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CALCULATING THE CLIMATE WATER BALANCE DURING THE RAINY MONTHS AND THE GENERAL TREND OF TEMPERATURES AND RAINFALL AND THEIR EXPECTED VALUES FOR THE YEAR 2030 AT THE DIWANIYAH, SAMAWAH AND NASIRIYAH STATIONS IN SOUTHERN IRAQ.

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ABSTRACT

In this study, the climatic water balance was calculated during the rainy months (January, February, March, April, May, October, November, and December) using the Thornthwait equation described in (Al-Tayef and Al-Hadithi, 1988). The general trend of temperatures and rainfall and their expected values for the year 2030 were determined at three selected stations in southern Iraq (Diwaniyah, Samawah, and Nasiriyah), shown in Figure 1. This was based on data from the Iraqi General Authority for Meteorology and Seismic Monitoring, which included monthly and annual averages of temperatures, monthly averages of rainfall, and their annual totals for the period (2000-2021). The following conclusions were concluded:-

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1-1- Climate Water Balance

1-1-1- The water surplus was concentrated at the three stations during December and January, with the values of (WS) for the two months above reaching (3.99 and 13.22) mm, respectively, at the Diwaniyah station, with a total of 17.21 mm and a percentage of 16.87% of the total rainfall of 102 mm. The values of (WS) for December and January reached (4.76 and 7.23) mm, respectively, at the Samawah station, with a total of 11.98 mm and a percentage of 12.28% of the total rainfall of 97.50 mm. At the Nasiriyah station, the values of (WS) for the two months above reached (9.91 and 6.34) mm, respectively, with a total of 16.25 mm and a percentage of 14.43% of the total rainfall of 112.25 mm

1-1-2- Water deficit (WD) starts during the rainy months of February. The (WD) values during this month reached (2.56, 2.08, 4.08) mm in the Diwaniyah, Samawah and Nasiriyah stations, respectively. The water deficit continues to gradually rise to reach its highest value during May, as the (WD) values during this month reached (214.21, 301.44, 303.83) mm in the above stations, respectively.

1-2- The general trend of temperature and rainfall and their expected values for the year 2030

Using simple linear regression equations derived from a time series study of annual average temperatures in degrees Celsius and total annual rainfall in mm for the period (2000-2021), the general trend of temperature and rainfall at the three study stations, as well as their expected values for the year 2030, were determined as follows:

1-2-1- Diwaniyah Station

The equation $Y=0.086X+24.71$ shows that the annual average temperature in degrees Celsius increases by $0.086^{\circ}\text{C} \cdot \text{Year}^{-1}$. Therefore, the annual average temperature in degrees Celsius will reach 27.37°C in 2030

As for the general trend of rainfall, the equation $Y = -1.247X + 114.3$ shows that the annual total rainfall (in mm) decreases by $1,247 \text{ mm} \cdot \text{year}^{-1}$. Therefore, the annual total rainfall will reach $75,643 \text{ mm}$ in 2030

1-2-2- Samawah Station

The equation $Y=0.081X+24.89$ shows that the annual average temperature in degrees Celsius increases by $0.081^{\circ}\text{C} \cdot \text{year}^{-1}$. Therefore, the annual average temperature in degrees Celsius will reach 27.40°C in 2030

As for the general trend of rainfall, it is shown from the equation $Y = 1.865X + 75.55$ that the annual total rainfall (in mm) is increasing by $1.865 \text{ mm} \cdot \text{year}^{-1}$. Therefore, the annual total rainfall will reach 133.36 mm in 2030

1-2-3- Al-Nasiriyah Station

The equation $Y=0.062X+25.93$ shows that the annual average temperature in degrees Celsius increases by $0.064^{\circ}\text{C} \cdot \text{Year}^{-1}$. Therefore, the annual average temperature in degrees Celsius will reach 27.91°C in 2030

As for the general trend in rainfall, it is shown from the equation $Y = -0.082X + 113.5$ that the annual rainfall total decreases by $0.082 \text{ mm} \cdot \text{year}^{-1}$. Therefore, the annual rainfall total will become 110.95 mm in 2030.

2- the introduction

Water deficit is one of the most important problems facing most countries in the world especially those located in arid and semi-arid regions including Iraq. That especially the southern part is characterized by long hot summers and short cold winters while spring and autumn are short transitional seasons (FAO, 2003). Water deficit occurs if effective rainfall - Effective rainfall is the part of the rain that seeps into the soil in quantities that depend on the soil texture and degree of its structure (Selkhoz prom, 1982) - is less than the amount of water lost through evaporation - transpiration. Water surplus occurs when effective rainfall is greater than the amount of water lost through evaporation - transpiration. (AL-samarayiy, 2000).

This quantitative relationship between effective rainfall and water lost through evaporation-transpiration is what is known as the climatic water balance. Calculating the climate water balance is an essential and important step to determine periods of water deficit and water surplus during a specific period of time at the climate stations available in the study area, and then taking all necessary measures to reduce the damage caused by soil moisture deficiency during periods of water deficit. including calculating the irrigation schedule, which means determining the amount of water required to irrigate crops using modern irrigation methods with high efficiency and a high degree of consistency, in addition to determining the time period between two consecutive irrigations (Al-Sharif, 2009). As for the most important necessary measures taken during periods of water surplus, they include building rainwater harvesting projects and storing it on the surface or underground to benefit from it during periods of water deficit.

Based on the above, this research is concerned with determining the periods of water deficit and water surplus during the rainy months (January, February, March, May, October, November and December) in the stations

(Diwaniyah, Samawah and Nasiriyah) in southern Iraq. In addition to determining the general trend of climate change in the study area by studying the time series of temperatures and rainfall for the period (2000-2021) and predicting their values in the year 2030, which greatly helps in developing appropriate policies for managing water resources and reducing the negative effects of drought.

3- Materials and Methods

The study was conducted to calculate the climatic water balance during the rainy months (January, February, March, April, May, October, November, and December) at the stations (Diwaniyah, Samawah, and Nasiriyah), the details of which are shown in Table 1, located in the governorates (Qadisiyah, Muthanna, and Dhi Qar), respectively, as shown in Figure 1. The study also studied the general trend of annual average temperatures and total annual rainfall during the period (2000-2021) and their expected values for the year 2030, as follows:

Table 1: Geographical locations of the stations (Diwaniyah, Samawah, and Nasiriyah)

The station	Governorate	Longitude	latitude
Diwaniyah	Al-Qadisiyah	44.57	31.57
Samawah	Al-Muthanna	45.16	31.16
Nasiriyah	Dhi Qar	46.14	31.01

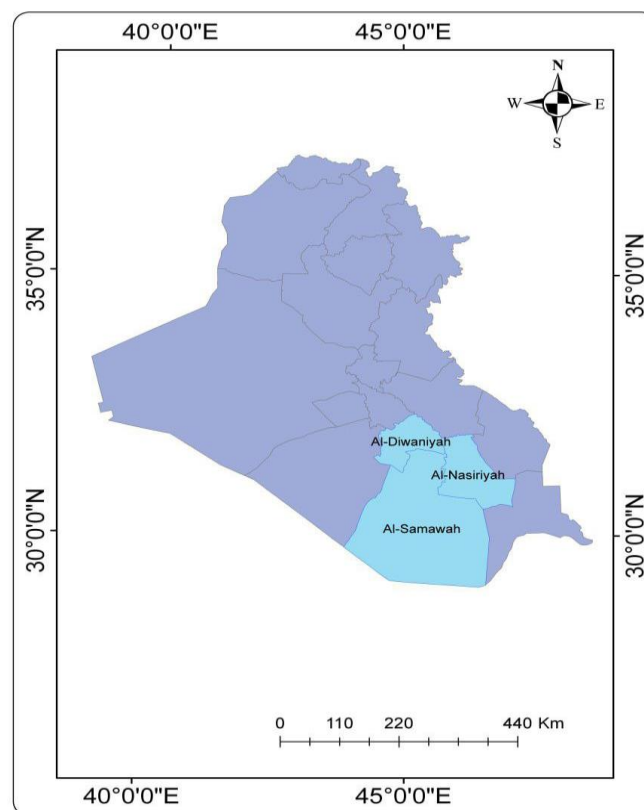


Figure 1: Map showing the locations of the stations (Diwaniyah, Samawah, and Nasiriyah) drawn using the Arc Map 10.8 application

3-1- Using the monthly averages of temperatures and rainfall during the rainy months for the three stations shown in Tables (2, 3) and the annual averages of temperatures and the annual total of rainfall shown in Table (4) for the period (2000-2021) based on data from the Iraqi General Authority for Meteorology and Seismic Monitoring.

Table 2: Monthly average temperatures during the rainy months for the period (2000-2021)

The Station	Monthly average temperature in degrees Celsius							
	January	February	March	April	May	October	November	December
Diwaniyah	12.40	15.30	20.00	25.450	31.40	27.150	18.850	13.90
Samawah	12.050	14.950	20.150	25.220	31.90	27.750	19.350	14.10
Nasiriyah	12.80	15.60	20.90	26.350	32.60	29.100	19.90	14.450

Table 3: Monthly average rainfall during the rainy months for the period (2000-2021)

The Station	Average monthly rainfall (mm)							
	January	February	March	April	May	October	November	December
Diwaniyah	20.80	12.10	8.20	14.60	3.40	5.10	23.00	14.80
Samawah	13.60	11.60	14.10	10.40	5.00	4.30	22.60	15.90
Nasiriyah	14.40	11.80	15.60	14.60	3.70	6.40	24.00	22.10

Table 4: Annual average temperatures in Celsius and annual total rainfall for the period (2000-2021)

years	Diwaniyah Station		Samawah Station		Nasiriyah station	
	Average annual temperature	Annual rainfall (mm)	Average annual temperature	Annual rainfall (mm)	Average annual temperature	Annual rainfall (mm)
2000	24.8	223.4	24.8	47.2	26.1	108.0
2001	25.4	93.4	25.1	76.2	26.5	62.9
2002	24.9	186.1	25.8	82.6	26.0	151.0
2003	26.3	109.7	25.7	95.1	26.7	113.3
2004	24.3	56.6	25.9	93.3	26.9	98.6
2005	25.0	100.6	25.85	94.9	25.9	105.7
2006	24.8	106.9	25.2	165.9	26.2	245.8
2007	24.8	43.6	24.8	62.3	26.2	112.5
2008	25.3	44.2	25.3	57.0	26.4	65.5
2009	25.6	46.203	25.4	54.102	26.2	56.9
2010	26.7	49.1	26.6	47.001	28.1	57.6
2011	25.6	81.4	26.3	58.402	26.8	85.1
2012	25.7	98.8	25.8	105.2	25.2	116.2
2013	25.9	124.0	25.5	247.9	26.0	175.2
2014	25.7	105.4	25.9	111.2	26.5	219.7
2015	26.1	139.7	25.5	101.2	27.0	93.2
2016	25.9	68.3	26.2	55.701	26.8	58.3
2017	26.3	29.7	26.3	52.702	27.2	27.002
2018	26.5	189.8	26.6	195.8	27.6	226.5
2019	26.5	98.0	26.2	103.5	26.8	103.6
2020	26.3	170.7	26.5	128.0	27.4	162.2
2021	27.1	33.2	27.1	38	28.1	33.6
average	25.7	99.9	25.8	94.2	26.6	112.6
Maximum	27.1	223.4	27.1	247.9	28.1	245.8
Minimum	24.3	29.7	24.8	38	25.2	33.6

3-2- Calculating the climatic water balance for the rainy months at the three stations based on the data indicated in Tables (2, 3) as follows:-

3-2-1 Calculate Evapotranspiration values using the Thornthwait equation described in (Al-Tayef and Al-Hadithi, 1988)

$$PE = 1.6 \left(\frac{10T_c}{I} \right)^a$$

PE= Potential Evapotranspiration capacity in mm

T_c = Monthly average temperature in degrees Celsius

I = The annual temperature coefficient is calculated from the sum of the monthly temperature coefficients (i) which is calculated in turn from the following equation:-

$$i = \left(\frac{T_c}{5} \right)^{1.514}$$

a= A constant calculated from the following equation:-

$$a = 0.000000675I^3 - 0.000771I^2 + 0.0179I + 0.49239$$

From the Thornthwait equation, the potential Evapotranspiration (PE) values are calculated assuming that the number of days in a month is 30 days, and the number of sunshine hours is 12 hours day⁻¹, while the months of the year differ in the number of days as well as the number of sunshine hours. Therefore, the (PE) values are adjusted by multiplying them by a correction factor (CF) specific to each month that varies according to latitude. Table 5 shows the correction factor specific to each of the rainy months according to latitude, as mentioned in (Al-Najm and Khalid, 1980)

3-2-2- Calculating the difference between the monthly rainfall (P) and the adjusted potential Evapotranspiration (PEC) values (PEC-P) to estimate the Climatic Water Balance that includes the water surplus (WS) and the water deficit (WD) according to the following as described in (Omar et al., 2012):-

1- If the (P) value is greater than the (PEC) value, the result is considered a water surplus (WS).

2- If the (P) value is less than the (PEC) value, the result is considered a water deficit (WD).

3-3- Using Microsoft Excel 2010 to derive simple linear regression equations when studying the time series of annual average temperatures and total annual rainfall for the period (2000-2021) for the three stations and their expected values for the year 2030

3-4- Use the Arc Map 10.8 application to draw a map showing the locations of the stations (Diwaniyah, Samawah, and Nasiriyah) in southern Iraq.

4- Results and discussion

4-1- Climate water balance for the stations (Diwaniyah, Samawah and Nasiriyah) during the rainy months

The results of the climatic water balance for the stations (Diwaniyah, Samawah, and Nasiriyah) for the period (2000-2021), which were calculated using the Thornthwait equation shown in Table 5, indicate the following:-

4-1-1- The PEC values varied at the three stations during the rainy months. They reached their highest levels in May, reaching (217.61, 306.44, 307.53) mm at the stations (Diwaniyah, Samawah, Nasiriyah), respectively. Then, the PEC values decreased to their lowest levels in January, reaching (7.50, 6.37, 8.06) mm at the above-mentioned stations, respectively.

4-1-2- Al-Nasiriyah station recorded the highest total values (PEC) during the rainy months, reaching 735.41 mm, followed by Al-Samawah station with a total of 698.20 mm, then Al-Diwaniyah station with a total of 546.73 mm

4-1-3- The results of the climatic water balance for the stations (Diwaniyah, Samawah and Nasiriyah) during the rainy months after subtracting the monthly average rainfall (P) from the adjusted Evapotranspiration (PEC) values calculated according to the Thornthwait equation showed the following:-

4-1-3-1-The water surplus (WS) was concentrated in the three stations during the months of December and January as follows:-

Table (5) Climate water balance for the stations (Diwaniyah, Samawah, Nasiriyah) for the period (2000-2021) by applying the Thornthwait equation

The station		Jan	Feb	Mar	Apr	May	Oct	Nov	Dec	the total	
Diwaniyah	(TC)	12.4	15.3	20	25.45	31.4	28.15	18.85	13.9		
	(PE) (mm)	8.52	17.05	41.27	91.42	182.86	127.51	33.95	12.42		
	CF	0.89	0.86	1.03	1.08	1.19	0.98	0.88	0.87		
	(PEC) (mm)	7.50	14.66	42.51	98.73	217.61	124.96	29.87	10.81	546.73	
	(P) mm	20.8	12.1	8.2	14.6	3.4	5.1	23	14.8	102	
	(WS) mm	13.22	-	-	-	-	-	-	3.99	17.21	
	(WD) mm	-	2.56	34.31	84.13	214.21	119.86	6.87	-	461.94	
	(I)	150.08									
	(a)	3.3									
Samawah	(TC)	12.05	14.95	20.15	25.55	31.9	27.75	19.35	14.1		
	(PE) (mm)	7.08	15.73	47.45	114.23	259.70	155.07	40.85	12.66		
	CF	0.90	0.87	1.03	1.08	1.18	0.98	0.89	0.88		
	(PEC) (mm)	6.37	13.68	48.77	123.37	306.44	151.96	36.35	11.14	698.20	
	(P) mm	13.60	11.60	14.10	10.40	5.00	4.30	22.60	15.90	97.50	
	(WS) mm	7.23	-	-	-	-	-	-	4.76	11.98	
	(WD) mm	-	2.08	34.78	112.97	301.44	147.66	19.35	-	612.69	
	(I)	150.2									
	(a)	3.7									
Nasiriyah	(TC)	12.8	15.6	20.9	26.35	32.65	29.10	19.9	14.45		
	(PE) (mm)	8.95	18.25	52.31	120.46	260.62	172.20	43.84	13.85		
	CF	0.90	0.87	1.03	1.08	1.18	0.98	0.89	0.88		
	(PEC) (mm)	8.06	15.88	53.88	130.10	307.53	168.76	39.02	12.19	735.41	
	(P) mm	14.4	11.8	15.6	14.6	3.7	6.4	24	22.1	112.6	
	(WS) mm	6.34	-	-	-	-	-	-	9.91	16.25	
	(WD) mm	-	4.08	38.28	115.50	303.83	162.36	15.02	-	639.06	
	(I)	150.4									
	(a)	3.6									

4-1-3-1-1-Diwaniyah Station

(WS) values during December and January reached (3.99, 13.22) mm, respectively, for a total of 17.21 mm, representing 16.87% of the total rainfall of 102 mm.

4-1-3-1-2- Samawah Station

(WS) values during December and January reached 4.76 and 7.23 mm, respectively, for a total of 11.98 mm, representing 12.28% of the total rainfall of 97.50 mm.

4-1-3-1-3- Nasiriyah Station

WS values during December and January reached (9.91, 6.34) mm, respectively, for a total of 16.25 mm, representing 14.43% of the total rainfall of 112.6 mm.

4-1-3-2-The water deficit (WD) values during the rainy months in the three stations begin to gradually rise starting from the month of February, where the (WD) values during this month reached (2.56, 2.08, 4.08) mm in the stations (Diwaniyah, Samawah and Nasiriyah) respectively, then the (WD) values reach their highest levels in the month of May, where they reached (214.21, 301.44, 303.83) mm in the stations mentioned above, respectively

4-1-3-3-Al-Nasiriyah station recorded the highest total water deficit (WD) values, reaching 639.06 mm, followed by Al-Samawah station with a total of 612.69 mm, while Al-Diwaniyah station recorded the lowest total water deficit values, reaching 461.94 mm.

4-2- The general trend of temperatures and rainfall in the Diwaniyah, Samawah and Nasiriyah stations for the period (2000-2021) and their expected values in the year 2030

Based on the data in Table 5 and the linear regression equations that were derived from the study of the time series of annual average temperatures and the annual total rainfall for the three stations for the period (2000-2021), the general trend of temperatures and rainfall and their expected values in the year 2030 were identified as follows:-

4-2-1-The general trend of temperatures for the period (2000-2021) and their expected values in the year 2030

4-2-1-1-Al-Diwaniyah Station

Table(4) shows that the average annual temperature for the 22-year period (2000-2021) was 25.7°C. The highest annual temperature average was in 2021, reaching 27.1°C, and the lowest annual temperature average was in 2004, reaching 24.3°C.

A simple regression equation ($Y=0.086X+24.71$) was derived when studying the time series of annual temperature averages shown in Figure(2) for the period (2000-2021). The equation shows that the annual temperature average increases by $0.086^{\circ}\text{C}\cdot\text{year}^{-1}$. Therefore, the annual temperature average will reach 27.37°C in 2030, a percentage increase of 6.12%

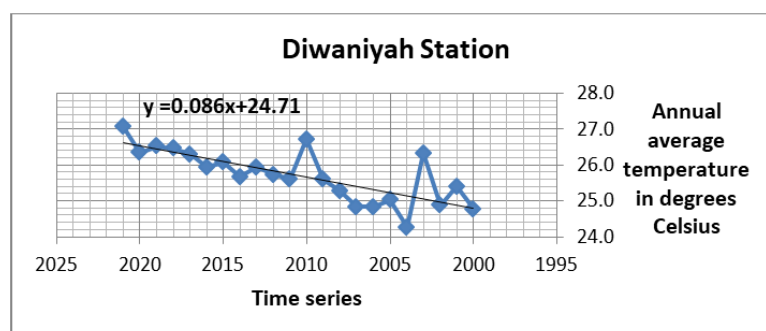


Figure 2: Time series of annual average temperatures for the period (2000-2021) for the Diwaniyah station

4-2-1-2- Samawah Station

Table (4) shows that the average annual temperature for the 22-year period (2000-2021) was 25.8°C. The highest annual average temperature was in 2021, reaching 27.1°C. The lowest annual average temperature was in 2007, reaching 24.8°C.

A simple linear regression equation ($Y=0.080X+24.89$) was derived when studying the time series of annual averages for the period (2000-2021), as shown in Figure(3). The equation shows that the annual average temperature increases by $0.080^{\circ}\text{C}\cdot\text{year}^{-1}$. Therefore, the annual average temperature will reach 27.4°C in 2030, a percentage increase of 5.8%.

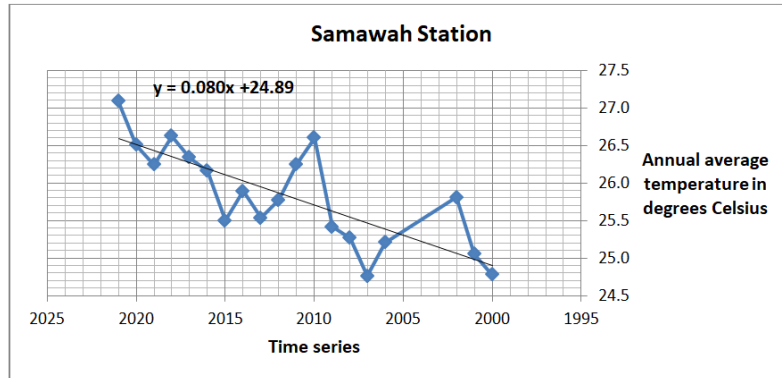


Figure 3: Time series of annual average temperatures for the period (2000-2021) for the Samawah station

4-2-1-3-Nasiriyah Station

Table (4) shows that the annual average temperature for the 22-year period (2000-2021) was 26.6°C. The highest annual average temperature was in 2010 and 2021, reaching 28.1°C., and the lowest annual average temperature was in 2012, reaching 25.2°C.

A simple linear regression equation ($Y=0.062X+25.93$) was derived when studying the time series of annual average temperatures for the period (2000-2021), as shown in Figure(4). The equation shows that the annual average temperature increases by 0.062°C.year⁻¹. Therefore, the annual average temperature will reach 27.91°C in 2030, a percentage increase of 4.9%

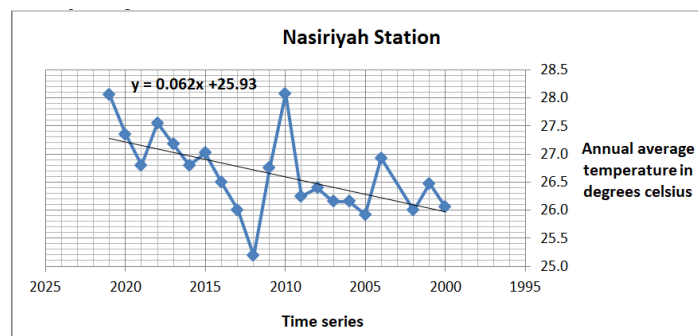


Figure 4: Time series of annual average temperatures for the period (2000-2021) for the Nasiriyah station

4-2-2- The general trend of rainfall for the period (2000-2021) and its expected values in the year 2030

4-2-2-1- Al-Diwaniyah Station

Table(4) shows that the average annual rainfall for the 22-year period (2000-2021) was 99.9 mm. The highest annual rainfall was in 2000, reaching 223.4 mm, and the lowest annual rainfall was in 2017, reaching 29.7 mm.

A simple linear regression equation ($Y=-1.247+114.3$) was derived when studying the time series of annual rainfall values for the period (2000-2021), shown in Figure(5). The equation shows that the annual rainfall decreases by 1.247 mm. year⁻¹. Therefore, the annual rainfall will reach 75.643 mm in 2030, meaning that the annual rainfall will decrease by 24.28%.

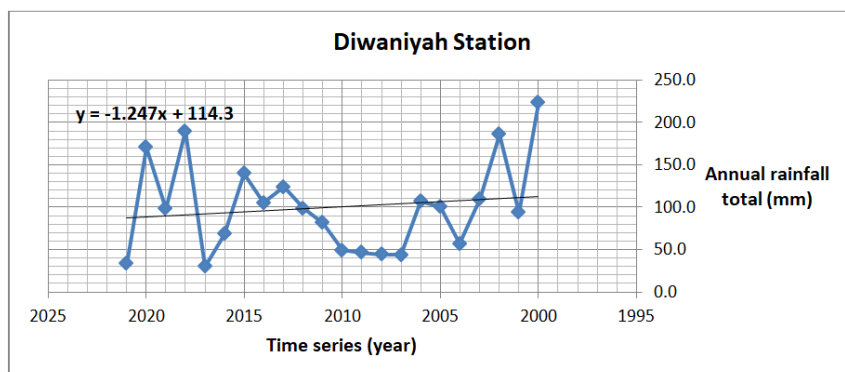


Figure 5: Time series of annual rainfall totals for the period (2000-2021) for the Diwaniyah station

4-2-2-2- Samawah Station

Table(4) shows that the average annual rainfall for the 22-year period (2000-2021) was 94.2 mm. The highest annual rainfall was in 2013, reaching 247.9 mm, and the lowest annual rainfall was in 2021, reaching 38 mm. A simple linear regression equation ($Y=1.865+75.55$) was derived when studying the time series of annual rainfall values for the period (2000-2021), shown in Figure 6. The equation shows that the annual rainfall increases by 1.865 mm. year⁻¹. Therefore, the annual rainfall will reach 133.36 mm in 2030, meaning that the annual rainfall will increase by 29.36%.

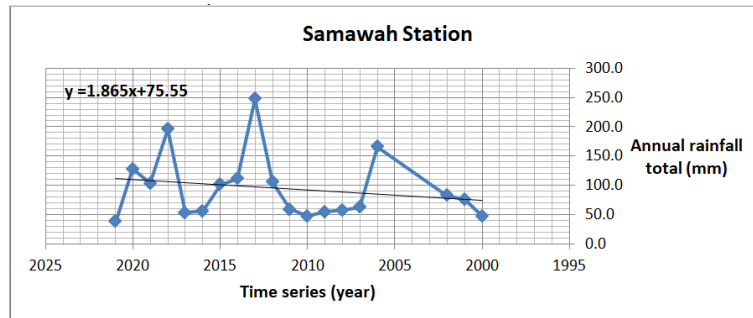


Figure 6: Time series of annual rainfall totals for the period (2000-2021) for Samawah Station

4-2-2-3-AI-Nasiriyah Station

Table (4) shows that the average annual rainfall for the 22-year period (2000-2021) was 112.6 mm. The highest annual rainfall was in 2006, reaching 245.8 mm, and the lowest annual rainfall was in 2021, reaching 33.6 mm. A simple linear regression equation ($Y=-0.082+113.5$) was derived when studying the time series of annual rainfall values for the period (2000-2021), shown in Figure 7. The equation shows that the annual rainfall decreases by 0.082 mm. year⁻¹. Therefore, the annual rainfall will reach 110.95 mm in 2030, meaning that the annual rainfall will decrease by 1.45%.

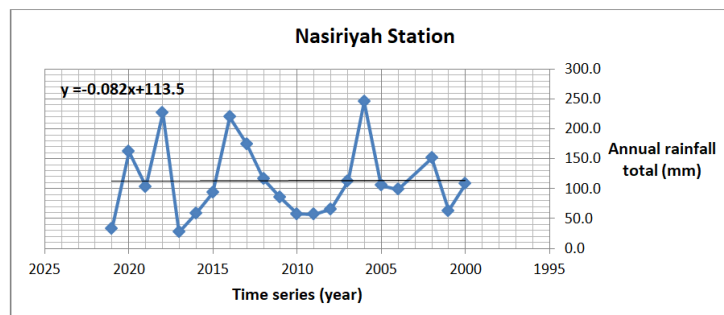


Figure 7: Time series of annual rainfall totals for the period (2000-2021) for Nasiriyah Station

Based on the above, the general trend of temperatures and rainfall and their expected values in the year 2030 at the stations (Diwaniyah, Samawah and Nasiriyah) can be summarized in Table 6 shown below:-

Table 6: General trend of temperatures and rainfall and their expected values in the year 2030 for the stations (Diwaniyah, Samawah and Nasiriyah)

General trend	Annual average temperature (°C)			Annual total rainfall (mm)		
	The station			The station		
	Diwaniyah	Samawah	Nasiriyah	Diwaniyah	Samawah	Nasiriyah
Type of change	increase	increase	increase	decrease	increase	decrease
Amount of change. year ⁻¹	0.086	0.080	0.062	1.247	1.865	0.082
General average	25.7	25.8	26.6	99.9	94.2	112.6
Expected value in 2030	27.37	27.4	27.91	75.643	133.36	110.95
percentage change	6.12%	5.8%	4.9%	24.28%	29.36%	1.45%

5- Conclusions and Recommendations

5-1- Conclusions

1- Evapotranspiration values vary during the rainy months at the study stations, reaching their lowest levels in January due to the low temperatures and increased rainfall during this month. They then gradually increase to their highest levels in May due to the gradual rise in temperatures.

2- Nasiriyah station recorded the highest total Evapotranspiration values during the rainy months, reaching 735.41 mm, followed by Samawah station with a total of 698.20 mm, and then Diwaniyah station with a total of 546.63 mm.

3-The water surplus of the three stations was concentrated during the months of December and January. The Diwaniyah station recorded the highest total water surplus during the two months above, reaching 17.21 mm, followed by the Nasiriyah station with a total of 16.25 mm, then the Samawah station with a total of 11.98 mm.

4- The results of the climatic water balance indicate that the water surplus constitutes a very small percentage of the total rainfall, reaching (16.87%, 12.28%, 14.43%) in the Diwaniyah, Samawah and Nasiriyah stations, respectively.

5- The water deficit begins to gradually increase during the rainy months starting from the month of February, as the water deficit values during this month reached (2.56, 2.08, 4.08) mm in the stations of Diwaniyah, Samawah and Nasiriyah, respectively. It then reached its highest value during the month of May, as the water deficit values during this month reached (214.21, 301.44, 303.83) mm in the stations mentioned above, respectively.

6- Al-Nasiriyah station recorded the highest total water deficit values during the rainy months, reaching 639.06 mm, followed by Al-Samawah station with a total of 612.69 mm, and then Al-Diwaniyah station with a total of 461.94 mm.

7- Based on the simple linear regression equations that were derived when studying the time series of annual average temperatures and total annual rainfall at the three stations for the period (2000-2021), the general trend of temperatures and rainfall and their expected values for the year 2030 were determined as follows:-

A- General temperature trend

The annual average temperature is increasing by (0.086, 0.081, 0.062) °C. year⁻¹ at the Diwaniyah, Samawah, and Nasiriyah stations, respectively. Accordingly, the expected annual average temperature values for the year 2030 will be (27.37, 27.40, 27.91) °C at the above-mentioned stations, respectively.

B- General trend of rainfall

The annual rainfall total is decreasing by (1.247, 0.082) mm.year⁻¹ at the Diwaniyah and Nasiriyah stations, respectively. Accordingly, the expected annual rainfall totals in 2030 will be (75.643, 110.950) mm at the above stations, respectively. As for the Samawah station, the annual rainfall total is increasing by 1.865 mm.year⁻¹. Accordingly, the annual rainfall total will be 133.36 mm in 2030

5-2- Recommendations

The results show that the study area, represented by the stations (Diwaniyah, Samawah, and Nasiriyah), located in southern Iraq and shown in Figure 1, suffers from a water deficit during most of the rainy months. Furthermore, it is located within an irrigated area, characterized by agriculture relying on total irrigation to provide moisture to the soil's root zone. Rainfall alone is incapable of providing moisture during all stages of crop growth. This problem can be solved or its impact reduced through the following measures:-

1- Sprinkler irrigation methods are used when growing strategic crops grown at high densities and over large areas, such as wheat, barley, and corn, as well as forage crops such as clover and alfalfa. Drip irrigation is used when growing vegetable crops, as these methods are characterized by the following:-

A-High efficiency in reducing water losses, represented by surface runoff and deep percolation below the root zone, to the lowest possible level.

B- Adequacy, which means keeping water within the root zone available for absorption by plant roots, in quantities that do not exceed the field capacity of the soil.

C- Uniformity, which means providing water to all parts of the field in a homogeneous manner and at equal depths within the root zone of the soil.

2- Storing rainwater during the period of water surplus (December and January), which is in the form of surface runoff, in underground reservoirs for use in cases where surface water is insufficient for irrigation needs.

6 – References

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