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Climatic assessment of the geographical distribution of the wheat crop in Iraq

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Abstract---The relationship between climate and agriculture is very close and agriculture is probably the most influential activity in climate conditions. The climate factor is one of the most influential natural factors in determining crop species as it identifies areas that can be cultivated with specific crops, including the wheat crop under study. The goal of this research is a study (climate assessment of the geographical distribution of Iraq's wheat crop) that identifies the geography of the applied climate. The study showed the extent to which climate elements and manifestations of dust atmosphere (solar radiation, wind, moisture, dust storms, rising dust and stuck dust) affect Iraq's wheat cultivation and production. The study relied on eight climate stations for the study area (Iraq) and climate data for the period 1990-2020. The study examined Iraq's climatic characteristics for monthly and annual rates (solar radiation, temperature rates, wind, relative humidity, dust phenomena). The study also examined the geographical distribution of the cultivation and production of wheat in Iraq for the cultivated area and total production and for the average productivity (yield) for the study years (2012, 2013, 2014, 2019, 2020).

Keywords---climatic assessment, the geographical distribution, the wheat crop.

Introduction

The wheat crop is one of the primary grain crops, as this crop is consumed in most countries of the world, and about (21%) of the world's population depends on it for food, and they combine about (41%) of the world's population between

wheat and other food grains for their food. As for Iraq, the wheat crop is one of the most important crops, as it represents the largest share in terms of the cultivated area, quantity and value of production and ranks first among the four essential grain crops. Heat is one of the most specific climatic elements for the cultivation and production of crops through its direct impact on the crop and indirect, among other climate elements, which in turn constitute the determinants of agricultural production. Growth depends on the various physiological processes that take place within the crop, as well as its role in determining the places of its concentration and spread.

Study problem

What is the climatic assessment of the geographical distribution of wheat crop in Iraq? You can put sub-questions and several secondary problems as follows:

- What are the most critical climatic characteristics of Iraq's climate?
- What is the appropriate geographical distribution for wheat cultivation and production in Iraq?

Study hypothesis

- Iraq is characterized by climatic characteristics of temperatures and humidity, which created an integrated personality, mainly due to the influence of a group of factors that contributed to these climatic features.
- The study area has regions that can contribute to the cultivation and production of the wheat crop

Study limits

Spatial boundaries

The study area is located astronomically between two latitudes (29-37°) in the north and longitudes (38-48°) in the east. km 2), bordered on the north by Turkey, on the east by Iran, on the west by Syria, Jordan and Saudi Arabia, or the south by Kuwait, the Arabian Gulf and Saudi Arabia, as shown in the map (1).

Map 1. of the study area stations
Source: The researcher is based on the Republic of Iraq, Ministry of Water Resources, General Authority for Surveying, Map Production Department, Administrative Map of Iraq, Baghdad, 2017, scale 1/1000000

Temporal limits

The study included eight climatic stations in Iraq, represented in table (1), which shows the climatic stations in terms of astronomical location, altitude, and the number of the anaerobic station. Duration from (2012, 2013, 2014, 2019 and 2020)

Table 1
The climatic stations selected in the study in terms of the astronomical location, altitude and number of the anaerobic station

Climatic station	Location about latitudes in the north	location about longitudes in the east	Analogue number	Height above sea level (m)
Mosul	36 - 19˚	43 - 9˚	608	223
Kirkuk	35 - 28˚	44 - 24˚	621	331
Humid	33 - 2˚	40 - 17˚	642	630.8
. Baghdad	33 - 18˚	44 - 24˚	650	31.7
Samawah	31 - 16˚	45 - 16˚	674	11
. Nasiriyah	31 - 1˚	46 - 14˚	676	5
Architecture	31 - 51˚	47 - 10˚	680	7.5
Basra	30 - 31˚	47 - 47˚	689	2

The source is from the researcher's work based on: Atlas of Iraq's climate (1971-2000) General Authority for Meteorology and Seismic Monitoring, Part One 2012, pg.5

The first topic: analysis of the monthly rates of climatic characteristics
Analysis and study of the monthly rates of theoretical brightness hours

It can be seen from the table (2) and Figure (1) that the hours of theoretical brightness vary temporally and spatially between the study stations according to their location in the latitude circles. 10,194 hours/day) respectively, while the lowest rates were recorded during these two months in the Mosul station (9,44, 9.59 hours/day), followed by Kirkuk station, which recorded (9,49, 10.4 hours/day) respectively, while During June and July, the maximum theoretical length of the day was, as the average of the two months was (14,13 and 13.9 hours/day), respectively. At the same time, the length of the theoretical day was recorded in Mosul station (14.4, 14.2 hours/day) and Kirkuk station (14.3, 14.2 hours/day), respectively.

Analyzing and studying the monthly rates of actual brightness hours

We note from Table (3) and Figure (2) that there is a discrepancy between the annual rates of the actual hours of brightness in Iraq between the study stations, where the highest annual rate of the actual hours of brightness was recorded for the Basra station, which amounted to (9.00) hours/day, while The lowest annual rate of actual hours of brightness was recorded for the Nasiriyah station, as it reached (8,19) hours/day.

Analysis and study of the monthly averages of temperature
Analysis and study of the monthly averages of maximum temperatures

We notice from the comparison of the table (4) and Figure (3) that the monthly averages of maximum temperature vary temporally and spatially between the study stations, as the highest maximum thermal rates were recorded in July and August, which are considered among the most months of the year with the highest thermal rates to reach about (44,50, 44,47 mº for each of them, respectively. The maximum thermal rates for July and August vary between the study stations. The maximum thermal rates ranged between (47.15 and 39.75) m º for each of the Basra and Rutba stations. Then the maximum monthly averages gradually declined, as the lowest maximum temperatures were recorded, especially in January, when they reached (16.10) ºC. In January, the lowest monthly average of maximum temperatures was recorded in the Mosul station, reaching (13.17). ºC, followed by Al-Rutba station, which reached (14.01) ºC, while Basra station's highest monthly average maximum temperature in January was recorded, reaching (18.64) ºC.

Analyzing and studying the monthly averages of minimum temperatures

By comparing table (5) and Figure (4), we note that the monthly averages of minimum temperatures vary temporally and spatially between the study stations, where we note the lowest monthly average of minimum temperatures recorded in January as it reached (5.38) Cº—moreover, recorded in January. The lowest average minimum temperatures were recorded in January in the Mosul and Al-Rutbah stations, reaching (2.62 2.65) ºC for each. Whereas the highest monthly average of minimum temperatures was reached in January in Basra station,

reaching (8.27) m °, then the monthly averages of minimum temperatures rose until July and August, reaching (27.96, 27.43) m °. In July, the highest monthly average of minimum temperatures was recorded in Basra station, which reached (30.70) m °, followed by Al-Amarah station, which reached (29.95) m °, while Al-Rutba station recorded 23.86 m °, and August only The minimum thermal rates ranged between (29.84, 24.07) °C for each of Basra and Rutba stations.

Analysis and study of monthly average temperatures

The monthly averages of temperatures vary temporally and spatially in the study stations, as the highest average monthly temperature was for July, as it reached (36.38) m°. In the Basra station, it reached (38.97) m °, followed by Al-Amarah and Nasiriyah, which reached (38,43, 37,95) m ° for each, respectively. The Rutba station, which reached (31,83) °C, is considered the lowest monthly thermal rate recorded in July. The monthly average temperature in January in Mosul station reached (7.42) °C, followed by Al-Rutba station, which reached (8.06) °C. While it reached its highest limit in January, it was for the Basra station, with a monthly average of (12.98) m°.

Analysis and study of the monthly rates of relative humidity

It is clear from the comparison that the monthly rates of relative humidity vary temporally and spatially between the study stations, as the highest monthly average relative humidity during the study period 1990-2020 was recorded in January, reaching (69.42)%. These monthly averages of relative humidity for January vary between the study stations. The monthly averages of relative humidity for January ranged between (79.35 and 64.29)% for each of the stations of Mosul and Samawah as a maximum and a minimum. Then, the monthly averages of humidity are taken. The relative humidity declined until July, when it was recorded (at 23.51)%. July is considered the month in which the relative humidity decreases. The highest monthly relative humidity rate in July in the Al-Rutba station, which amounted to (29.11)%, was followed by the Mosul station. It reached (25.92)%, while the Nasiriyah station recorded its lowest in July, reaching (19.61)%.

The second topic
Geographical distribution of wheat cultivation and production in Iraq
First - the general average of the area cultivated for wheat in Iraq for the years of study (2012 - 2013 - 2014 - 2019 - 2020)

The rates of the area planted with the wheat crop for the study period vary among the regions of Iraq, where the highest area was in Nineveh Governorate, which amounted to (3019930 dunums), constituting (24.53%) of the total average cultivated area in Iraq, which amounted to (12312281 dunums), see table (8).) and map (2). Wasit governorate comes in second place, reaching (1485598 dunums), constituting (12.07%) in terms of the general average of the cultivated area. The third rank was the share of Salah al-Din governorate, which amounted to (1184985 dunams), constituting (9 62%) in terms of the general average of the cultivated area. Kirkuk governorate comes forth, reaching (1129518 dunams), constituting (9.17%) in terms of the general average of the cultivated area. The

fifth rank was taken by Diyala governorate, which amounted to (1017615 dunams), constituting (8.27%) in terms of the average The governorates of (Al-Qadisiyah and Al-Anbar) ranked sixth, as Al-Qadisiyah governorate amounted to (838591 dunums), constituting (6.81%). Al-Anbar governorate reached (77,1116.8 dunums), constituting (6.26%) of the cultivated area.

Where is the general average of the cultivated area? As for the seventh rank, it was the share of the governorates of (Babil and Maysan), as the governorate of Babylon reached (583885 dunams), which constituted (4.74%), and the governorate of Maysan reached (563,977.8 dunams), which constituted (4.58%) in terms of the general average of the cultivated area. As for the eighth rank, it was the share of Mukal of the governorates (Dhi Qar, Baghdad, Najaf), where the governorate of Dhi Qar amounted to (432541.8 dunums), which constituted (3.51%), and the governorate of Baghdad amounted to (411240.4 dunums), which constituted (3, 34%). Najaf governorate amounted to (404058,2 dunums) as it constituted (3.28%) in terms of the general average of the cultivated area. As for the ninth rank, it was the share of Al-Muthanna Governorate, which amounted to (257,362.4 dunums), constituting (2.09%) in terms of the general average of the cultivated area. As for the tenth and last rank, it was the share of the governorates of (Basra and Karbala), where the governorate of Basra reached (130,359 dunums), which constituted (1.06%), and the governorate of Karbala reached (81,502.8 dunams), which constituted (0.66%), which is the lowest general average for the area planted.

The general average quantity of production for the wheat crop in Iraq for the years of study (2012 - 2013 - 2014 - 2019 - 2020)

The rates of the number of products with the wheat crop for the study period vary between regions of Iraq, where the highest quantity of production was in Nineveh Governorate, which amounted to (427060 tons), which constituted (17.79%) of the total average of the total amount of production in Iraq, which amounted to (2400243 tons), see table (9) and a map (3). Wasit Governorate came in second place, reaching (333728 tons), constituting (13.90)% of the general average production quantity. The third place was for Diyala Governorate, which amounted to (271739 tons), constituting (11.32%) in terms of the average year for production quantity. As for the fourth place, it was the share of the governorates of (Salah al-Din and Kirkuk), as Salah al-Din governorate amounted to (258,150 tons), constituting (10.76%), and the governorate of Kirkuk reached (255038 tons) ton, which constituted (10.63%) in terms of the general average of the quantity Production.

As for the fifth place, it was the share of the Al-Qadisiyah governorate, which amounted to (187750 tons), which constitutes (7.82%) in terms of the general average of the quantity of production. As for the sixth rank, it was the share of the governorates of (Babil and Anbar), where the governorate of Babel reached (137,687 tons), which constituted (5.74%), and the governorate of Anbar reached (127,833) tons, which constituted (5.33%) in terms of the general average of the quantity of production. As for the seventh place, it was the share of each of the governorates (Maysan, Baghdad, Dhi Qar, Najaf), where Maysan amounted to (87010.9 tons), which constituted (3.63%), and the governorate of Baghdad

reached (6068.2 tons), which constituted (3%). Dhi Qar governorate amounted to (74,661.9 tons), which constituted (3.11%), and Najaf governorate reached (74,213.7 tons), which constituted (3.09%) in terms of the general average of the quantity of production. The eighth and last place was from The share of each of the governorates (Al-Muthanna, Karbala, Basra) reached (37,726.2 tons), as constituted (1.57%), and the Karbala governorate reached (21511.1 tons), as it constituted (0.90%) as the Basra governorate amounted to (20065.1 tons, which constitutes (0.84%) in terms of the general average of the quantity of production.

The general average of average productivity (yield) of the wheat crop in Iraq for the years of study (2012 - 2013 - 2014 - 2019 - 2020)

The average productivity rates (yield) of the wheat crop for the study period vary between the regions of Iraq, where the highest rate of yield was in the Karbala governorate, which amounted to (2944.2 kg/dunum), constituting (14.43%) of the total average of the average productivity (The yield) in Iraq is (20409 kg/dunum), see table (10) and map (4). Diyala Governorate comes in second place, as it reached (1682.9 kg/dunum), constituting (8.25%) in terms of the general average of average productivity. As for the third place, it was the share of the governorates of (Babil and Kirkuk), where the governorate of Babil reached (1597,4 kg/dunum), which constituted (7.83%), and the governorate of Kirkuk reached (kg/dunam 1512,1), which constituted (7.41%). In terms of the overall average productivity. As for the fourth place, it was the share of the governorates (Baghdad, Wasit, Salah al-Din), as the governorate of Baghdad reached (1492.3 kg/dunum), which constituted (7.31%), and Wasit governorate reached (1468,5 kg/dunum), which constituted (7 And the governorate of Salah al-Din amounted to (1,434.1 kg/dunum), which constituted (7.03%) in terms of the general average of the average productivity.

Al-Qadisiyah governorate comes in the fifth rank as it reached (1376.8 kg/dunum), constituting (6.75%) in terms of the general average of average productivity. As for the sixth place, it was the share of the governorates (Najaf, Basra, Anbar, Maysan, Dhi Qar), where the Najaf governorate reached (1198.5 kg/dunum), which constituted (5.87%), and the governorate of Basra reached (1096,1 kg/dunum). It constituted (5.37%), and Al Anbar governorate amounted to (1,092.5 kg/dunam) it constituted (5.35%), and the governorate of Maysan reached (1056,5 kg/dunam), which constituted (5.18%). Dhi Qar governorate reached (1040 kg/dunum), which constitutes (5.10%) in terms of the general average of average productivity. Al-Muthanna Governorate comes in seventh place, reaching (858.76 kg/dunum), constituting (4.21%) in terms of the general average of average productivity. Nineveh Governorate comes in the eighth and last place, reaching (558.74 kg/dunum), constituting (2.74%) in terms of the general average of average productivity.

The statistical relationship between climatic characteristics and agricultural variables

The statistical characteristics of the climatic and agricultural study variables, which are based on multiple statistical parameters, including the arithmetic mean, standard deviation, mean, standard error, and t-test, confirmed that the

most significant value of the standard deviation for climatic variables was in the average total evaporation (43.25) with an average measurement error (15.29). Moreover, the arithmetic mean (255 mm) and the value of the t-test was (16,678), which is greater than the tabular t-value of (0.0), which is statistically significant at a significant level (0.05). The amount of total solar radiation comes in the second degree in the value of the standard deviation (32.72), the mean, standard error (11,567), and the calculated t value was (39.88), which is greater than the tabular t value (3.01), which is statistically significant at a significant level (0.05). The value of the standard deviation coefficient for the average, maximum and minimum thermal rates converged (2,57, 2.47, 2.48), with an average standard error of (0.91, 0.87, 0.87) for each of them, and the value of t Calculated (26,55, 35,73, 19,46) for each of them, respectively, which is greater than the tabular t-value (1.80), and it is statistically significant at a significant level (0.05).

It indicates that there are few differences between thermal rates in general and that the percentage of deviation or variation in thermal rates between regions or parts of the study area is relatively close compared to the rest of the standard deviation values of other climatic variables. The value of the standard deviation coefficient of the average total rainfall (8.55) with an average standard error of (3.21) indicated that there is a significant variation in the amount of rainfall between the different months of the year, with an arithmetic mean of (15.3). The calculated t value (5), 07) is greater than the tabular t-value (0,19), and it is statistically significant at the level of significance (0.05). The standard deviation of the relative humidity decreases or decreases (4.17), with an average standard error of (0.47) and arithmetic mean (43.86), and the calculated t value is (29.76), which is greater than the tabular t value (3.22), which is the same Statistical significance at a significant level (0.05). The lowest value of the standard deviation coefficient of wind speed (1) with an average standard error of (0.35) and arithmetic mean (2.89), and the calculated t value was (8.16), which is greater than the value of t Tabular (0), which is statistically significant at the level of significance (0.05). see table (1)

Table 1
Statistical characteristics of climatic and agricultural variables

	mean standard	deviation mean	standard error	t– test
Actual brightness	8.6300	0.3407	0.1205	71.6420
Theoretical brightness	12.0150	0.0864	0.0305	393.5340
Amount of radiation	461.3500	32.7164	11.5670	39.8850
Average temperature	24.0863	2.5656	0.9071	26.5540
Maximum temperature averages	31.1488	2.4659	0.8718	35.7280
Minimum Temperature Averages	16.9750	2.4674	0.8724	19.4590

Average total rainfall	15.3100	8.5466	3.0217	5.0670
Average relative humidity	43.8638	4.1687	1.4738	29.7610
Average wind speed	2.8850	1.0000	0.3536	8.1600
Total evaporation rate	255.0175	43.2477	15.2904	16.6780
Yield	1142.0750	234.7586	82.9997	13.7600
Area	839505.7500	934249.9729	330307.2456	2.5420
Production	250974.5000	245871.6434	86928.7532	2.8870

The researcher's work is based on a table (2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15)

The results of the statistical relationship between the area planted with wheat and the climatic elements: the agricultural variables of the subject of the study were characterized by that the area factor has a significant standard deviation (934249.9) and an average standard error of (330,307,25) and arithmetic mean (839505,75) and the calculated t value is (2, 54), which is greater than the most considerable tabular t value (0,0), and it is statistically significant at a significant level (0.05). The value of the standard deviation of the total production was (245871,6), with an average standard error of (86,928.75) and an arithmetic mean of (250,974,5). The calculated t value was (2.89), which is greater than the most considerable tabular t value (0.0), which is of Statistical significance at the level of significance (0.05). The yield variable was characterized as having the lowest value in the standard deviation (234.76) and with an average standard error of (82.99) and an arithmetic mean (1142,075), and the calculated t value was (2.54). It is greater than the immense tabular t value (0,0) and is statistically significant at a significant level (0.05). The results of the statistical relationship between the area planted with wheat and the climatic elements in the table (12) and Figure (7) showed that the most vital direct correlation relationship was with the number of hours of theoretical brightness (0.91).

It is statistically significant at a significant level (0.05). This strong relationship indicates that an increase in the cultivated areas offsets the increase in the hours of theoretical brightness and then the relative humidity rates in the strength of their relationship (0.908). It is statistically significant at a significant level (0.05), indicating that the relative humidity significantly impacts the areas planted with wheat. Total evaporation, which is characterized by a strong inverse correlation (-0.89) with the areas planted with wheat, which indicates that the more evaporation rates increase, the effect on the decrease or decrease in the areas planted with wheat. Inverse and close correlation in the study area (- 0.609, -0.68, -0.64, - 0.696) indicates that its increase negatively and adversely affects the areas planted with wheat.

Table 2
Results of the statistical relationship between the area planted with wheat and the climatic elements

	link
Actual brightness	0.5904-
Theoretical brightness	0.9175
Radiation amount	0.6098-
Temperature averages	0.6849-
Average maximum temperature	0.6453-
Minimum Temperature Averages	0.6963-
Average total rainfall	0.8248
Relative humidity	0.9087
Wind speed ratings	0.8116-
Total evaporation rate	0.8952-

The researcher's work is based on table (16)

Results of the statistical relationship between wheat production and climatic elements: the correlation between total production and climatic elements were distinguished in table (13) and Figure (8) that the strongest direct correlation was with relative humidity rates (0.92) and then the correlation relationship with Total average rainfall (0.91) and the theoretical brightness rate (0.87), which are statistically significant at the level of significance (0.05). The strongest inverse correlation is with the rate of total evaporation (-0.92) and then with the average wind speed (-0.89), and then with the average maximum temperature (-0.70), which is statistically significant at a significant level (0, 05).

Table 3
Results of the statistical relationship between wheat production and climatic elements

	Link
Actual brightness	0.6482-
Theoretical brightness	0.8760
Radiation amount	0.6640-
Temperature averages	0.7070-
Average maximum temperature	0.7080-
Minimum Temperature Averages	0.6885-
Average total rainfall	0.9055
Relative humidity	0.9281
Wind speed ratings	0.8903-
Total evaporation rate	0.9229-

The researcher's work is based on table (16)

Results of the statistical relationship between the yield planted with wheat and the climatic elements: The results of the statistical relationship showed us the correlation between yield and the climatic elements in the table (14) and Figure (9) that the strongest direct correlation is between the rate of yield and the total rainfall (0,24), which is Weak to limited relationship, which is statistically

significant at the level of significance (0.05). Then comes the correlation with relative humidity rates (0,19), which is a weak relationship and is statistically significant at a significant level (0.05). The strongest inverse correlation was with wind speed rates (-0.25), which is statistically significant at a significant level (0.05). It is weak to the limited relationship that confirms that the increase in the rate of wind speed affects the amount of yield per acre in a hostile and inverse manner. Whereas the inverse correlation in its strength converged with the rates of total solar radiation and maximum temperatures (-0.24), a weak to a limited relationship is statistically significant at a significant level (0.05). We conclude from all of the above that the factors. Climatic factors significantly impact the total production and cultivated area, more and more than the average yield per acre. The climatic factors varied in terms of the strength of their impact. And the nature of the negative or direct effect on the cultivation and production of the wheat crop.

Table 4
Results of the statistical relationship between wheat planted yield and climatic elements

	Link
Actual brightness	0.1475-
Theoretical brightness	0.0389
Radiation amount	0.2458-
Temperature averages	0.1561-
Average maximum temperature	0.2447-
Minimum Temperature Averages	0.0942-
Average total rainfall	0.2492
Relative humidity	0.1914
Wind speed ratings	0.2517-
Total evaporation rate	0.2050-

The researcher's work is based on table (16)

Conclusion

- The study found that the geographical distribution of the total production of the wheat crop in Iraq (2012) in the Nineveh Governorate has decreased in the proportion of its contribution to wheat production for the previous season. It represented the first position in the area planted with wheat for the same season, and this is due to the damage to large areas in it. The reason is also due to the lack of goodness and fluctuation in the occupation of one centre.
- We deduce from all the previous climatic factors a significant impact on the total production and the cultivated area more and more than the average yield per dunum. The climatic factors have varied regarding the strength of their influence. And the nature of the opposite side effects in the cultivation and production of the wheat crop.

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