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Article

The Effect of Climatic Factors on The Cultivation of My Crops (Wheat and Barley) in The Salahiyah District

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Abstract: Climate represents a critical determinant of agricultural productivity, particularly for strategic field crops such as wheat and barley in arid and semi-arid regions. Despite the importance of these crops in Iraq, empirical studies that quantitatively link long-term climatic variability with crop productivity at the district level remain limited, creating a clear knowledge gap in localized climate–agriculture assessments. This study addresses this gap by analyzing climatic data from the Diwaniyah Meteorological Station and agricultural production records for the Salahiyah District over the period 1995–2022. An analytical–descriptive approach was applied, combining descriptive statistics and Pearson correlation analysis to examine relationships between key climatic elements—sunshine duration, temperature, rainfall, wind speed, relative humidity, and evaporation—and wheat and barley yields. The findings reveal that relative humidity and rainfall exhibit positive correlations with crop productivity, while high temperatures, excessive sunshine, and increased evaporation show inverse effects, particularly on barley yields. The results indicate that the study area generally possesses suitable climatic conditions for wheat and barley cultivation, although water scarcity necessitates effective irrigation management. These findings imply that aligning planting schedules, crop selection, and water management strategies with local climatic conditions can enhance productivity and support sustainable agricultural planning under increasing climatic variability

Keywords: Climatic factors; Wheat; Barley; Crop productivity; Climatic suitability; Salahiyah District

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1. Introduction

Wheat is a primary source of human nutrition and ranks second in importance after rice in many countries worldwide, while barley comes third globally in terms of economic significance after rice. Therefore, this research will address the climatic conditions for cultivating wheat and barley and the suitability of these conditions for growing these crops. It will also clarify the statistical relationship between climatic conditions and crop requirements, concluding with a set of results and recommendations [1].

First: Problem of study:

The problem was represented by

1. What are the climatic requirements for the growth of field crops, wheat and barley, to achieve the best yield?
2. What are the available climatic resources for cultivating field crops (wheat and barley) in the Salahiyah area?

3. Is there a correlation between climatic capacity and its effect on the yield of wheat and barley?

Second: The Hypothesis:

1. Wheat and barley are field crops that heavily depend on the availability of specific climatic elements, requiring sunlight, suitable temperatures, rainfall, in addition to moderate levels of humidity, and the effects of wind which influence their different growth stages.
2. In terms of suitability, there are climatic capabilities that enable the cultivation of wheat and barley.
3. There is a correlation between climatic capabilities and the yields of wheat and barley. Third: Importance of the study:

My wheat and barley crops are considered important strategic crops for the economy in general, and for production in particular.

These field crops are primarily affected by climatic factors such as temperature and rainfall, which influence their yield.

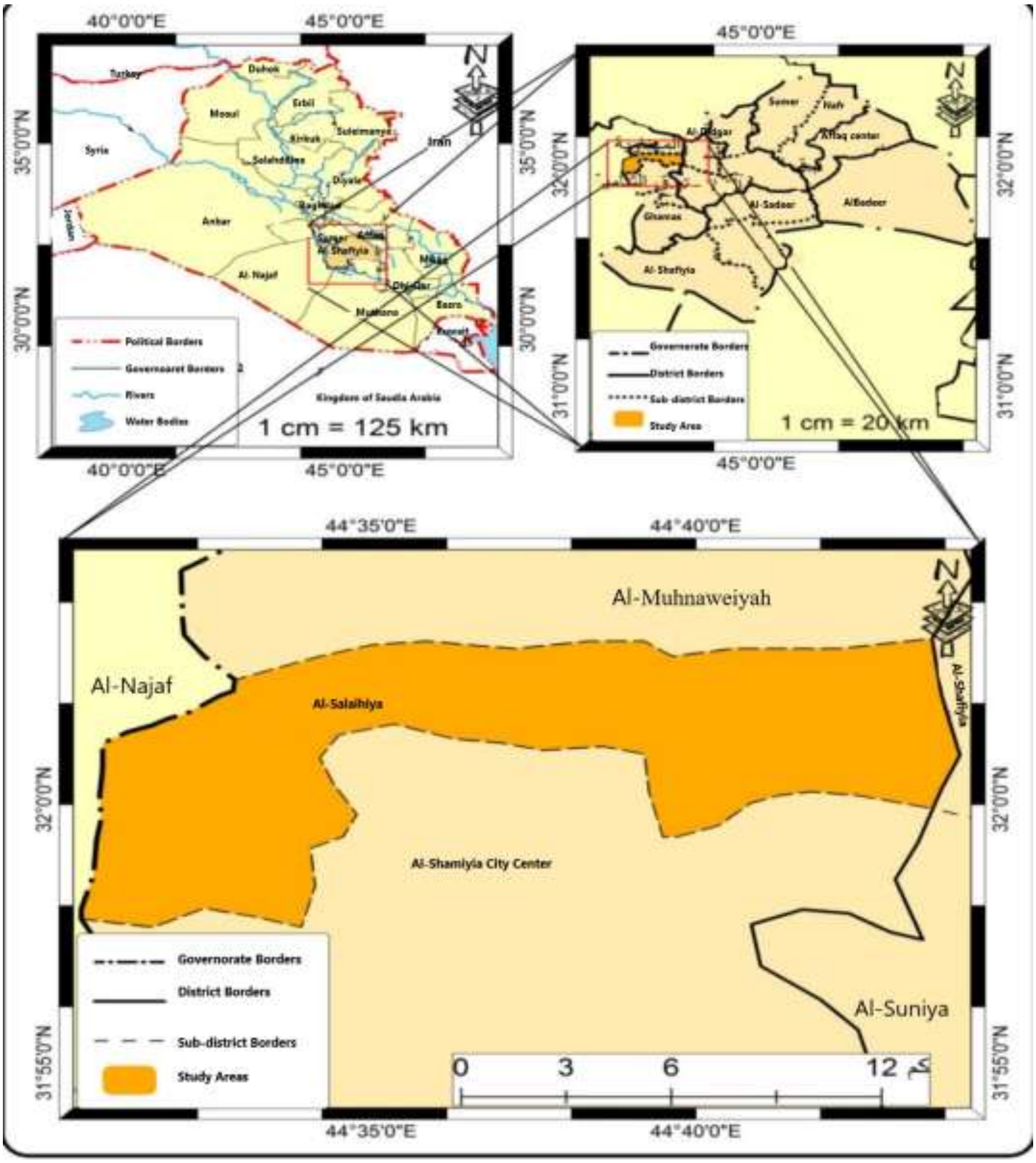
Fourth: The objective: It is as follows:-

1. By understanding the suitable climatic conditions for growing wheat and barley, it is possible to identify the environmental factors that contribute to their successful growth and achieving high yields.
2. To study the available climatic potentials in the research area.
3. To analyse the statistical relationship between climatic factors and the yield of wheat and barley.

2. Materials and Methods

The study relied on climatic data from the Diwaniya Meteorological Station for the period (1995-2022) for climate elements (solar radiation, temperature, wind, rainfall, humidity, and evaporation). The data were analysed to reveal the correlation between climatic factors and the production of cereal crops (wheat and barley). Sixth: Research Boundaries: The study area covers an area of 387 km², located geographically between latitudes 31° 57′ – 32° 20′ N and longitudes 44° 30′ – 44° 44′ E, see Map (1). It is one of the agricultural districts of Al-Qadisiyyah Governorate, situated in the central part of the alluvial plain. It is bordered to the north by Al-Muhnaweiyah District, to the south by Al-Shamiya District, to the west by Al-Abbasiya District, and to the east by Al-Shafiya District. The temporal boundaries are from 1995 to 2022.

Map (1) Al-Salahiya District in Al-Qadisiyyah Governorate and the Republic of Iraq



Source/ Prepared by the researcher using ArcGIS software and based on the Ministry of Planning, the Central Bureau of Statistics and Information Technology, Administrative Map of Najaf Governorate, 2016.

Chapter One/ Climatic requirements for the cultivation of wheat and barley:

Climate is considered one of the most prominent natural factors that affect the growth and cultivation of crops. Agricultural crops differ in their climatic needs, whether thermal, water, or light requirements, and each crop has specific climatic limits that must be met to complete its growth stages. Therefore, climate is a fundamental factor in determining the success or failure of agriculture. In this discussion, we will address the climatic requirements suitable for the cultivation of wheat and barley [2]

1. Wheat

Wheat is a staple for the people of Iraq, and therefore countries strive to provide it at a low price for all members of society due to its high protein content and nutritional value. There are many classifications of wheat, but the important classification depends on the quality of the wheat and its suitability for making bread and pastries [3]. This quality is due to its gluten content, which is determined according to the moisture content in the soil, especially during the flowering stage, and the type of soil and its nitrogen content. Therefore, wheat is divided into soft wheat and hard wheat, and also classified according to the type of cultivation, which is (winter wheat and summer wheat [4]

The climatic suitability for growing wheat crops:

Wheat has numerous climatic requirements that help it grow optimally. The wheat crop needs a photoperiod of (12-14) hours per day during the vegetative growth stage and the stages of maturation and spike formation [5] .

Sunlight is considered an essential requirement for plants at all stages of their growth, as it is important for providing the energy needed for photosynthesis and food production. The light that plants benefit from depends on the length of the day and the changing seasons due to the differences in location relative to the latitudinal lines [6]

Sunlight has an effect on chlorophyll and carbohydrate formation, and its influence extends to the opening and closing of stomata as well as transpiration in plants. It also affects the leaves of the plant and the bending of its stems[7].Winter wheat is planted in late autumn and continues to grow during the winter until it matures in late spring or early summer. The growing season for winter wheat lasts 5 to 6 months until it reaches maturity. As for spring wheat, it is planted in spring and harvested in late summer [8]

Plants need suitable temperatures during their life cycle to ensure proper growth [9]

It can be observed from Table (1) that the optimal maximum temperature for the wheat crop is (30-32)°C, as exceeding these limits leads to irregular seed germination. Additionally, high temperatures negatively affect the fertilization process, causing pollen grains to die, which results in the failure of grain formation or the production of shriveled and weakly growing grains [10]. However, the harmful maximum temperature for the crop is (38°C), while the minimum temperature that wheat can tolerate is (4°C), and a decrease

Table 1. Heat requirements for wheat and barley crops

harmful high temperature	Harmful minimum temperature	Upper temperature	Optimal temperature	Minimum temperature	crop
38	4-	32-30	25	4	Wheat
42	2	30-28	25	10	Barley

Source: Muhammad Abdul Saidi, Fundamentals of Field Crop Production, Baghdad, Dar Al-Hurriya Printing House, 1987, p. 142.

When temperatures exceed the level that a plant can tolerate, it leads to a slowdown in its growth, without completely stopping the growth process [11]. Wheat is considered a crop capable of withstanding sub-zero temperatures; however, the minimum harmful temperature that can cause severe damage to the crop and lead to its spoilage is -4°C. As for the optimal temperature for germination, it is shown in Table (1) to be 25°C, which is the temperature at which the plant's vital processes are most active, allowing the crop to maximize the benefits of photosynthesis to achieve the highest level of growth [12]

As for the soil, wheat requires fertile soil that is free of salts, well-drained, with a neutral reaction and a pH between 6.0 and 7.5. This is the ideal range for growing wheat crops, in addition to brown, red, and chestnut soils, as well as mixed and alluvial soils, especially if they are combined with fertilizers. Therefore, sedimentary soil and a variety of soil types are suitable for growing wheat [13]. While the amount of rainfall needed by wheat ranges from 350-450 mm during the growing period [14].

See Table (2), and these amounts of rainfall are not available in the study area, so they are compensated by irrigation with surface water. As for humidity, the wheat and barley crops require a humidity level of up to 70% to achieve optimal growth rates, and an increase in humidity leads to the occurrence of diseases and epidemics. Winds play an important role in the cultivation of wheat and barley, as they contribute to the thermal exchange between plants and air, and transport water vapor in suitable amounts that allow the plant to breathe normally. Light winds help activate the plant's vital processes, such as photosynthesis (food production), They also help renew the air around the plant, in addition to their role in reducing soil moisture and lowering temperatures [15]. It is evident from Table (2) that the wheat and barley crops require wind conditions ranging between 6.5 and 7 km/h.

Table 2. Rainfall, Humidity, and Wind Requirements for the Wheat Crop

Light/clock requirements	**Wind requirements km/h**	**Humidity**	**Rainfall (mm)**	**crop**
14	**7-6,5**	**%70**	**450-350**	Wheat
14	**7-6,5**	**%70**	**300-200**	Barley

Source: Abdul Hassan Madfoon Abu Rahil and Fadel Abdul Abbas, A Geographical Analysis of Climate Characteristics and Their Relationship to Wheat and Barley Cultivation in Babylon Governorate, University of Kufa, College of Arts, p. 20.

2.Barley Product:

It is considered one of the ancient cereal crops belonging to the grass family, and it is used as food for humans, feed for animals, and is also used in the production of some beverages such as beer [16] . Barley can withstand different climatic conditions such as drought and salinity, and it has nutritional value containing a high percentage of carbohydrates (79.0%) and protein (7.6%) [17]

Climatic suitability for barley cultivation:

Barley is considered one of the crops most capable of adapting to various climatic conditions. The temperature that barley can tolerate ranges between 28-30°C, as shown in Table (1). It becomes harmful when it reaches 42°C. The reason for the poor growth of crops at these high temperatures is the depletion of carbohydrates stored in the plant. If the high temperature is accompanied by low humidity, it leads to increased transpiration and reduced water in the plant, resulting in leaf drying and shedding [18]. The minimum temperature is (10°C), which the crop can tolerate, and if it drops to (2°C), it causes damage to the barley crop, while the optimal temperature is (25°C).

The ideal soil for cultivating barley is (loamy-silty) soil, and barley can tolerate poor soil and withstand salinity. Therefore, barley is characterized by its ability to grow in highly saline soil up to (16 mM/ha), which is considered high salinity in irrigated areas [19] . Table (2) shows that barley requires rainfall amounts ranging between 200-300 mm during its growth period, which is less than what wheat needs. Due to its lower water requirements, the growth cycle of barley is shorter than that of wheat. In addition to its resistance to soil salinity, these combined characteristics enable it to withstand drought and adapt to harsh environments[20]

Chapter Two / Climatic Potential Available for Cultivating Wheat and Barley in the Study Area

Climate is considered one of the most important natural elements that determines the geography of any area, due to the reflection of its elements and their impact on all different human economic activities. It determines the type of crop, its planting seasons, and its harvest, as each crop has specific natural requirements, and otherwise, the crop will grow abnormally. Based on the available data on climate elements from the period (1995-2022) for the Al-Diwaniya meteorological station, the researcher attempts to analyze the climatic data of the climate elements as follows:

1.Sunlight:

The wheat and the barley crops need a relatively long day and grow well when the photoperiod increases. These two crops flower when the day is long and the night period is short. Agricultural crops need light to separate carbon from carbon dioxide, which is available in the air or present in water.

And from Table (3), which shows the monthly averages In order to obtain the essential nutrients for the plant Regarding the actual sunshine hours in the study area, it appears that the annual average reached 8.7 hours/day, which is suitable for the growth of field crops (wheat and barley) to sustain the photosynthesis process for these crops. The study area receives large amounts of solar radiation throughout the year, and the lowest average of actual sunshine hours during winter (December, January, February) was 6.5 hours/day. This is due to the sun's rays being perpendicular to the Tropic of Capricorn during the winter season, This leads to shorter daylight hours due to the cloudy skies in the cold winter, which is less than the average number of sunshine hours in the spring months (March, April, May), which is (8.6 hours/day). The highest actual sunshine duration was recorded in the summer months (June, July, August), reaching (11.3 hours/day) due to the angle of the sun's rays being at its highest during these months. In contrast, during the autumn months (September, October, November), the average number of sunshine hours was (8.5 hours/day), which coincides with the time for planting wheat and barley roots.

Table 3. Average daily sunshine hours (hours/day) for Al-Diwaniyah station during the period (1995-2022)

jan	feb	Mar	apr	may	jun	jul	aug	sep	oct	nov	dec	Annual rate
6.4	**7,2**	**8**	**8,3**	**9,5**	**11,3**	**11,4**	**11,1**	**10,1**	**8,3**	7.2	**6,1**	**8,7**

Source: Republic of Iraq, Ministry of Transport and Public Communications for Meteorology, Climate Department, Data (unpublished) Baghdad 2022.

2.Temperature:

Temperature is one of the most prominent natural factors affecting crop growth, as it plays a vital role in regulating their physiological and biological functions such as respiration and nutrient absorption [21]. Temperature has a broad role in carrying out vital processes. Plants need different temperatures depending on their life cycle, as each plant has three stages. It is evident from Table (4), which shows the temperature rates, that the temperature decreases during the winter season (December, January, February), with an average temperature of 13.4°C. This is due to the sun's rays being perpendicular to the Tropic of Capricorn, which is located south of the equator, As for the minimum temperature, it recorded the lowest average for the months of (December, January, February), reaching (8.4, 6.6, 8.9)°C respectively. As for the maximum temperature, it was recorded during the months of (December, January, February) at (19.6, 18.2, 21.3)°C. In the spring season, which is considered a transitional period between winter and summer, the average temperature during its months reached about 25.5°C, while in the summer season, which is characterized by high temperatures, the average temperature for the months of (June, July, August) reached 36.4°C. The reason for the increase in temperatures is due to the direct angle of the sun's rays and the long days that accompany the amount of heat received, The maximum temperatures recorded were higher than the average for the months of June, July, and August (43.0, 45.7, 45.0) °C, respectively, with the highest average occurring in July. As for the minimum temperatures during the summer months (June, July, August), they reached (26.8, 29.0, 28.4) °C, respectively. This rise in temperatures is attributed to the increase in solar radiation received during those months, along with the increase in the number of actual sunshine hours during the summer season. The autumn season, which is considered a transitional season following summer, shows an average temperature of (26.2 °C). Table (4) shows the maximum and minimum temperatures for the months of September, October, and November, which reached (41.6, 35.4, 25.4) °C and (25.4, 20.5, 12.7) °C, respectively. Wheat and barley crops are planted in October and November in the study area, where the temperature is suitable for the requirements of these crops. The differences during the months of the seasons are due to the variation in the amount of radiation reaching the Earth's surface.

We conclude from the above that the temperatures in the study area are consistent with the climatic requirements necessary for the growth of wheat and barley, which are considered winter crops. Any drop in temperatures during the cold winter months (December, January) leads to damage to field crops (wheat and barley). The annual average temperature reached (22.3°C), which is suitable for the growth of these two crops.

Table 4. Average Temperature at Al-Qadisiyah Station for the Period (2010-2022)

months / element	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec	Annual rate
Maximum temperature	18,2	21,3	26,4	32,4	38,9	43,0	45,7	45,0	41,6	35,4	25,4	19,6	32,7
Minimum temperature	6,6	8,9	12,8	18,3	24,1	26,8	29,0	28,4	4,25	20,5	12,7	8,4	18,5
monthly average	12,0	14,7	19.7	25,3	31,5	35,0	37,1	37,1	33,2	26,9	18,5	13,6	22,3

Source: Republic of Iraq, Ministry of Transport and Public Communications for Meteorology, Climate Department, Data (unpublished) Baghdad 2022.

3.The winds:

Winds are considered one of the factors that significantly affect plants, as their speed, temperature, and the level of humidity they carry influence the vital processes of the plant, especially the process of evaporation. When wind speed increases, the rates of evaporation and transpiration from plants also increase. If the wind is dry and hot, it contributes to raising the evaporation rate by an average of up to 10%. Moreover, a wind speed of 8 km/h may lead to an increase in the evaporation rate by up to 50%, and this percentage increases even more when the speed reaches 24 km/h. [22].

The winds also play a positive role as they help provide carbon dioxide, which is essential and necessary for the process of photosynthesis. They also play an important role in the process of threshing, through which grains are separated from impurities, such as wheat and barley [23].

From Table (5), which shows the monthly averages and the annual average wind speed (m/s) in the study area for the period (1995-2022), the annual average is (2 m/s). Wind speed varies between the months of the year, increasing in the summer months, reaching (2.3 - 2.5 m/s) in June and July. Then, the averages begin to decrease in the study area during September, October, November, December, and January, with monthly averages of (1.7, 1.6, 1.4, 1.6, 1.8) m/s, respectively.

Table 5. Monthly Average Wind Speeds (m/s) for Al-Diwaniyah Station during the Period (2010-2022)

jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec	Annual rate
1,8	1,2	2,3	2,5	2,2	2,5	2,3	1,8	1,7	1,6	1,4	1,6	2

Source: Republic of Iraq, Ministry of Transport and Public Communications for Meteorology, Climate Department, data (unpublished) Baghdad 2022.

4.Rain:

Rain plays an important role in the growth of agricultural crops as it is considered a primary source of fresh water necessary for plants. Therefore, rain affects agricultural production, as the amount of rainfall and the seasons in which it falls influence the types of crops that can be cultivated. [24] Rain plays an important role for the wheat crop during the germination stage, benefiting it in the process of photosynthesis and nutrient absorption, while rain is not beneficial for the wheat crop during the maturity stage and causes delays.

We observe from Table (6) that the annual average rainfall at the Diwaniyah station is (12.4 mm). Rainfall begins in the study area in October, recording (4.7 mm), marking the beginning of the winter season, as weather depressions start arriving from the Mediterranean Sea. The highest rainfall averages were recorded in November, December, and January, reaching (19.9, 14.3, 20.3 mm), respectively. Rainfall continues until May, which recorded (2.6 mm). During the summer months of June, July, and August, no rainfall is recorded. The dryness in this season is due to the dominance of the Azores High Pressure over parts of the western and southwestern Mediterranean, causing depressions to move away from the Mediterranean toward Northern and Central Europe, This prevents the arrival of frontal depressions [25].

Table 6. Monthly Averages and Annual Total of Precipitation (mm)

jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec	Annual rate
3,20	13,1	10,9	13,7	2,6	-	-	-	-	4,7	19,9	14,3	12,4

Source: Republic of Iraq, Ministry of Transport and Public Communications for Meteorology, Climate Department, Data (unpublished) Baghdad 2022.

5.Air humidity:

Relative humidity is considered one of the most important climatic elements that affect agricultural crops, as it is inversely influenced by temperature and wind. When the relative humidity falls below the level required by the plant, it exposes most agricultural crops to drought and scorching, especially if the decrease in humidity is accompanied by high temperatures. High humidity also contributes to the spread of diseases in some crops, as well as the proliferation of fungi, insects, and pests, which leads to a decline in agricultural crop productivity [26].

Table 7. Monthly Average Relative Humidity (%) at Al-Diwaniyah Station during the Period (1995-2022)

jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec	Annual rate
3,68	60,2	49,6	42,4	32,1	27,7	27,6	29,5	33,9	42,6	59,6	67,3	45

Source: Republic of Iraq, Ministry of Transport and Public Communications for Meteorology, Climate Department, Data (unpublished) Baghdad 2022.

We note from Table (7) that the annual average relative humidity at the Diwaniyah station reached (68.3 - 67.3) in December and January. Relative humidity begins to increase from October until the end of April, while it decreases during the hot summer season starting in May and reaches its lowest levels during the months of June, July, August, and September (27.7, 27.6, 29.5, 33.9) respectively. The reason for this decrease in relative humidity is due to the high temperatures during these months, increased solar radiation, and the blowing of hot and dry winds in summer.

6. Evaporation:

Evaporation is the process of turning water from a liquid state into a gaseous state, and it has an important effect on plants, as it helps reduce the intensity of solar radiation and its impact. When the air is saturated or close to saturation, it contributes to reducing the frequency of watering for plants grown in arid and semi-arid areas [27]. As can be seen from Table (8), the annual average at the Diwaniya station reached (277.3), and evaporation rates begin to rise from March to November (191.5, 275.3, 393.5, 473.5, 495.3, 469.1, 356.5, 254.9, 138.7 mm, respectively). This is due to higher temperatures and lower rainfall and humidity.

Table 8. Monthly and annual average evaporation amounts at Al-Diwaniyah station for the period (1995-2022)

jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec	Annual rate
77	112,9	191,5	275,3	393,5	473,5	495,3	469,1	356,5	254,9	138,7	89,2	**277,3**

Source: Republic of Iraq, Ministry of Transport and Public Communications for Meteorology, Climate Department, Data (unpublished) Baghdad 2022.

3. Results and Discussion

Section Two / The Reality of Wheat and Barley Production for the Period (2010-2024)

Production has great and primary importance in economic studies through creating or increasing utility, and the wheat crop is considered one of the important crops that plays a significant economic role in many countries around the world [28]. It is the main staple food for most developing countries, including Iraq, as the population gets calories and proteins from it, providing an individual with 81% of the total calories supplied by grains per day, and it contains a protein content of about 63.2 grams [29] . As for barley, it comes in second place after wheat in terms of economic importance, and it is mainly used as animal feed and as a food item by some people[30].

Table (9) shows the area, production, and productivity of wheat and barley during the period (1995-2022). The variation in the cultivated area of wheat affected agricultural production and, consequently, productivity, which reached a total of (1191 kg/dunum). The highest productivity occurred in the agricultural seasons of the years (2005, 2014, and 2016-2022), with productivity for these years reaching (50, 55, 53, 62) kg/dunum, respectively. The reason for this increase in wheat productivity is due to the use of improved seeds that are resistant to plant diseases, alongside providing the necessary water, opening many irrigation channels and ditches, and using modern agricultural machinery and equipment for plowing, sowing, and harvesting. Additionally, the rise is attributed to the higher economic, cultural, and health levels of the farmers, as well as the suitability of climatic conditions for wheat cultivation [31] [32][33][34]

As for the barley crop, it is noted from the table above that the area cultivated with barley is small compared to the area cultivated with wheat. This is because farmers grow wheat as it provides them with a good economic return. The area cultivated with barley varies, which affects both production and productivity. The total productivity reached 697 kg/ha, with the highest barley productivity recorded in the agricultural seasons 1995-1996, 1999-2003, 2012, reaching 40-41-42-48 kg/ha respectively. The lowest productivity was recorded in the agricultural seasons 1996-1997, 2015-2017, reaching 13-15-16-16 kg/ha respectively. In recent years (2021-2022), barley is no longer cultivated in the study area, with farmers shifting towards wheat cultivation. The low yield per hectare in Iraq is attributed to the fact that production costs are nearly the same, as well as the limited or poor use of agricultural machinery allocated for barley cultivation, and the farmers' failure to adhere to the appropriate planting and harvesting times for wheat.

Table 9. Area, Production, and Productivity of Wheat and Barley Crops (1995-2022)

Production	Production (tons)	barley area (dunums)	Production	Production (tons)	Wheat area one dunam	agricultural season
41	82	200	16	2930	18710	1995
26	51	200	40	7477	18500	1996
13	22	170	36	6678	18500	1997
16	27	170	40	7200	18000	1998
48	95	200	41	8320	20390	1999
34	101	300	39	8500	22000	2000
30	105	350	40	9200	23100	2001
40	160	400	48	11300	23400	2002
30	135	450	50	11000	22000	2003
29	145	500	48	13200	27500	2004
20	185	925	50	13800	27534	2005
21	160	750	46	12500	27200	2006
25	187	750	45	12500	27860	2007
30	225	750	47	13100	27860	2008
25	190	750	48	13500	27860	2009
33	250	750	47	13200	27860	2010
42	300	715	38	6500	17200	2011
24	170	715	36	6344	17840	2012
35	250	715	25	6700	26646	2013
20	89	445	55	13269	23969	2014
19	85	445	43	10500	24680	2015
20	49	249	53	10670	20064	2016
16	45	276	38	9477	24750	2017
20	36	180	39	9324	24000	2018
20	60	300	38	9214	24550	2019
20	30	150	38	9858	26000	2020
nothing	nothing	nothing	45	11725	26000	2021
nothing	nothing	nothing	62	8067	13000	2022
697	3234	924217	1191	276053	646973	Total

Source: Al-Qadisiyah Governorate Agriculture Directorate, Al-Salahiyah District Agriculture Directorate, Plant Production Department (Unpublished Data).

Chapter Three / Analysis of the Statistical Relationship Between the Climatic Requirements for Growing Wheat and Barley Crops and the Available Climatic Potential in the Salahiyah Area

The impact of climatic conditions on wheat crop production

Through the results shown below, the interrelationship between wheat production and climatic elements in Al-Qadisiyah Governorate can be understood on one hand, and on the other hand, the correlation between wheat production and climatic elements in the study area can be clarified.

Table 10. shows the statistical relationships between climate elements and wheat production

Type and degree of relationship	Correlation coefficient for production	climatic elements
Weak inverse	-0.269	**Average hours of sunshine**
Weak direct	0.248	**Average temperature**
Very weak direct	0.158	**Maximum temperature**
Weak direct	0.045	**Minimum temperature**
Very weak inverse	-0.120	**Monthly average wind speed**
Weak direct	0.265	**Average rainfall**
Weak direct	0.411	**Monthly average relative humidity**
Weak inverse	-0.201	**Average evaporation**

Source: Researcher using Excel 2010.

Based on the results presented in the table above, these relationships can be summarized as follows:

The relationship between wheat production quantity and average sunshine hours is a weak inverse relationship, with a correlation coefficient of (-0.269), indicating a limited effect. Similarly, the relationship between wheat production and average temperature is a weak direct relationship, with a correlation coefficient of (0.248). The relationship between wheat production quantity and average maximum temperature is a very weak direct relationship, with a correlation coefficient of (0.158), while the relationship between wheat production quantity and average minimum temperature is a weak direct relationship, with a correlation coefficient of (0.045). This pattern is attributed to the fact that wheat, as a winter crop, thrives in non-harmful cold conditions, whereas higher temperatures—even if not directly harmful—affect production reduction. Moreover, the relationship between wheat production quantity and average monthly wind speed is a very weak inverse relationship, with a correlation coefficient of (-0.120), This indicates that wind speed during the winter season remains within acceptable limits and does not significantly affect production. On the other hand, it has been shown that the relationship between wheat production and the amount of rainfall is a weak positive correlation, with a correlation coefficient of 0.265, indicating that increased rainfall enhances irrigation efficiency and consequently leads to higher production. The relationship between wheat production and monthly relative humidity is also a weak positive correlation, with a correlation coefficient of 0.411, suggesting that higher humidity during the winter season positively contributes to crop growth. Conversely, the relationship between wheat production and evaporation rate is a weak negative correlation, with a correlation coefficient of -0.201, indicating a clear effect of increased evaporation in reducing wheat production due to moisture loss.

The statistical relationships between the different climatic factors and wheat production vary in terms of correlation strength and impact, which is attributed to the variation in production quantities and the distribution of climatic elements during the agricultural season.

The effect of climatic conditions on barley production

Table 11. shows the statistical relationships between climatic elements and barley production

Type and degree of relationship	Correlation coefficient for production	climatic elements
Weak inverse	-0.409	**Average hours of sunshine**
Weak inverse	-0.437	**Average temperature**
Very weak inverse	-0.128	**Maximum temperature**
Weak inverse	-0.315	**Minimum temperature**
Very weak direct	0.185	**Monthly average wind speed**
Weak direct	0.137	**Average rainfall**
Weak direct	0.424	**Monthly average relative humidity**
Very weak direct	0.053	Evaporation rate

Source/Researcher using Excel 2010.

The relationship between barley production quantity and average sunshine hours is a weak inverse relationship, with a correlation coefficient of (-0.409), indicating a limited effect of excessive sunlight on barley production. As for the relationship between barley production quantity and average temperature, it is also a weak inverse relationship, with a correlation coefficient of (-0.437). This is attributed to barley being a winter crop that grows better in lower temperatures, although the general average used includes the summer season, which weakens the statistical relationship. Regarding the relationship between barley production quantity and average maximum temperature, it is a very weak inverse relationship, with a correlation coefficient of (-0.128), reflecting the negative impact of high temperatures during the winter season. It was also found that the relationship between barley production quantity and average minimum temperature is a weak inverse relationship, with a correlation coefficient of (-0.315), indicating that a decrease in minimum temperature (within non-harmful limits) positively affects production, Apart from the effect of high maximum temperatures, which reduce crop yield, the relationship between barley yield and the average monthly wind speed showed a very weak positive correlation, with a correlation coefficient of (0.185), indicating that any increase in wind speed—especially if it is dry or strong—leads to a decline in production.

Regarding the relationship between the amount of barley production and the rate of rainfall, there was a weak positive correlation, with a correlation coefficient of 0.137, as increased rainfall provides the necessary moisture to improve growth conditions. A weak positive relationship also appeared between production and relative humidity, with a correlation coefficient of 0.424, reflecting the importance of moisture availability at the beginning of the winter season to provide a suitable environment for barley cultivation.

Finally, the relationship between the amount of barley production and the evaporation rate was a very weak positive relationship, with a correlation coefficient of (-0.053), indicating that increased evaporation resulting from higher temperatures, low rainfall, and low humidity negatively affects barley production.

Statistical relationships show that barley production is influenced by several climatic factors, although the effect is generally weak to moderate. This reflects the crop's flexibility in adapting to different climatic conditions, but it still requires a relatively mild and moist winter environment to achieve optimal yields.

Results:

1. The annual average of sunshine hours in the study area from 1995 to 2022 is 8.7 hours/day, reaching a maximum in the summer of 11.4 hours/day in July, which are suitable conditions for crop production.

2. The average temperature was 13.4°C in winter, 25.5°C in spring, 36.4°C in summer, and 26.2°C in autumn. These temperatures are suitable for the growth of wheat and barley crops.
3. The annual average rainfall (12.4 mm), although the amount does not fully meet the needs of the two crops, falls in line with their planting schedule, which partially contributes to the success of cultivation.
4. The annual average wind speed reached 2 m/s, which is a moderate speed that does not negatively affect crop growth.
5. The data showed a variation in the cultivated areas, production, and productivity of wheat and barley during the period (1995–2022), with an improvement in wheat productivity observed in recent years, while barley cultivation declined due to the equalization of production costs between the two crops, without a clear economic benefit for barley.
6. The study proved that the research area enjoys favorable climatic conditions that make it a suitable and ideal area for growing wheat and barley, which contributes to meeting the local needs for these crops.
7. The research indicated a clear correlation between natural climatic factors and the level of wheat and barley productivity, confirming the importance of climatic suitability in achieving stable agricultural production.

Recommendations:

1. The necessity of raising farmers' awareness and emphasizing their commitment to the specified climate-based planting dates, to ensure they benefit from monthly changes in temperature and rainfall timing in a way that aligns with the growth stages of the crops.
2. Providing financial and technical support to farmers, alongside organizing awareness and guidance campaigns to encourage them to expand the cultivation of field crops.
3. Using high-quality seeds that are compatible with local climatic conditions, with a precise determination of the climatic requirements for each crop in the study area.
4. Conducting studies to determine the suitability of lands for growing wheat and barley, using modern assessment methods that help identify soil suitability.
5. Establishing a database within a Geographic Information System (GIS) for each crop, with the aim of identifying arable land suitable for investment and achieving optimal utilization of available agricultural land.

4. Conclusion

The present study validates that climate is the ultimate controlling factor in the spatial distribution and productivity and stability of wheat and barley production in the Salahiyah District. Analysis showed that the climate conditions in the study area are generally advantageous—especially regarding temperature regimes, sunshine duration, wind speed, and relative humidity—as both crops behave as winter cereals and thus rely on winter conditions. Rainfall averages are low in amount and not sufficient for complete crop water supply, but occur at a seasonal time period, at planting and early crop growth stages, therefore irrigation is an important supplement (Rockström et al, 1999). Statistical analysis indicated the presence of differential associations between climatic factors and crop yields with relative humidity and rainfall having positive correlations with wheat and barley production and high temperature, evapotranspiration and high sunshine hours having negative ones, notably barley. These results illustrate the sensitivity of cereal output to climatic variability, highlighting that climatic suitability is vital for consistent and sustainable agricultural production. Implications of results for practice: This work implies that adaptation measures—e.g. adjustment of planting dates, using resilient varieties and increased irrigation efficiency—could help to lessen climatic limits and increase yields. Additional studies are needed for the climate change scenarios, with advanced GIS as well as remote sensing methods for land suitability assessment, as well as for predictive models integrating climatic, hydrological, and socio-economic variables for long-term planning and food security strategies in arid and semi-arid environment

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