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THE EFFECT OF CLIMATE ELEMENTS ON THE PHENOMENON OF DESERTIFICATION IN AL- ZAB DISTRICT

Ehab Ali Hussein, Prof. Dr. Ali Mukhlif Saba
Department of Geography, College of Education for Human Sciences, Tikrit University

Abstract
The climate directly or indirectly affects the emergence and exacerbation of the phenomenon of desertification through its elements, not only in the study area, but in all arid, semi-arid and sub-humid areas. The study area is located within the area with an arid climate. The climate also has a major and effective role in the emergence and development of this problem and for determining the extent of the impact of climatic elements in the emergence and exacerbation of this problem in the Zab district, and since there is no climatic station in the study area, it will rely on the station climate between (1990-2021)

1-1. Study Problem

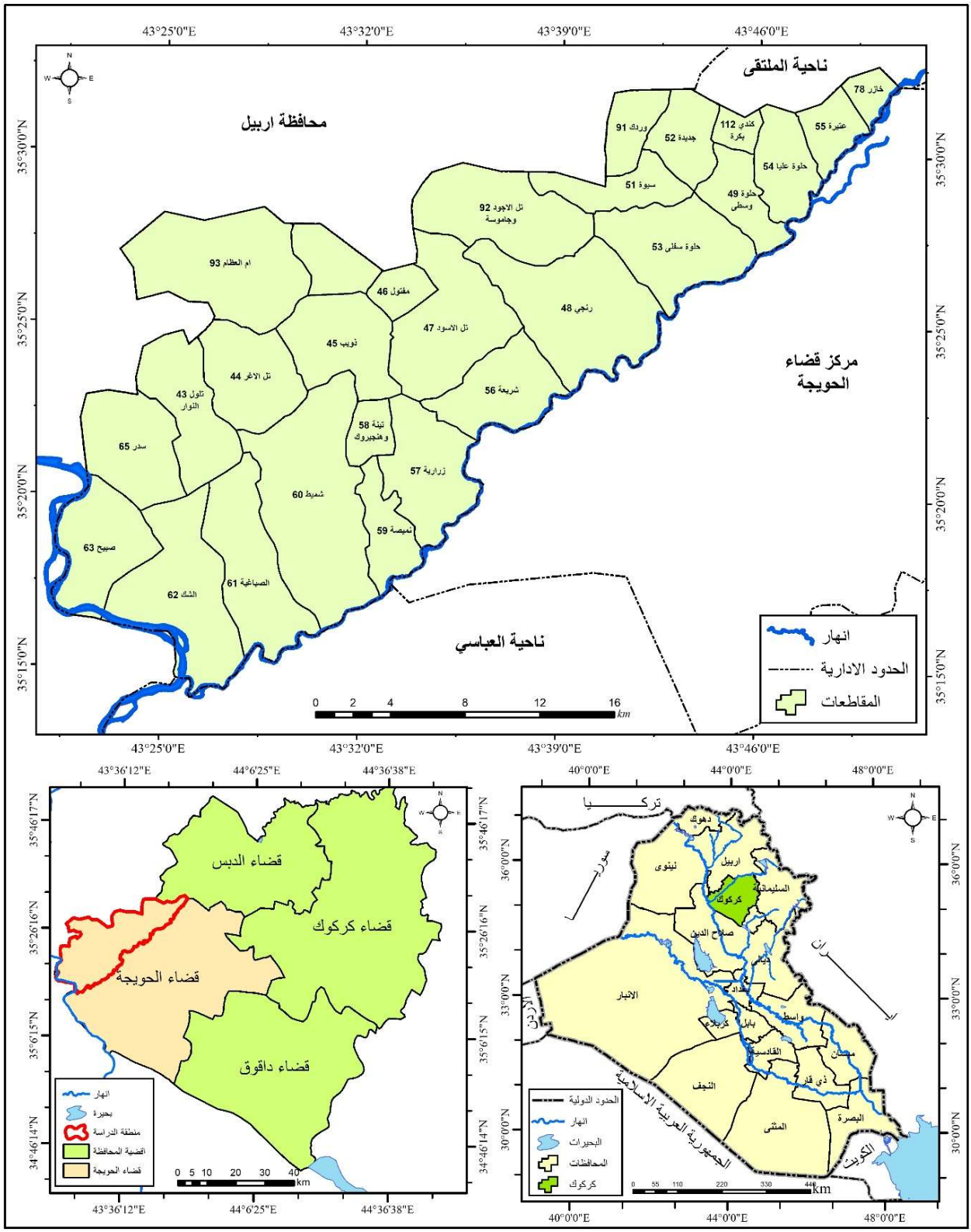
In recent years, the study area has faced a transformation in its ecosystem, from a prosperous area of vegetation and agriculture to semi-barren lands, which led to the formation of a basic idea. Thus, the region suffers from a defect in the ecosystem that led the study to state its causes and the direction of its change over the years.

1-2. The Location of the Study Area:

Al-Zab District is located in the northwest of Hawija City in the province of Kirkuk within the plain lands located on the right bank of the little Al-Zab River until its confluence with the Tigris River and is located coordinates between two latitudes (52″14′35° - 53″32′35°) north and longitude (57″20″43° -30″51′43°) east, and includes the district within its administrative boundaries (27) province, and is bordered to the north by the district of Al-Qaraj in the city of Makhmour. As for the northeast, there is Al-Multaqa district of Dibs district in Kirkuk Province, and from the south is Abbassid district in the city of Hawija, and from the east and southeast the center of Hawija , and from the west is the Tigris River, which separates it from the Shirqat city, and the southwest is Al-Zwaya village in the city of Baiji in Salah Al-Din Province. The total area of the district is (593.5) square kilometers.

**Autora de correspondencia / Corresponding author.*

Map (1-1) Location of the Study Area



Source: From the work of the researcher based on the General Authority for Survey of Iraq, and on the satellite visual Land sat8 on (10/5/2021).

Climatic elements include:

1- **(Temperature:**

Temperatures are one of the factors directly affecting the problem of desertification. They also have an active role in the dryness of the soil and increase evaporation rates, the effect of heat on plants appears through their type and size because of their association with the process of evaporation / transpiration because each plant has a minimum and maximum ability to withstand temperatures in which it can bloom and grow, which is (5) ° C ( ). As a result, the importance of studying temperatures comes through their relationship to the composition of vegetation cover and the amount of evaporation and their relationship to drought and then the prevalence of desertification manifestations ( ).

Table (1-1) Monthly averages normal and maximum temperature (°C) and minimum temperature and temperature range at Baiji station for the period (1990-2021)

Average	Dec.	Nov.	Oct.	Sept.	Aug.	Jul.	Jun.	ا May.	Apr.	Mar.	Feb.	Jan.	Months
29.9	16.7	23.3	32.6	39.6	43.6	43.8	40.7	35.6	28.7	22.6	17.5	15.1	**Highest Temperature**
15.6	5.2	9.6	17.1	22.4	26.7	27.6	24.9	20.7	14.9	9.2	5.7	4	**Lowest Temperature**
22.6	10.6	15.9	24.3	30.9	35	35.9	33.3	28.2	21.6	15.8	11.2	9.3	**Ordinary Temperature**
13.8	11.5	13.7	15.5	17.2	16.9	16.2	15.8	14.9	13.8	13.4	11.8	5.3	**Scope**

Source: Ministry of Transport, General Authority for Meteorology and Seismic Monitoring, Climate Section, Baghdad, 2021, (unpublished data).

By observing Table (1-1), it is clear that there is a variation in the rates of maximum temperatures in the study area, as it is characterized by a gradual increase, starting from March, in which the rate reached (22.6) ° C to reach its maximum rates during the months (June, July, August, September). When it reaches for each of the months (40.7, 43.8, 43.6, 39.6) ° C, and after September, the average temperatures begin to decrease gradually to reach their lowest values in January to reach (9.3) ° C.

As for the average monthly minimum temperatures, they are less than (10) ° C for the months (November, December, January, February, March) in the study area. Its rates for those months were (9.6, 5.2, 4, 5.7, 9.2 ° C) respectively, that this decrease in minimum temperatures is due to the inclination of the angle of incidence of solar radiation and the accompanying decrease in the number of daylight hours. As a result, this decrease leads to a decrease in the activity of microorganisms in the soil, which increases when temperatures range between (18-30) ° C. The low temperatures also affect agricultural production, as some sources indicated that

the optimum temperature for the germination of seeds of summer crops ranges between (20-30) ° C, while the optimum temperature for the germination of winter crops is between (15-20) ° C. Thus, a temperature drop below 10°C affects the productivity of the soil and thus loses its biological and productive ability to germinate during the cold season. As for the monthly averages of the normal temperature, it rises during the months of (July and August), as its average during the month of July reached (35.9) ° C, while in the month of August its rate reached (35) ° C, and the reason for this is due to the angle of incidence of solar radiation, which is vertical and semi-vertical, which is reflected throughout the theoretical and actual day during those months, as well as the lack of vegetation cover and its scattering, which results in the arrival of large amounts of solar radiation and then high temperatures And heat the floor surface. We conclude from the above that the monthly averages of temperatures (average and maximum) in the study area were characterized by the rise for most months of the year. This rise affects some soil properties, including the loss of moisture of the surface layer of the soil and raising its temperature due to the high temperature of the air in contact with it or close to the surface layer, this rise in temperatures leads to the activity of the capillary property that works to raise ground water to the surface of the soil and then evaporate it and the survival of salts on the surface of the soil High temperatures increase the decomposition of organic matter, as well as increase the severity of organic matter and convert it into materials that do not benefit the plant. Also, the increased heating of the surface of the earth, especially during the day, has an impact on the occurrence of a state of turbulence and the rush of convection currents strongly towards the top, so the very soft dry disassembled minutes rise from the surface of the soil and the atmosphere is filled with dust, leading to a dust storm and the deterioration of visibility to below (1000 meters), although the wind speed may be low which leads to the appearance of dust in the study area in its various parts.

Table (1-2) Annual average normal, maximum and minimum temperatures (°C) (1990-2021)

Ordinary Temperature	Lowest Temperature	Highest Temperature	Years	Ordinary Temperature	Lowest Temperature	Highest Temperature	Years
23.4	15.6	30.7	2006	22.5	15.3	30	1990
23.8	15.6	32	2007	22.2	15.5	29.2	1991
23.8	16.7	30.9	2008	20.6	14.1	27.6	1992
23.6	17	30.1	2009	21.5	15	29	1993
24.8	18.2	31.6	2010	22.8	16.1	29.7	1994
23	16.5	29.8	2011	22.4	15.3	29.9	1995
21.9	13.9	28	2012	23	16.2	30.2	1996
22.2	14.4	29.2	2013	21.9	15	28.9	1997
20.9	14.9	28.9	2014	23.5	16.1	31.2	1998
21.7	14.7	29.5	2015	23.6	16.1	31.1	1999
21.8	15.5	29.6	2016	22.9	15.7	30.2	2000
22.8	15.3	30	2017	23.4	16.1	30.6	2001
22.5	15.1	28.9	2018	23.1	16.1	30.1	2002
23	15.3	30	2019	23.7	16.2	31.6	2003

21.9	15.6	31.1	2020	22.8	15.6	30	2004
22.9	16.5	30.7	2021	22.9	15.5	30.3	2005
22.7	15.6	30.0	Averag e				

Source: Ministry of Transport, General Authority for Meteorology and Seismic Monitoring, Climate Section, Baghdad, 2021, (unpublished data).

It is noted from Table (1-2) the following facts: The annual average of the maximum temperature totals for the period (1990-2021) amounted to (30.0) C, it turned out that the highest average maximum temperatures were in (2007) amounting to (32) °C, and the lowest in (1992) and reaching (27.6) °C. With regard to minimum temperatures: The annual average of the minimum temperature totals for the period (1990-2021) reached (15.6) ° C, the highest average minimum temperature was in (2010) of (18.2) ° C, while the lowest rate was in (2012) when it reached (13.9) ° C. As for the normal temperature: the annual average for the period (1990-2021) was (22.7) °C. The highest average normal temperature was in (2010) when it reached (24.8) °C. The lowest rate was in (1992) when it was (20.6) °C.

2- **Rainfall:**

The rainy season in the study area starts from September to June, due to the arrival of Mediterranean depressions to Iraq in general, and to the study area in particular. It is clear from Table (2-1) that the highest rainfall rates are during the months (December, January), which reaches (33.4, 40.2) mm, respectively, There is also a variation in rainfall rates, due to the lack of frequency of frontal depressions that reach the region. The rains of the region are mostly cyclonic rains that fall in their highest quantities in the winter, while the spring and autumn seasons are characterized by ascending and thunderstorms accompanied by thunder and strong winds. Knowing the amount of rainfall is very important with regard to the importance of the presence of precipitation and its quantity, and when the precipitation is heavy for a short period, plants do not benefit from it. On the contrary, when it is in the form of a spray for long periods. The rain also has a clear impact on the study area due to its impact on the quantity and quality of the plant, as well as its impact on the soil, as large raindrops lead to the scattering and disintegration of soil grains and exposure to erosion, which leads to the emergence of the phenomenon of desertification.

Table (2-1) Monthly and annual rainfall totals (mm) for the period 1990-2021 at Baiji Station

Total	**Dec.**	**Nov.**	**Oct.**	**Sept.**	**Aug.**	**Jul.**	**Jun.**	**May.**	**Apr.**	**Mar.**	**Feb.**	**Jan.**	Months
201.7	33.4	23.9	7.3	0.7	0	0	0.3	8.1	19.8	35	33	40.2	Rains/ML.
100	16.6	11.8	3.6	0.3	0	0	0.1	4	10	17.3	16.3	20	Percentage

Source: Ministry of Transport, General Authority for Meteorology and Seismic Monitoring, Climate Section, Baghdad, 2021, (unpublished data).

We note that the total rainfall rate peaks during the months of (December, January, February, March), as it

reached (70.2) %, of the annual total premission, while we note that the percentage of rain for the rest of the months is (29.8) %, this indicates that there is a fluctuation in rain in the study area from month to month and from year to year.

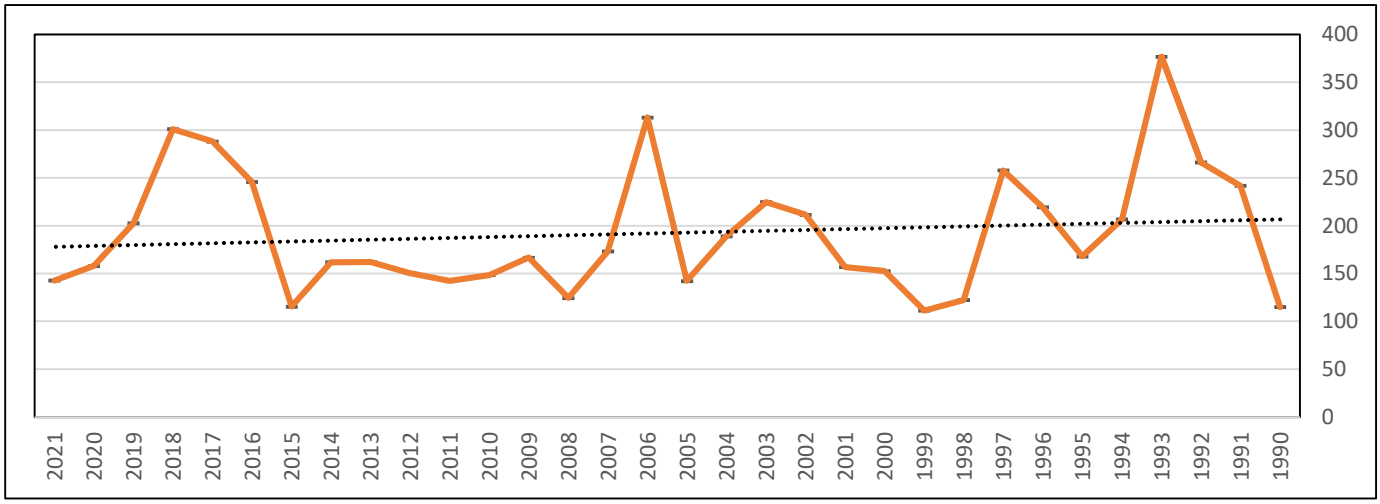
Table (2-2) Monthly and annual rainfall totals (mm) for the period 1990-2021 at Baiji Station

المجموع	Dec.	Nov.	Oct.	Sept.	Aug.	Jul.	Jun.	May.	Apr.	Mar.	Feb.	Jan.	Months
115	10.4	4.9	1	0	0	0	0	0.1	16.9	19.6	55.2	6.9	**1990**
241.7	24.4	59.5	8	0	0	0	0	0	0.7	82.5	36.4	30.2	**1991**
266.1	20.5	92	0	0.001	0.001	0	0.3	15.1	11	24.1	54.6	48.5	**1992**
376.7	20.7	26.2	24.1	0	0	0	0	97.4	112.1	24.9	18.6	52.7	**1993**
206.7	34.9	66.7	11.1	0	0	0	0	0.001	10	22	24	38	**1994**
168	6.6	0.7	0.4	3.4	0	0	11.5	5.7	24.2	28.2	61.9	25.4	**1995**
219.4	51.4	8.2	1.2	2	0	0.001	0	19.2	3.6	76.6	10.9	46.3	**1996**
257.8	63.4	54.7	13.9	0	0	0	0	2.9	3.6	25.7	42	51.6	**1997**
122.3	6.8	0.001	0	0	0	0.001	0	3.2	7.9	17.2	17.3	69.9	**1998**
111.2	23.5	0.2	8.4	0	0.1	0	0	0.001	8.8	2.4	27.7	40.1	**1999**
152.6	57.1	25.1	19.7	0.001	0	0	0	10.9	4.4	6.9	2.2	26.3	**2000**
156.7	29.5	13	0.3	1.1	0	0.3	0	7.1	24	29.8	25.8	25.8	**2001**
211.4	44.8	25.4	25.8	0	0	0	0	4.6	21.9	48.9	8.8	31.2	**2002**
224.7	76.3	46.3	3.9	0	0	0	0	3	15.2	19.3	26	34.7	**2003**
189.1	14.3	7.3	0.001	0	0	0	0	14.4	36.1	0.6	71.8	44.6	**2004**
142.2	1	0.001	0.001	15.2	0	0	0	3.8	0	25	54.5	42.7	**2005**
313.1	18.3	1	18.1	0	0	0	0	28	68.8	0	116.8	62.1	**2006**
173.1	1.7	0	0	0	0	0	0	57	22.5	7.9	44.1	39.9	**2007**
124.5	1.7	20.1	11	0.001	0	0	0	0	0	40.8	24	26.9	**2008**
166.7	18.7	37.5	32.8	4.4	0	0	0	0	23.4	20.8	4.6	24.5	**2009**
148.4	37.1	0.3	1.2	0	0	0	0	26.9	15.8	27.2	24.4	15.5	**2010**
142.2	42.9	6.1	0	0	0	0	0	1.3	34	12.6	5.2	40.1	**2011**
150.5	56.4	5.6	0	0	0	0	0	0	33.3	136.3	65.3	59.8	**2012**
162.2	28.7	9.7	0	0	0	0	0	0	35.1	9.5	31.5	36	**2013**

161.8	36.3	21.77	0	0	0	0	0	0	0	88.2	21.4	16.3	**2014**
115.4	43.3	46	1.1	0	0	0	0	0	0	14.4	8.5	48.5	**2015**
245.8	32.5	0.8	2.3	0	0	0	0	0.5	2.3	16.8	35.3	24.9	**2016**
288	19.9	13.2	37.4	2.5	0	0	0	2	0.3	20.3	27	123.2	**2017**
301	41.8	17.6	3.7	0	0	0	0	3.5	44.4	23.2	74	16.5	**2018**
202.6	96.3	32.2	6.4	0	0	0	0	24.1	4.4	35.2	37.9	25.5	**2019**
158	29	61.5	18.8	3.9	0	0	0	16.2	47.9	18	24.9	109.4	**2020**
142.7	33.6	51.1	1.1	0	0	0	0	0	0	14.4	23.4.5	42.5	**2021**
192.4	33.6	23.6	7.4	0.8	0	0	0.3	8.3	20.1	34	33.4	40.9	**Average**

Source: Ministry of Transport, General Authority for Meteorology and Seismic Monitoring, Climate Section, Baghdad, 2021, (unpublished data).

Figure (1) Time Series of Rainfall of the Study Area



The source is from the researcher's work based on Table (2-2).

- It is noted from Table (2-2) and Figure (1) the following facts: The annual average rainfall totals for the period (1990-2021) were (192.4) mm, and it is approaching the year (2004). It turns out that the highest amount of rainfall was in (1993) (375.5) mm, and the lowest in (1999) was (111.2) mm. The overall time series of rainfall in the study area is declining

It is also noted through the table above that rainfall rates fluctuate in the study area from year to year. This fluctuation is caused by the fluctuation of air depressions, which reflects negatively on agriculture, as well as makes the region ready for the expansion of desertification manifestations, and in years when rainfall decreases. It is offset by a lack of moisture content of the soil, which facilitates the process of mechanical

weathering, which leads to the disintegration of soil grains and prepares them for wind and water erosion, which reduces the thickness of the soil and becomes poor in matter Membership. As well as the high temperatures with the lack of rain, it increases the evaporation process, and thus the lack of moisture content in the soil, its dryness and salinization, as the increase in evaporation leads to the activity of the capillary property that works to raise groundwater to the surface, forming a salt layer that reflects negatively on plant growth, and these are all manifestations of desertification

3- Relative Humidity:

It is the percentage between the water vapor actually present in the air and the amount of water vapor needed for the air to be saturated at the same temperature and pressure ( ). In addition, the relative humidity factor is of great importance, because it is related to the degree of quantities of water vapor actually present in the air. It is observed that when temperatures rise, the relative humidity decreases and the relationship between them is completely inverse due to the inability of the air to carry water vapor. As well as the problem of drought suffered by most arid and semi-arid areas and its impact on their development.

Table (3-1) Monthly average relative humidity in the study area (%) for the period 1990-2021 at Baiji Station

Average	Dec.	Nov.	Oct.	Sept.	Aug.	Jul.	Jun.	May.	Apr.	Mar.	Feb.	Jan.	Months
49.1	**74**	**62**	**46**	**34**	**28**	**27**	**28**	**37**	**50**	**60**	**68**	**76**	**Moisture%**

Source: Ministry of Transport, General Authority for Meteorology and Seismic Monitoring, Climate Section, Baghdad, 2021, (unpublished data).

We note through Table (3-1) that the highest percentage of humidity was recorded in the months of (January and December), as its rates reached (76, 74) % respectively, and the lowest percentage of humidity recorded in the following months (June, July, August), as it reached as follows (28, 27, 28) % We note the high level of relative humidity rates with low temperatures and vice versa.

Table (3-2) Annual average relative humidity (%) for the period (1990-2021) at Baiji Station

Total	Year	Total	Year	Total	Years
45	2010	49	2001	47	1990
48	2011	44	2002	54	1991
50	2012	46	2003	55	1992
53	2013	46	2004	54	1993
60	2014	43	2005	54	1994
52	2015	45	2006	50	1995
50	2016	42	2007	48	1996
52	2017	42	2008	53	1997
55	2018	44	2009	47	1998
50	2019	45	2006	46	1999
51	2020	42	2007	45	2000
52	2021				

49.1	Average				

Source: Ministry of Transport, General Authority for Meteorology and Seismic Monitoring, Climate Section, Baghdad, 2021, (unpublished data).

It is noted from Table (3-2) the following facts: The annual average of the relative humidity groups for the period (1990-2021) was (49.1)%. It turned out that the highest rate of humidity was in (2014) amounting to (60)%, and the lowest in (2007, 2008) amounting to (42.42)%. We conclude from the above that relative humidity is an important element that is no less important than the rest of the other climatic elements in affecting the manifestations of desertification, through its direct and indirect impact on exposure to drought, which is reflected on the plant and soil, which exposes agricultural production to risks, destruction and the prevalence of desertification manifestations

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4- Wind:

Wind is the horizontal movement of air, occurs as a result of a difference in the values of atmospheric pressure in different places, as its movement from areas of high pressure to areas of low pressure, if it were not for the wind, the rain that falls on land would be less than it is because it works to displace moisture from water bodies to land ( ). The winds that blow over the study area are the northwest winds in summer are blowing in the form of currents with a blowing rate in the summer more than the winter reeds. While the winds blowing over the region in winter are mostly northwesterly winds and by looking at the data of Table (4-1) that shows the annual rate of wind speed in Baiji station has reached (1.8) m / s. Its average speed increases from that rate during the months (April, May, June, July, August), as the average monthly wind speed in those months reached (2.4, 2.3, 2.9, 3, 2.6) m / s respectively, then the monthly rates of wind speed decrease from the annual rate starting from September until the end of February, as the rate for each of those months (1.6, 1.2, 1.1, 1.1, 1.2, 1.5) m / s, and it is worth noting that the wind speed is not less in the study area than the monthly rates mentioned above, but it exceeds that for a number of days in the year

Table (4-1) Monthly Rates and Annual Average Wind Speed (m/s) for the Period (1990-2021) at Baiji Station

Average	Dec.	Nov.	Oct.	Sept.	Aug.	Jul.	Jun.	May.	Apr.	Mar.	Feb.	Jan.	Months
1.8	**1.1**	**1.1**	**1.2**	**1.6**	**2.6**	**3**	**2.9**	**2.3**	**2.4**	**1.8**	**1.5**	**1.2**	**Speed of Wind m/S**

Source: Ministry of Transport, General Authority for Meteorology and Seismic Monitoring, Climate Section, Baghdad, 2021, (unpublished data).

The wind speed has a major role in the formation of various manifestations of desertification in the region, especially during the aforementioned drought months, as the increase in wind speed during the summer months (June, July, August) in which temperatures rise, leads to an increase in the amount of evaporation and then the loss of the surface layer of moisture, as well as the resulting dryness and dismantling of the

surface layer of the soil that is not protected by vegetation cover, which is ready for the process of wind erosion when the wind blows at speed. The rapid winds that blow with high temperatures also lead to an increase in the amount of evaporation and the movement of ground water upwards by increasing the activity and effectiveness of the capillary property, especially during the summer months, and then salting the soils as a manifestation of desertification in the study area.

5- Evaporation:

Evaporation is defined as the process of transferring water molecules from water surfaces and from soil in the form of water vapor to the air, and the amount of evaporation is affected by a number of climatic elements such as solar radiation, temperatures, air humidity and wind speed, as well as affected by the nature of soil characteristics, groundwater level, vegetation cover and the size of the German flat. With regard to the study area, the monthly evaporation quantities vary according to the varying factors affecting it, especially solar radiation, temperatures and wind speeds that are directly proportional to it, and through Table (5-1) it is clear that the monthly quantities of evaporation vary in the study area from month to month, as its quantity decreases during the winter months (October, November, December, January, February), as the total evaporation during which at the Baiji station reached (345.9) mm, due to low temperatures During these months, as well as increasing relative humidity rates that are inversely proportional to evaporation.

Table (5-1) Monthly Evaporation Rates (mm) at Baiji Station for the Period (1991-2020)

Average	**Dec.**	**Nov.**	**Oct.**	**Sept.**	**Aug.**	**Jul.**	**Jun.**	**May.**	**Apr.**	**Mar.**	**Feb.**	**Jan.**	Months
110.2	68.8	68.9	70.4	101.9	205.3	205.6	136.7	131.7	108.3	87.5	71.4	66.4	Esteem /ml.

Source: Ministry of Transport, General Authority for Meteorology and Seismic Monitoring, Climate Section, Baghdad, 2021, (unpublished data).

Then the monthly evaporation rates gradually increase, starting from March, in which the amount of evaporation reached (87.5) mm, to reach its highest values during the summer months (June, July, August), as it reached an average of (136.7, 205.6, 205.3) mm, respectively, due to the high temperatures in those months with low relative humidity, as well as the increase in wind speed and the predominance of dry northwest winds in those months.

Table (5-2) Annual Evaporation Rate (mm) for the period (1990-2021) at Baiji Station

Esteem	Years	Esteem	Years	Esteem	Years
1098	2014	1626	2002	1548	1990
1068	2015	1536	2003	1482	1991
1146	2016	1503	2004	1506	1992
1095	2017	1491	2005	1629	1993
1389	2018	1140	2006	1548	1994
1353	2019	1113	2007	1311	1995

1413	2020	1098	2008	1350	1996
1385	2021	975	2009	1491	1997
1323.3	Average	996	2010	1542	1998
		996	2011	1479	1999
		1029	2012	1545	2000
		1041	2013	1425	2001

Source: Ministry of Transport, General Authority for Meteorology and Seismic Monitoring, Climate Section, Baghdad, 2021, (unpublished data).

It is noted from Table (5-2) the following facts: The annual average of evaporation groups for the period (1990-2021) was (1323.3) mm. It turned out that the highest rate of evaporation was in (1993) of (1629) mm, and the lowest in (2009) of (975) mm

We conclude from the above that the amount of evaporation in the Baiji station is characterized by its height, as the annual rate of it reached (1323.3) mm, and that the annual rate of evaporation exceeds the annual rate of rain in the Baiji station by (6.8) times, as the high rates of evaporation values, especially in the dry months, lead to the drying of the surface layer of the soil, especially for the period extending from March to the end of September, and the lack of moisture content of the soil, which leads to a lack of cohesion of soil particles with each other, so they appear Incoherently, which exposes its fine minutes to the process of erosion by the wind and then affects the chemical and physical properties of the soil, and the high rates of evaporation have effects that lead to an increase in the activity of the capillary property and the rise of salty groundwater to the soil surface, which results in the accumulation of salts on the soil surface after water evaporation.

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