodic spatial and temporal variations in the characteristics of maximum temperatures and wind speed in Iraq.
2- The boundaries of the periodic bioclimatic regions can be determined by applying comfort criteria and using quantitative and statistical methods.
Characteristics of average maximum temperatures in Iraq and their variations:
From Table (1), it is observed that the maximum temperatures increase as we move from the northern stations towards the central and southern regions of Iraq, due to the difference in location with respect to latitudes. As is known, solar radiation intensity decreases with increasing latitude, with the decreasing angle of sun elevation and the increasing reflection coefficient, resulting in differences in temperature rates. The southern region of Iraq is closer to the Tropic of Cancer, so the maximum temperatures are higher there. The opposite happens in the northern region. In addition to other reasons related to the elevation and deviation from sea level, as the northern region is higher than the central and southern regions, the temperatures there decrease compared to other areas in the central and southern regions, and the temperature decreases by about 0.6 °C for every 100 meters above sea level.
Clear temporal variations can be observed, with July recording the highest averages in all stations, while January records the lowest maximum temperatures in line with the alignment of the sun's rays in summer and its inclination in winter, in addition to the clarity of the atmosphere in summer and the abundance of cloud cover in winter. The most important of these variations can be identified as follows:
1- It is observed that the month of July recorded the highest average maximum temperature in Basra station during the third period (2010-2020) with a value of 48.0 °C. This is due to clear weather and long daylight hours, confirming that temperatures are increasing, especially in the third period (2010-2020). This change will have an impact on the spatial and temporal distribution of Iraq's bioclimatic regions. On the other hand, the month of January had the lowest average maximum temperatures in all stations during the three periods, reaching around 8.8 °C in Erbil station during the first period (1988-1998).

Table (1): Monthly average 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	

Source based on:
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.
Characteristics of the variation in wind speed rates in Iraq:
Analysis of the data in Table (2) reveals temporal and spatial variations in monthly wind speed rates between different periods. This can be attributed to the prevalence of atmospheric instability in the study area during the hot months and relatively stable weather conditions during the cold months. The spatial variation can be attributed to differences in topography, its forms, elevations, as well as variations in temperatures. These spatial and temporal variations in wind speed rates will undoubtedly have a significant impact on the changing pattern of Iraq's bioclimatic regions. The following points can summarize these findings:
1- The highest average wind speed rate was recorded monthly at the Nasiriyah station during July, reaching approximately 6.9 m/s in the first period (1988-1998). The lowest wind speed rate was recorded at 0.6 m/s in the third period (2010-2020) during the month of November at the Zakhho and Baiji stations, and during December at the Khanqin station. This can be attributed to the presence of high terrains, which significantly reduce wind speed.

Table (2): Monthly average wind speed rates (m/s) in Iraq for the period (1988-2020).

Dec.	Nov.	Oct.	Sep.	Aug.	July	Jun	May	Apr.	Mar.	Feb.	Jan.	Duration	Location
1.4	1.6	1.9	1.9	1.7	1.7	1.9	1.9	1.9	1.9	2.0	1.8	1988-1998	
1.5	1.6	1.8	1.7	1.6	1.6	1.8	1.8	1.8	1.8	1.8	1.8	1999-2009	Zakho
0.7	0.6	0.7	0.7	0.8	0.9	0.9	1.0	1.0	0.9	0.8	0.8	2010-2020	
2.2	2.3	2.4	2.6	2.3	3.0	2.8	3.2	3.0	3.0	2.6	3.9	1988-1998	
1.8	2.0	2.1	2.0	2.3	2.4	2.5	2.7	2.7	2.5	2.7	2.1	-1999 2009	Erbil
1.8	1.4	1.6	1.2	1.4	1.4	1.7	1.7	1.9	1.9	1.5	1.6	2010-2020	
1.0	0.8	0.9	1.2	1.5	1.8	1.8	1.9	1.6	1.7	1.5	1.3	1988-1998	
1.2	0.8	1.1	1.3	1.7	1.8	1.9	2.1	1.9	1.6	1.4	1.2	1999-2009	Mosul
0.8	0.7	0.9	1.0	1.2	1.4	1.6	1.5	1.4	1.3	1.1	1.4	-2010 2020	
1.3	1.8	2.0	2.4	2.1	2.2	2.8	2.9	3.1	2.7	2.3	1.7	1988-1998	Sulaymaniyah
1.1	1.3	1.8	1.7	1.8	2.1	2.4	2.2	2.4	2.3	1.8	1.4	1999-2009	

0.8	**1.0**	**1.1**	**1.3**	**1.5**	**1.7**	**1.8**	**1.3**	**1.3**	**1.5**	**1.3**	**1.0**	**2010-2020**	
1.0	**1.1**	**1.4**	**1.4**	**1.6**	**1.7**	**1.8**	**2.0**	**1.7**	**1.5**	**1.4**	**1.0**	**-1988 1998**	
1.6	**1.5**	**1.7**	**1.6**	**2.0**	**2.3**	**2.3**	**2.3**	**2.2**	**2.0**	**1.9**	**1.5**	**1999-2009**	Kirkuk
1.3	**1.4**	**1.4**	**1.5**	**1.5**	**1.6**	**1.8**	**1.8**	**1.8**	**1.9**	**1.8**	**1.7**	**2010-2020**	
1.3	**1.3**	**1.4**	**2.1**	**3.0**	**3.7**	**3.3**	**2.8**	**2.4**	**2.3**	**1.9**	**1.4**	**1988-1998**	
0.9	**0.8**	**1.0**	**1.3**	**2.0**	**2.5**	**2.5**	**2.0**	**2.5**	**1.5**	**1.3**	**1.1**	**-1999 2009**	Baiji
0.6	**0.6**	**0.7**	**0.8**	**1.2**	**1.7**	**1.6**	**1.1**	**1.1**	**1.2**	**0.9**	**1.0**	**2010-2020**	
1.5	**1.8**	**2.0**	**1.9**	**2.0**	**2.2**	**2.3**	**2.8**	**2.5**	**2.4**	**2.2**	**1.7**	**1988-1998**	
0.8	**0.8**	**1.0**	**1.1**	**1.0**	**1.2**	**1.3**	**1.3**	**1.5**	**1.3**	**1.2**	**1.1**	**1999-2009**	Khanaqin
0.6	**0.7**	**0.9**	**0.8**	**1.0**	**1.1**	**0.9**	**1.0**	**1.1**	**1.1**	**0.9**	**0.9**	**-2010 2020**	
2.5	**2.7**	**2.5**	**2.7**	**3.5**	**4.3**	**3.7**	**3.4**	**3.2**	**3.4**	**2.8**	**2.5**	**1988-1998**	Baghdad
2.6	**2.4**	**2.8**	**3.1**	**3.4**	**4.0**	**4.1**	**3.4**	**3.3**	**3.2**	**2.9**	**2.5**	**1999-2009**	
2.6	**2.5**	**2.7**	**2.9**	**3.6**	**4.2**	**4.0**	**3.4**	**3.2**	**3.4**	**3.0**	**2.9**	**2010-2020**	
1.9	**1.9**	**2.0**	**2.1**	**2.9**	**3.7**	**3.2**	**3.1**	**3.1**	**3.3**	**3.1**	**2.4**	**-1988 1998**	Rutba
1.2	**1.1**	**1.3**	**1.6**	**1.9**	**2.8**	**2.1**	**2.2**	**2.3**	**2.3**	**2.0**	**1.8**	**1999-2009**	
1.2	**1.0**	**1.5**	**1.5**	**1.9**	**2.5**	**2.3**	**2.1**	**2.4**	**2.5**	**2.1**	**1.6**	**2010-2020**	
1.4	**1.3**	**1.6**	**1.7**	**2.2**	**3.0**	**2.5**	**2.5**	**2.6**	**2.7**	**2.4**	**1.9**	**1988-1998**	Ramadi
1.7	**1.7**	**1.7**	**2.0**	**2.4**	**2.9**	**2.7**	**2.5**	**2.3**	**2.4**	**2.3**	**1.8**	**-1999 2009**	
1.7	**1.8**	**1.8**	**2.3**	**2.5**	**3.0**	**3.0**	**2.9**	**2.7**	**2.6**	**2.4**	**2.0**	**2010-2020**	
1.9	**2.0**	**1.9**	**2.0**	**2.0**	**2.5**	**2.6**	**2.3**	**2.5**	**2.2**	**2.0**	**1.9**	**Avg.**	
3.4	**3.7**	**3.8**	**4.4**	**5.2**	**5.7**	**5.1**	**4.3**	**4.2**	**3.9**	**3.7**	**3.3**	**1988-1998**	Hayy
2.9	**3.2**	**3.2**	**4.2**	**4.7**	**5.2**	**5.3**	**3.9**	**3.9**	**3.8**	**4.0**	**3.2**	**-1999 2009**	
2.2	**2.1**	**2.5**	**3.0**	**3.3**	**3.9**	**4.2**	**2.9**	**2.7**	**2.8**	**2.7**	**2.6**	**2010-2020**	
1.2	**1.2**	**1.2**	**1.6**	**2.2**	**3.1**	**2.6**	**2.2**	**2.0**	**2.4**	**1.9**	**1.3**	**1988-1998**	Hilla
1.2	**1.0**	**1.0**	**1.4**	**1.7**	**2.2**	**2.4**	**1.9**	**2.0**	**2.0**	**1.7**	**1.3**	**1999-2009**	
1.4	**1.3**	**1.3**	**1.4**	**1.9**	**2.4**	**2.4**	**2.0**	**1.9**	**2.0**	**1.7**	**1.6**	**-2010 2020**	

1.7	**1.8**	**1.8**	**2.4**	**3.6**	**4.8**	**4.0**	**3.3**	**3.1**	**3.0**	**2.6**	**2.0**	**1988-1998**	Karbala
1.9	**1.8**	**2.0**	**2.5**	**3.0**	**3.9**	**4.2**	**3.1**	**3.1**	**3.0**	**2.5**	**2.2**	**1999-2009**	
1.9	**1.7**	**1.9**	**2.1**	**2.4**	**3.0**	**3.3**	**2.8**	**2.8**	**2.8**	**2.3**	**2.1**	**2010-2020**	
1.1	**1.4**	**1.6**	**1.9**	**2.5**	**3.4**	**3.0**	**2.4**	**2.3**	**2.3**	**1.8**	**1.4**	**-1988 1998**	Najaf
0.9	**0.9**	**1.2**	**1.5**	**1.8**	**2.3**	**2.6**	**1.8**	**1.9**	**1.8**	**1.3**	**0.8**	**1999-2009**	
1.1	**1.0**	**1.1**	**1.1**	**1.5**	**2.0**	**2.0**	**1.8**	**1.6**	**1.8**	**1.5**	**1.2**	**2010-2020**	
2.0	**1.9**	**1.7**	**1.8**	**2.5**	**3.3**	**2.9**	**2.7**	**2.8**	**2.9**	**2.5**	**2.1**	**1988-1998**	Diwaniyah
1.6	**1.5**	**1.7**	**2.0**	**2.1**	**2.6**	**2.8**	**2.5**	**2.9**	**2.5**	**2.4**	**2.0**	**-1999 2009**	
1.5	**1.4**	**1.6**	**1.5**	**1.6**	**2.1**	**2.3**	**2.0**	**2.1**	**2.2**	**2.0**	**1.8**	**2010-2020**	
2.0	**2.1**	**2.2**	**2.5**	**3.0**	**3.5**	**3.1**	**3.0**	**3.0**	**3.2**	**2.7**	**2.2**	**1988-1998**	Samawah
2.7	**2.6**	**3.0**	**3.7**	**4.0**	**4.4**	**4.8**	**4.1**	**4.1**	**3.5**	**3.2**	**2.7**	**1999-2009**	
2.9	**2.8**	**3.1**	**3.2**	**3.5**	**4.0**	**4.1**	**3.8**	**3.6**	**3.8**	**3.4**	**3.2**	**-2010 2020**	
3.3	**3.6**	**3.4**	**4.6**	**5.6**	**6.9**	**6.1**	**5.3**	**4.9**	**4.7**	**4.0**	**2.0**	**1988-1998**	Nasiriyah
2.4	**2.5**	**2.7**	**3.7**	**4.1**	**4.5**	**5.2**	**3.8**	**3.9**	**3.5**	**3.2**	**1.9**	**1999-2009**	
2.5	**2.4**	**2.6**	**2.9**	**3.4**	**3.8**	**3.7**	**3.2**	**3.1**	**3.2**	**2.9**	**2.7**	**2010-2020**	
3.1	**3.6**	**3.3**	**4.5**	**5.9**	**6.4**	**6.1**	**4.4**	**4.3**	**4.2**	**3.5**	**3.2**	**-1988 1998**	Imarah
2.8	**2.8**	**3.1**	**4.3**	**4.6**	**5.1**	**5.5**	**4.4**	**4.0**	**4.1**	**3.5**	**3.0**	**1999-2009**	
2.2	**2.3**	**2.6**	**3.0**	**3.3**	**4.1**	**4.6**	**3.5**	**3.3**	**3.3**	**2.8**	**2.4**	**2010-2020**	
2.8	**3.0**	**2.7**	**3.7**	**4.9**	**5.7**	**5.4**	**4.1**	**4.1**	**4.0**	**3.5**	**3.1**	**1988-1998**	Basra
3.4	**3.3**	**3.3**	**4.4**	**4.6**	**5.1**	**5.5**	**4.3**	**4.0**	**4.2**	**3.8**	**3.7**	**-1999 2009**	
2.8	**2.8**	**2.9**	**3.2**	**3.7**	**4.5**	**5.2**	**3.9**	**3.7**	**3.7**	**3.6**	**3.4**	**2010-2020**	

4- Wind Chill Index:

Researchers Siple and Passel (1945) developed the Wind Chill Index to quantify the effect of wind on cooling the human body. Experiments have shown that temperature and wind speed have a significant impact on the time required for freezing to occur. They also concluded that the effect of this index is more pronounced in cold regions. In such areas, the movement of air removes the warm air in contact with the body and replaces it with cooler air, thereby increasing the temperature difference between them. However, in areas where the temperature exceeds 33°C, winds will increase the skin temperature by displacing the surrounding air and replacing it with warmer air, causing evaporation and leading to an increased sensation of heat [4].

Air movement gives a sensation of coolness to the human body, although it does not actually reduce the actual temperature. However, it enhances the effectiveness of heat loss through convection and evaporation, allowing for an increase in the upper limit of physiological comfort by increasing the air movement speed up to 3.5 m/s.

The Wind Chill Index is defined as the measure of the amount of heat that can be absorbed from the gas envelope within an hour from an exposed surface area of one square meter. It has significant human benefits as it can determine the level of risk faced by individuals in cold weather conditions and help identify suitable activities and appropriate clothing. The index can be calculated using the following mathematical formula [5-7]:

$K = (\sqrt{(100V)} + 10.45 - V) * (33 - ta)$

Where:

K = Wind Chill Index (kilocalories/m^2/hour)

ta = Dry air temperature (°C)

V = Wind speed (m/s)

33 = Skin temperature constant (°C)

Table (3): Values of the K Standard - Human Sensation for Weather Conditions

K Value	Human Sensation
Less than 50	Hot
50 - 100	Warm
100 - 200	Mild (Refreshing)
200 - 400	Cool (Tending towards cold)
400 - 600	Chilly (Inclined too cold)
600 - 800	Cold

Results of the Wind Chill Index Application for Iraq's Daytime Climate based on the cycles for the period (1988-2020):

The table (4) indicates the presence of spatial and temporal variations in the values of the bioclimatic boundaries based on the Wind Chill Index in Iraq during the studied cycles. The following points can be highlighted:

1.Hot Region: This region appears in all stations and cycles included in the study, mainly during the summer months (June, July, August, September). It prevailed in all stations and cycles during these months, as well as in April, May, and October. The least recurring month for this region is April due to moderate daytime temperatures. It appears in the third cycle in Khanqin station and in stations (Al-Hay, Al-Hillah, Karbala, Najaf, Nasiriyah, and Amarah) except for the first cycle. It also exists in both Diwaniyah and Samawah stations, and in Basra station except for the third cycle [8]. The spatial and temporal variations in the values of the bioclimatic boundaries for the hot region can be clarified as follows:

First Cycle (1988-1998): The Diwaniyah station recorded the highest value of the region's boundaries in April, reaching approximately (48.8), while the Basra station recorded the lowest value in July, around (366.4-).

Second Cycle (1999-2009): The Hillah station recorded the highest boundaries of this region in April, reaching approximately (40.7), while the Basra station recorded the lowest value, around (396.7-), in July.

Third Cycle (2010-2020): In this cycle, Khanqin station recorded the highest value of the region's boundaries in April, around (45.6), while the Basra station recorded the lowest value, approximately (407.4-), in July.

2.Warm Region: This region rarely appears in a few stations and only three months, namely April, May, and October. It is most prevalent in April, including the third cycle in Kirkuk and Basra stations, as well as the overall Baghdad and Ramadi stations. It also appeared in the first cycle in stations (Al-Hay, Al-Hillah, Karbala, Najaf, Nasiriyah, and Amarah). The least recurring month for this region is

May, limited to the first cycle in Baiji station and overall Sulaymaniyah station [9]. The spatial and temporal variations in the values of the bioclimatic boundaries for the warm region can be explained as follows:

First Cycle (1988-1998): The Ramadi station recorded the highest boundaries of the region in April, approximately (95.6), while the Al-Hay station recorded the lowest value, around (53.5), in April.

Second Cycle (1999-2009): In this cycle, the Baiji station recorded the highest boundaries of this region, around (92.7), in April, while the Rutba station recorded the lowest value, approximately (55.5), in October.

Third Cycle (2010-2020): In this cycle, the Baiji station recorded the highest value, around (92.7), in April, while the Rutba station recorded the lowest boundaries of the region, approximately (50.9), in October.

3.Mild (Refreshing) Region: This region appears in the study area in a varying manner in five months (March, April, May, October, November), with November being the most recurring month. It includes most of the stations except for Zakho, Erbil, Sulaymaniyah, Baghdad, and Rutba. The first and second cycles included stations (Mosul, Kirkuk, Ramadi), and the first cycle included Karbala station. On the other hand, the month of May had the least occurrence, as it was only present in stations (Zakho, Erbil, Sulaymaniyah) except for the third cycle [10]. The occurrence of this region can be summarized in terms of spatial and temporal variations in the bioclimatic boundary values of the Pleasant Refreshing Region as follows:

The first cycle (1988-1998): The highest value for the region was recorded in Beiji station with (197.3) in November, while the lowest value was recorded in Khanqin station with (106.9) in April.

The second cycle (1999-2009): Karbala station recorded the highest value for the region with (196.4) in November, while Sulaymaniyah station recorded the lowest value with (103.7) in October.

The third cycle (2010-2020): Mosul station recorded the highest value for the region with (199.3) in November, while the same station recorded the lowest boundary value for this region with (131.6) in April.

4 - The Cool Inclined Region: This region is observed in most stations and is concentrated in the winter months and transitional seasons, while it is absent during the hot summer months. The month of December appeared the most, including all stations and cycles except for Erbil station and the first cycle in Sulaymaniyah station. April had the least occurrence for this region, as it was only present in stations (Zakho, Erbil, Sulaymaniyah) except for the third cycle. The appearance of this region in the annual average was limited to the first and second cycles in Erbil station [11]. The significant spatial and temporal variations in the bioclimatic boundary values in the Moderate Cool Inclined Region can be summarized as follows:

The first cycle (1988-1998): Beiji station recorded the highest value with (398.8) in January, while Kirkuk station had the lowest value with (208.3) in November.

The second cycle (1999-2009): The highest boundary value for the region was recorded in Sulaymaniyah station with (398.7) in March, while the lowest value was recorded by Karbala station with (200.6) in November.

The third cycle (2010-2020): Mosul station had the highest boundary value for the region with (394.7) in January, while Rutba station recorded the lowest boundary value for the region with (206.2) in November.

5 - The Cool-Inclined Region: It is evident that this region is rare in terms of its appearance, both temporally and spatially, in the study area. It is limited to a few stations and months, with January being the month in which this region appears the most. It appeared in the first and second cycles in stations (Zakho, Mosul, Baghdad, Rutba), as well as in Erbil station except for the first cycle. It also appeared in Sulaymaniyah station as a whole, the second cycle of Kirkuk station, the first cycle of stations (Ramadi, Hayy, Karbala), and the first and second cycles of Amarah station.

6 - The Cold Region: This region did not appear during the daytime in the study area due to the high daytime temperatures, which exceeded the boundaries of the cold region and prevented its occurrence in all study stations except for the first cycle in the Erbil station in January, with a value of approximately (636.4).

Table (4): Results of applying the wind chill index for the climate of Iraq during the daytime according to the cycles for the period (1988-2020).

Dec.	Nov.	Oct.	Sep.	Aug.	July	Jun	May	Apr.	Mar.	Feb.	Jan.	Duration	Location
367.5	313.9	53.6	-44.7	-141.6	-143.8	-49.1	89.3	225.6	348.4	411.2	445.7	1988-1998	Zakho
390	268.7	77.2	-63.2	-169.8	-178.4	-103.7	39.7	262.6	308.9	432.5	454.6	1999-2009	
324.3	219.9	63.4	-85.1	-169.2	-178.9	-99	33.1	161.4	266.5	334.7	381.2	2010-2020	
496.3	363.7	155.4	-2.4	-109.6	-121.4	-2.4	133.2	304.7	440.9	546.6	636.4	1988-1998	Erbil
487.7	363.7	155.3	20.3	-95.6	-91.8	-2.4	142.7	302.3	413.4	551.3	545.9	1999-2009	
403.8	250.6	68.8	-70.7	-175.4	-192.1	-128.6	6.5	142.9	297	366.7	410.6	2010-2020	
363.7	217.6	43.8	-97	-201.4	-205.2	-134.6	8.9	176.3	318.1	400.6	433.6	1988-1998	Mosul
361.7	215.7	29.8	-106.9	-226.6	-233.9	-158.6	-16	151.9	260.1	359.2	404.1	1999-2009	
316.1	199.3	7.6	-126.4	-224.3	-227.6	-148.3	-14.8	131.6	256.9	327.3	394.7	2010-2020	
400.8	300.1	81.3	25.9	-95.9	-124.6	2.4	61.4	282	394.2	403.4	455.4	1988-1998	Sulaymaniyah
398.7	306.2	103.7	-28.3	-139	-139.3	-65.9	83.1	247.2	342.7	454.6	476.1	1999-2009	
353.3	266.5	87.3	-61.7	-152.6	-165.6	-86.1	57.5	191.1	324.3	415.1	410.4	2010-2020	
332.6	208.3	25.1	-110.7	-208.5	-226.6	-156.7	-22.6	143.8	292.5	375.9	383.2	1988-1998	Kirkuk
354.7	212	43.6	-90.3	-232.7	-244.8	-172.5	-32.6	136.2	246.3	359.6	400.6	1999-2009	
312.4	198.4	-12.5	-135.7	-245.9	-251.5	-192	-57.4	92.7	232.3	333.2	379.1	2010-2020	
337	197.3	10.4	-141.6	-250.2	-278	-184.8	-51.2	108.3	275.1	368.5	398.8	1988-1998	Baiji

304.6	172.9	-3.9	-135.6	-246.3	-261.4	-187.7	-74.6	92.7	175.9	300.1	351.1	1999-2009	
281.5	161.9	10.9	-132	-228.3	-246.2	-176.3	-41.7	65.5	194	279.8	334.5	2010-2020	
322.2	192	-18.1	-158.6	-257.6	-265.4	-205.2	-87.8	106.9	277.8	362.4	387.8	1988-1998	Khanaqin
280.8	159.9	-31.1	-154.7	-241.2	-242.5	-201.4	-84.3	65.7	180.9	295	351.1	1999-2009	
228.7	134.1	-41.9	-180.4	-270.4	-273.8	-205.6	-93.4	45.6	170.6	249.4	272.2	2010-2020	
365.9	222.5	-9.5	-166.9	-264.3	-293.1	-220.9	-94.3	72.9	267.6	370.6	430.1	1988-1998	Baghdad
362	218.9	-36.6	-182.2	-298.2	-312.1	-244.7	-109.6	60.8	178.5	322	406.3	1999-2009	
350	206.7	-24.2	-189.3	-312.5	-328.9	-248.6	-107.1	55.3	209	329.4	390.8	2010-2020	
397.5	265.8	76.8	-59.4	-140.1	-148.1	-85.5	25	164.7	357	456.7	477.9	1988-1998	Rutba
331.4	230.1	55.5	-68.8	-160.8	-163.4	-91.4	13.8	139.9	272.8	366	419.3	1999-2009	
335.4	206.2	50.9	-86.9	-156.3	-166.3	-107.3	6.9	131.8	278	379.2	397.7	2010-2020	
348.6	213.5	17.4	-117.5	-200.1	-213.8	-152.3	-45.1	95.6	266	368.4	408.2	1988-1998	Ramadi
337.7	218.5	2.2	-137.6	-237.6	-252.7	-183.3	-76.2	77.4	201.4	327.2	388.6	1999-2009	
339.5	189.8	-15.6	-176.2	-253	-270.9	-211	-74.6	64.2	177.7	318.5	359.6	2010-2020	
356.8	189.7	-49.7	-227	-311.4	-323.5	-276.5	-139.8	53.5	249.8	366.4	425.3	1988-1998	Hayy
336.7	178.5	-88	-246	-370.3	-361.9	-315.5	-170.9	7.9	156.9	312.1	394.7	1999-2009	
309.3	178.2	-59.4	-232.8	-331.6	-344.5	-280.8	-135.2	19.3	173.1	299.9	366.8	2010-2020	

295	169.7	-10.1	-139.7	-223.9	-252.1	-194.2	-90	54.2	230.7	323.8	351.4	1988-1998	Hilla
305.1	161.4	-23.3	-144.1	-237.5	-223.9	-200.1	-100.5	40.7	149.1	268	335	1999-2009	
288.2	158.2	-24.7	-165	-252.4	-268.4	-209.5	-97.1	35.7	155.9	268	324.6	2010-2020	
331.2	200.8	-8.8	-160.1	-271.1	-303.1	-227.5	-101.3	64.9	257.6	359.6	404.4	1988-1998	Karbala
332.8	196.4	-31.6	-173.5	-294.8	-307.7	-254.1	-122.3	34.9	200.6	316	392.4	1999-2009	
312.7	187.4	-35.7	-207.9	-296.6	-314.6	-248.1	-117	34.1	178	293.8	347.2	2010-2020	
291.6	179.6	-10.7	-154.1	-247.1	-282.9	-222.9	-108.3	53.6	230.8	324.4	367.5	1988-1998	Najaf
276	158	-36.4	-178.1	-278	-293.8	-249.3	-128	26.8	141.2	256.9	301.2	1999-2009	
271.8	157.5	-57.5	-186.5	-273.4	-298.2	-239.5	-125.8	21.5	147.8	258.6	303.1	2010-2020	
320.8	176.4	-26.1	-156.7	-244.7	-278.5	-226.1	-113.7	48.8	233.5	337.4	383.7	1988-1998	Diwaniyah
305.3	178.1	-50.1	-180.7	-276.4	-278.1	-236.5	-130.7	24.6	137.8	287.2	357	1999-2009	
275.6	154.5	-58	-209.9	-264.4	-322.1	-240.2	-131	2.3	145.4	239.5	306.7	2010-2020	
307.3	157.6	-48.5	-187.7	-267.5	-287.4	-239.6	-133.8	29.7	218.7	331.3	373.9	1988-1998	Samawah
328.9	143.8	-52	-223.5	-330.6	-329.7	-289.4	-162.3	21.3	143.7	296.6	399	1999-2009	
322	192.6	-59.9	-233.8	-333.6	-330.6	-284.6	-162.1	23.2	159.5	295.7	364.5	2010-2020	
344.3	170.4	-61.2	-234.8	-333.6	-351.9	-290.5	-154.9	63.7	230.4	359.7	366	1988-1998	Nasiriyah
306	166.3	-89.5	-249.5	-372.4	-364	-314.2	-188.2	-15.8	136	291.6	343.9	1999-2009	

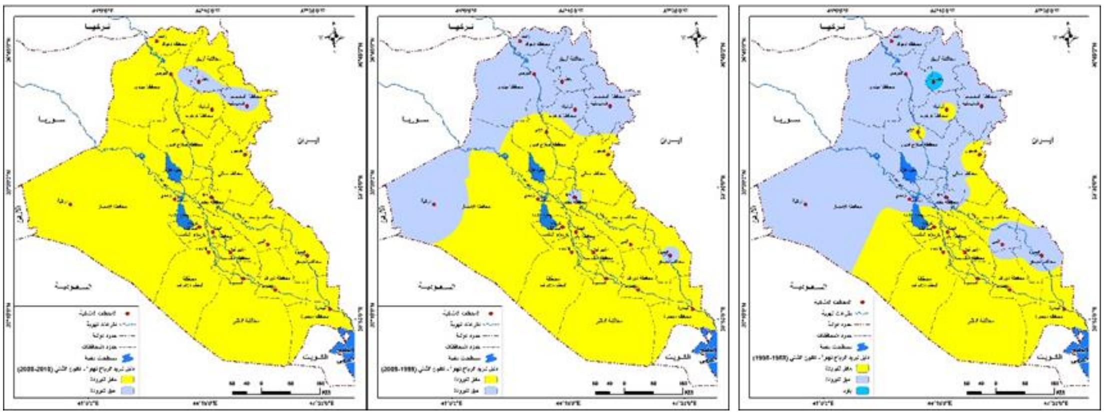
294.6	153	-95.9	-282.7	-367	-368.6	-306.6	-176	-2.5	133.2	267.9	326.5	2010-2020	
346.9	175.6	-45.6	-239	-340.3	-363.9	-305	-64.9	78.3	280.8	366.9	414.8	1988-1998	Imarah
336.5	175.6	-87.3	-260.8	-382.2	-379.9	-332.3	-183.8	7.9	154.3	310.5	403.8	1999-2009	
309.3	181.9	-71.9	-260.1	-351.9	-367.1	-319.4	-164.2	25.3	162	285.3	343.7	2010-2020	
307.2	141.2	-75	-252.1	-359.9	-366.4	-308.3	-164.9	13.3	219.5	325.9	389.3	1988-1998	Basra
333.9	157	-116.5	-259.5	-395.8	-396.7	-355	-223.2	-26.5	141.7	292.8	384.6	1999-2009	
290.2	146.3	-113.1	-284.1	-382	-407.4	-345.1	-199.9	62.4	197.5	271.1	331.4	2010-2020	

The cartographic representation of the bioclimatic regions will be done using the ArcGIS 10.5 software. It will involve drawing sets of maps, where each set represents a month or a combination of several months if they have identical values. Each set consists of three maps representing the three cycles: the first cycle (1988-1998), the second cycle (1999-2009), and the third cycle (2010-2020) [12]. This is done to illustrate the bioclimatic regions and the magnitude of their changes caused by climate change.

1- Bioclimatic regions during the daytime in January based on the wind chill index in Iraq for the period (1988-2020):

From the set of maps (1), three regions appear in January during the first cycle, with the largest one being the Cold Region that dominated the stations in the northern and central regions and the Amarah station. The Cool-Mild Region came in second, including stations such as Kirkuk, Baiji, Khanaqin, Al-Hilla, Al-Najaf, Al-Diwaniyah, Al-Samawa, Al-Nasiriyah, and Basra. The Cold Region was limited to the Erbil station, while in the second cycle, the boundaries of the regions changed. The Cold Region disappeared from the Erbil station, replaced by the Cool-Mild Region. The region in the Kirkuk station changed from Cool-Mild to Cold. In stations such as Ramadi, Hayy, and Karbala, the Cool-Mild Region disappeared, replaced by the Mild-Cool Region. The changes continued in the third cycle at stations such as Zakho, Mosul, Kirkuk, Baghdad Al-Rutbah, and Amarah, where the Cool-Mild Region disappeared, and the Mild-Cool Region appeared instead. This is due to the relative increase in temperatures in the third cycle caused by climate change.

Map set (1): Bioclimatic regions during the daytime in January according to the wind chill index in Iraq for the three cycles.

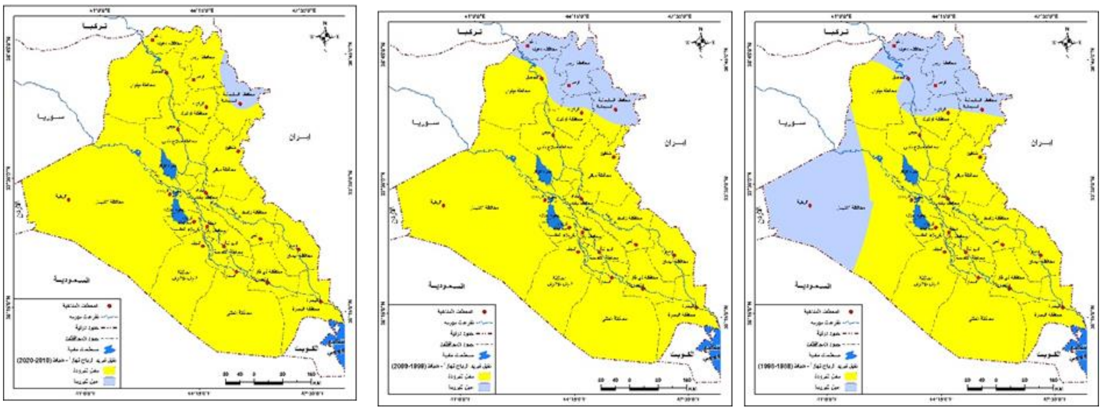


2.Bioclimatic regions during the daytime in February according to the wind chill index in Iraq for the period (1988-2020):

The results show that during the first cycle in February, two regions appeared, with the larger one being the cool-moderate region present in most of the study stations, except for stations (Zakho, Arbil, Mosul, Sulaymaniyah, and Rutba), where the cold region appeared due to lower temperatures in these stations. This is because they are located relatively far north of Iraq's Tropic of Cancer compared to other stations, resulting in the sun's rays being more inclined in the central and southern regions. Additionally, these stations are at a higher elevation above sea level, and it is known that temperatures decrease with increasing elevation above sea level.

In the second cycle, the boundaries of the bioclimatic regions changed in the Mosul and Rutba stations from the cool-moderate region to the cool region. This change was due to relatively higher maximum temperature rates recorded in this cycle compared to the first cycle. The changes in the boundaries of the bioclimatic regions continued in the third cycle, as seen in the Zakho and Arbil stations, where the cool-moderate region disappeared and was replaced by the cool region. This is reflected in map set (2).

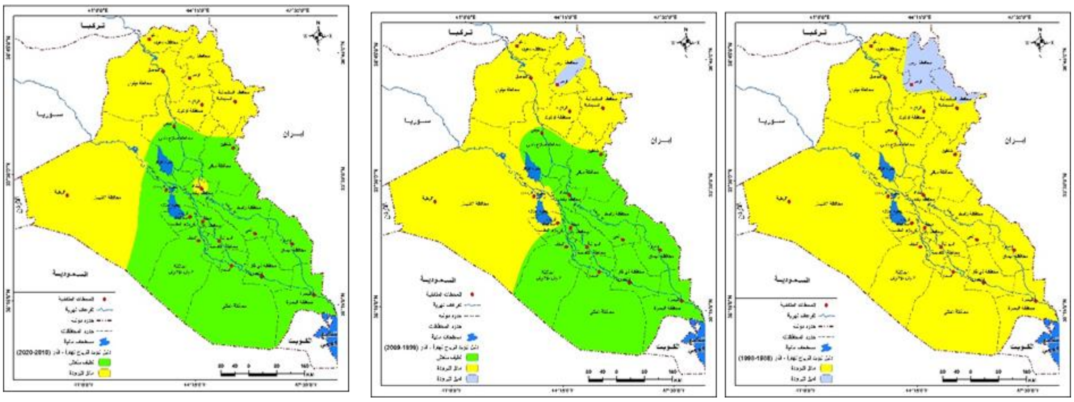
Map set (2): Bioclimatic regions during the daytime in February according to the wind chill index for the three cycles.



3. Bioclimatic regions during the daytime in March according to the wind chill index for the period (1988-2020).

In the first cycle, two regions were observed in March: the cool region, which prevailed in all stations under study except for Erbil station, where the mild region appeared. In the second cycle, the boundaries of the regions changed significantly in most stations, such as Beiji, Khanqin, Baghdad, Al-Hay, Al-Hilla, Al-Najaf, Al-Diwaniyah, Al-Samawa, Al-Amara, and Basra, where the mild region disappeared and was replaced by the refreshing mild region. The change in the boundaries of the regions continued in the third cycle, with a shift in Erbil station from the mild region to the refreshing mild region. In Baghdad station, the refreshing mild region disappeared and was replaced by the mild region. As for Ramadi and Karbala stations, the region changed from the mild region to the refreshing mild region due to the relatively higher temperatures in the second and third cycles [13]. This confirms the hypothesis of the study regarding the changing map of bioclimatic regions in Iraq as a result of climate change.

Map set (3): Bioclimatic regions during the daytime in March according to the wind chill index in Iraq for the three cycles.

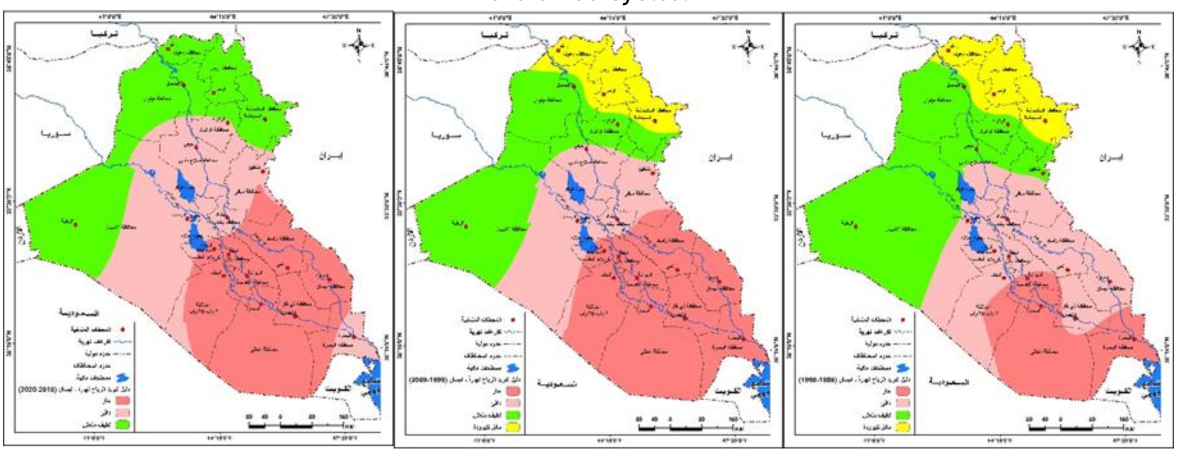


4. Bioclimatic regions during the daytime in April according to the wind chill index in Iraq for the period (1988-2020).

From map set (4), it is observed that during the first cycle in April, there are four bioclimatic regions. The largest region is the warm region, which appeared in stations (Baghdad, Ramadi, Al-Hay, Al-Hillah, Karbala, Najaf, Nasiriyah, Al-Amara). The smallest region is the cool region, which appeared in stations (Zakho, Erbil, Sulaymaniyah). The pleasant and refreshing region appeared in stations (Mosul, Kirkuk, Baiji, Khanqin, Rutba). The hot region is present in stations (Diwaniyah, Samawah, Basra).

In the second cycle, there were significant changes in the boundaries of the regions in the stations of Baiji and Khanqin, as they changed from the pleasant and refreshing region to the warm region. The warm region disappeared from stations (Al-Hay, Al-Hillah, Karbala, Najaf, Nasiriyah, Al-Amara), and instead, the hot region appeared. Changes in the boundaries of the bioclimatic regions continued in the third cycle, as in stations (Zakho, Erbil, Sulaymaniyah), where the region changed from cool to pleasant and refreshing. In Kirkuk station, the pleasant and refreshing region disappeared, replaced by the warm region. The region in Khanqin station changed from warm to hot, and in Basra station, the warm region appeared instead of the hot region.

Map set (4): Bioclimatic regions during the daytime in April according to Oliver's guide in Iraq for the three cycles.



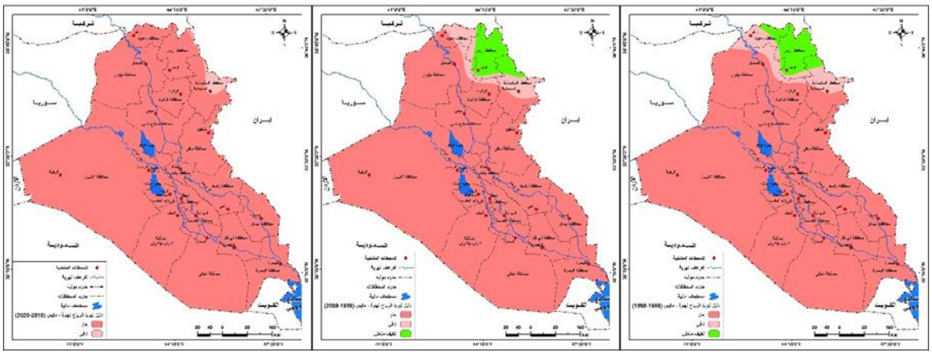
5.Bioclimatic regions during the daytime in May according to the wind cooling guide in Iraq for the period (1988-2020).

The results of the wind cooling guide for the climate of Iraq during the daytime in May, in the first cycle, indicate the presence of three distinct bioclimatic regions. The largest region is the hot region, which appeared in all stations in the central and southern regions, including Kirkuk, due to the high temperature rates during this month. The warm region comes second, including the stations of Zakho and Sulaymaniyah. The third and smallest region is the mild and refreshing region, which appeared only in the Erbil station.

In the second cycle, there are noticeable changes in the boundaries of the bioclimatic regions, especially in the Zakho station where the hot region disappeared and was replaced by the warm region. This change in the boundaries of the regions is attributed to the relatively higher temperature rates in the second cycle compared to the first cycle, due to climate change.

In the third cycle, the changes in the boundaries of the bioclimatic regions continued. This is evident in the Erbil station, where the hot region appeared instead of the mild and refreshing region.

Map set (5): Bioclimatic regions during the daytime in May according to Oliver's guide in Iraq for the three cycles.

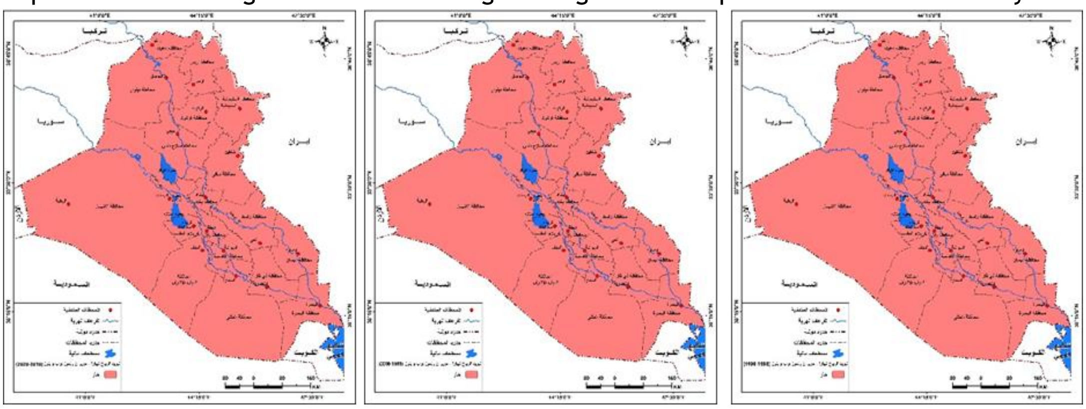


6. Bioclimatic regions during the daytime in the months of June, July, August, and September according to the wind cooling index guide in Iraq for the period (1988-2020).

The results of applying the wind cooling index guide during the daytime in the months of June, July, August, and September indicate the dominance of the hot region in all studied stations without exception, across the three climatic cycles. The reason for the dominance of this region in all stations within the study area during these months is attributed to the high average maximum monthly temperatures recorded in all Iraqi stations during these months.

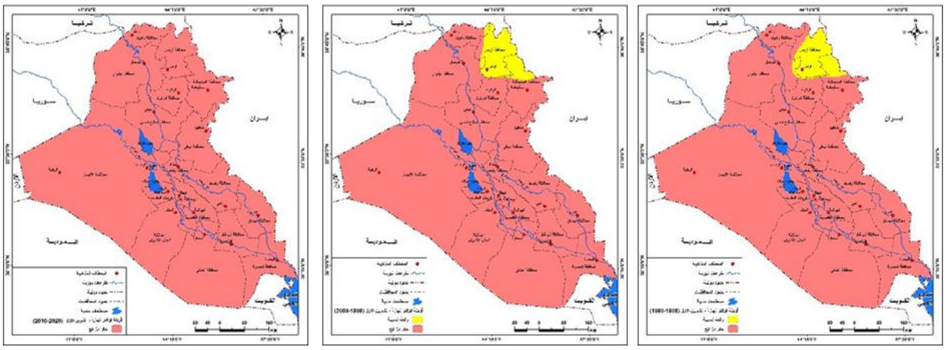
It is well known that the reasons for the high temperatures in Iraq during these months are attributed to several factors, including the alignment of the sun's rays during these months due to the apparent movement of the sun, as well as the length of the day and clear weather conditions resulting from the low cloud cover and increased actual sunshine hours. These factors have led to an increase in temperature rates, resulting in the hot bioclimatic region depicted in this map set (6).

Map set (6): Bioclimatic regions during the daytime in the months of June, July, August, and September according to the wind cooling index guide in Iraq for the three climatic cycles.

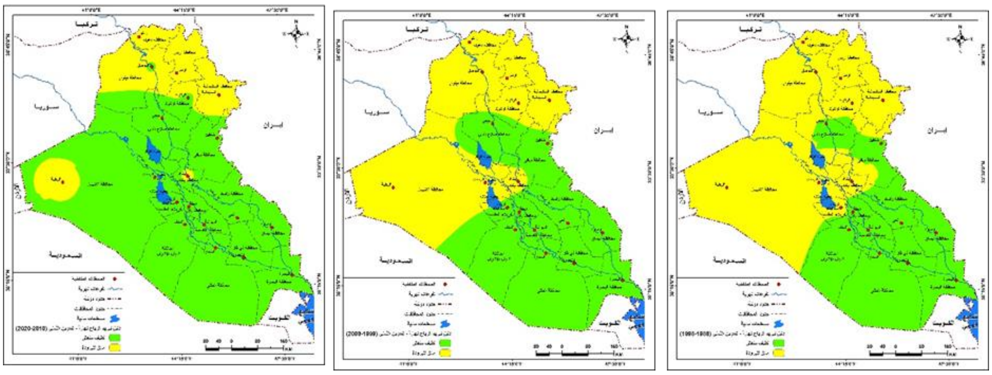


7.The bioclimatic regions during the daytime in the month of October, according to the Wind Cooling Guide in Iraq for the period (1988-2020), are as follows:
The temperatures gradually start to decrease starting from the month of October. Therefore, in the first cycle, we observe the emergence of two new regions after the hot region dominated the previous months in all stations without exception. We notice the warm region in the stations of Zakho and Sulaymaniyah, and the pleasant and refreshing region appears in the station of Erbil. In the second cycle, there is a change in the boundaries of the bioclimatic regions in the Sulaymaniyah station, where the warm region disappears and is replaced by the pleasant and refreshing region. In the third cycle, we observe a change in both Erbil and Sulaymaniyah stations, where the warm region appears, replacing the pleasant and refreshing region. This confirms the hypothesis of the study that assumed changes in the boundaries of the bioclimatic regions due to climate change, which has led to increased temperatures globally and in the study area. Map set (7).

Map collection (7) presents the bioclimatic regions during the daytime in the month of October, based on the Wind Cooling Guide in Iraq for the three cycles.



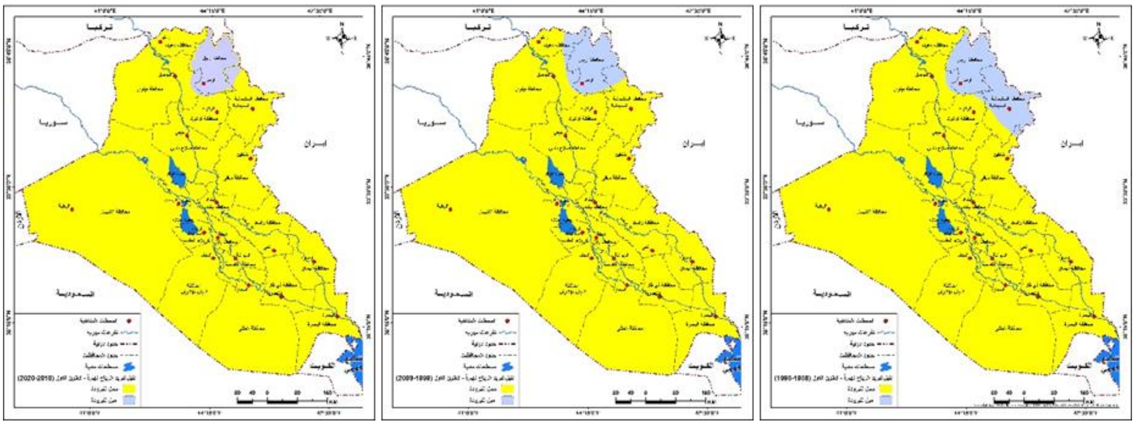
8. Reveals the presence of two regions. The larger region is the cool-temperate region, which includes all stations in the northern region and stations such as Baghdad, Rutba, Ramadi, and Karbala. The remaining stations in the central region and all stations in the southern region belong to the mild-refreshing region. This is because they generally record relatively higher temperatures compared to the stations in the northern region and its adjacent areas, due to reasons related to astronomical location.
In the second cycle, we observe a change in the boundaries of the bioclimatic regions in the Karbala station. The cool-temperate region disappears, and the mild-refreshing region appears in its place. In the third cycle, there is a further expansion of the changes in the boundaries of the bioclimatic regions, especially in the stations of Mosul, Kirkuk, and Ramadi. The cool-temperate region disappears from these stations, replaced by the mild-refreshing region. This is due to a relative increase in temperature rates during the third cycle compared to the preceding cycle, especially in the stations mentioned.
Map collection (8) shows the bioclimatic regions during the daytime in the month of November according to the wind cooling guide in Iraq for the three cycles.



9- Bioclimatic regions during the day in the month of December according to the wind cooling guide in Iraq for the period (1988-2020):

The cool-temperate region dominated most of the studied stations in December during the first cycle, encompassing all stations in the study area except for Erbil and Sulaymaniyah stations where the cool-temperate region appeared. The dominance of the cool-temperate region in most of the studied stations can be attributed to the lower recorded maximum temperatures during December, influenced by solar radiation inclination due to the apparent movement of the sun, shorter daylight hours, increased cloud cover, and subsequently reduced actual sunshine hours. These factors ultimately led to a decrease in the recorded maximum temperatures. In the second and third cycles, we observe a change in the boundaries of the bioclimatic regions in the Sulaymaniyah station. The cool-temperate region disappears, and the cool-temperate region appears in its place. Map collection (9).

Map collection (9) displays the bioclimatic regions during the daytime in the month of December based on the wind cooling guide in Iraq for the three cycles.



RESULTS

1- The highest average maximum temperatures were recorded in the months of June, July, and August. The city of Basra had the highest average temperature during the third cycle in the month of July, reaching 48.0°C.

2- The highest monthly average wind speed for the three cycles was recorded in Al-Nasiriyah station during the month of June at 5.5 m/s, while the lowest average was recorded in Zakho station in the months of October and December at 0.9 m/s.

3- The results of applying the wind cooling guide during the daytime showed that the hot region had the largest area, appearing in the months of April, May, June, July, August, September, and October. The warm region had the smallest area, concentrating its presence in the months of April, May, and October. As for the results of applying the guide during the nighttime, the region inclined to coolness had the largest area, appearing in the months of May, June, September, and October. The warm region had the smallest area and appeared intermittently in the months of July and August.

REFERENCES

[1] Adel Sa'eed Al-Rawi and Qusay Abdul-Majeed Al-Samarra'i, Al-Munaakh Al-Tatbiqi (Applied Climate), Dar Al-Hikma for Printing and Publishing, Baghdad, 1990, p. 227

[2] Abdul Ali Al-Khaffaf, Tha'ban Kazim Khudair, Al-Munaakh wal-Insan (Climate and Humans), Dar Al-Maseera for Publishing, Distribution, and Printing, Amman, 1999

[3] Kareem Dragh Mohammed Al-Awabid, Al-Mawqi Al-Falaki wal-Jugrafi Lil-Iraq wa Atharuhu fi Ta'arrudih Ila Zawaahir Jawiyah Qasiyah Fi Munakhihi (Th

[4] Astronomical and Geographic Location of Iraq and its Impact on Exposure to Severe Weather Phenomena in its Climate), Al-Buhuth Al-Jugrafiyah Journal, Issue 11, College of Education for Girls, Al-Kufa University, 2009, p. 240

[5] Ali Salem Al-Shawwara, Jughrāfiyat ʿIlm al-Munaakh wal-Ṭaqs (Geography of Climatology and Weather), Dar Al-Maseera for Publishing and Distribution, Amman, 1st edition, 2012, p. 73.

[6] Ali Sahib Talib Al-Moussawi and Abbas Zghair Al-Maryani, Al-Munaakh Al-Ṭibbī (Medical Climate), Maktabat Al-Abda', Al-Najaf Al-Ashraf, 2018, p. 224.

[7] Haider Radi Kazim Al-Khazali, Al-Munaakh wa Tatbiqatuhu Al-Bi'iyah (Climate and its Environmental Applications), Dar Al-Sadiq for Printing and Publishing, 1st edition, 2022, p. 129.

[8] General Authority for Meteorology and Seismic Monitoring in Iraq, Climate Department, unpublished data, Baghdad, 2021.

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

[10] Almudhafar, S.M. Spatial Variation of Biological Contamination Of Soil From Najaf City. Indian Journal of Environmental Protectionthis link is disabled, 2020, 40(2), pp. 192–196.

[11] Almudhafar, S.M., Alattabi, I.A. Effect of environmental factors on drainage water network in Najaf governorate, Iraq. Indian Journal of Environmental Protection, 2019, 39(11), pp. 1050–1056.

[12] Almudhafar, S.M. Environmental assessment of shut alkufa in Iraq. Plant Archives, 2018, 18(2), pp. 1545–1551.

[13] Almudhafar, S.M., Abboud, H.A. Spatial variation of surface water contamination by heavy elements in Alhira relative to tourism. African Journal of Hospitality, Tourism and Leisure, 2018, 7.(4)