

## اثر التغيرات المناخية على الهجرة السكانية في قضاء الرطبة

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## *Climate Change Impact on Population Migration in Rutba District*

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## المستخلص

تهدف الدراسة إلى بيان أثر التغير المناخي في حركات السكان التي قد تحدث في المناطق القاحلة وشبه القاحلة عموماً، وفي المنطقة الغربية من العراق وقضاء الرطبة على وجه الخصوص. ولتحقيق ذلك، اعتمد الباحثون منهجية علمية لتحديد طبيعة تأثير التغير المناخي على الهجرة، بما في ذلك الاستعانة ببرنامج (Minitab Statistical Software) لرسم اتجاهات التغيرات المرصودة - بما في ذلك مقدار التغير استناداً إلى معادلة خط الاتجاه - وتوضيح كل معدل مضرراً في العدد. على مدى سنوات، ومعرفة اتجاه التغير في كل من درجات الحرارة ومعادلات هطول الأمطار على مدار (36) عاماً بالنسبة لمحطة الرطبة. وفيما يتعلق ببيانات منطقة الدراسة، فقد بلغ عدد السكان (20,848) نسمة في عام (1997)، بينما وصل إلى (65,000) نسمة في عام (2023). وتمكن الباحثون من الحصول على بيانات الهجرة السكانية من الدوائر التابعة لمنطقة الدراسة، حيث هاجر (6,020) شخصاً لأسباب مختلفة. وخلصت الدراسة إلى أن مقدار التغير في الحد الأدنى لدرجة الحرارة في محطة الرطبة بلغ (1.14) درجة مئوية، في حين سُجِّل أعلى مقدار للتغير الشهري في شهر سبتمبر بمقدار (2.95) درجة مئوية، ويشير خط الاتجاه العام إلى وجود زيادة. وبالمثل، بلغ مقدار التغير في الحد الأقصى لدرجة الحرارة (1.63) درجة مئوية، وسُجِّل أعلى مقدار للتغير الشهري في شهر أغسطس ليصل إلى (3.57) درجة مئوية، مع اتجاه التغير نحو الزيادة. أما بالنسبة لشهر أبريل، فقد كان مقدار التغير سالباً مشيراً إلى انخفاض، حيث بلغ (-1.15) درجة مئوية. وفيما يخص كمية الأمطار خلال فترة الدراسة، فقد أظهرت المؤشرات اتجاهها نحو الانخفاض بمقدار (-19.26) ملم. وبالنسبة للتغيرات الشهرية، سجلت أشهر الشتاء والخريف مقداراً سالباً للتغير، إذ بلغ (-15.73) في شهر أبريل كقيمة إيجابية، ويشير الاتجاه يشير مؤشر خط الاتجاه إلى ارتفاع، إذ بلغت قيمة التغير (4.68) درجة مئوية. وقد نزح نحو (1020) شخصاً بسبب الوضع الأمني، بينما نزح (5000) شخص بسبب التغير المناخي.

الكلمات المفتاحية: تغير المناخ ، الهجرة السكانية ، الرطبة ، غرب العراق .

## Abstract

*The study aims to demonstrate the impact that climate change can have on population movements that may occur in arid and semi-arid areas in general in the western region of Iraq and Rutba district in particular. To achieve this, the researchers adopted a scientific methodology to determine the nature of the impact of climate change on migration, including relying on the (Minitab Statistical Software) program. In drawing the trends of changes observed by the researchers, including the amount of change based on the trend line equation, and showing each rate multiplied by the number of years, and knowing the direction of change for both temperatures and rainfall during (36) years for the Rutba station. As for the data of the study area, the population in (1997) was (20,848) people, while in (2023) it reached (65,000) people. The researchers were able to obtain population migration data from the departments affiliated with the study area, as (6,020) people migrated for various reasons. The study concluded that the amount of change in the minimum temperature of Rutba station reached (1.14) C, while the highest amount of monthly change was recorded in September with a change of (2.95) C, and the trend line indicates an increase. Likewise, the amount of change in the maximum temperature reached (1.63) C, while the highest amount of monthly change was recorded in August, reaching (3.57) C, and the change indicator is toward an increase. As for April, the amount of change was negative toward a decrease, reaching (-1.15) C. While the amount of change in rainfall for the study period was an indicator toward a decrease, reaching (-19.26) mm. As for the monthly changes, the winter and autumn months recorded a negative amount of change, reaching (-15.73) in December, and the trend line indicator is toward a decrease. While in April, the highest amount of change was recorded as positive, and the trend line indicator is toward an increase, as the amount of change in them reached (4.68) C. About (1020) people migrated due to the security situation, while (5000) people migrated due to climate change.*

**Keywords:** Climate change, population migration, Rutba, western Iraq.

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

## 1. Introduction

Climate change and global warming are among the greatest challenges of our time, affecting the hydrological cycle on a global and regional scale (Sasanpour, 2022). Their impacts contribute to multiple problems, including increased desertification, scarcity of water resources, a decline in agricultural production, disruption of food security, and increased migration. In 1990, the Intergovernmental Panel on Climate Change (IPCC) noted that the single greatest impact of climate change could be human migration—with millions of people displaced by coastal erosion, coastal flooding, and agricultural disruption. Since then, numerous analysts have attempted to estimate future flows of climate-induced migrants (sometimes called climate refugees)—the most widely repeated prediction being that of 200 million by 2050. While the scientific case for climate change is becoming increasingly convincing, the consequences of climate change on human population distribution are unclear and unpredictable. With the presence of many other influential social, economic and environmental factors, establishing a linear causal relationship between climate change resulting from human activity and migration has been difficult until now (Kadhim et al., 2022). Therefore, it is necessary to create urban cities with architectural planning that keeps pace with climate change through their engineering designs that operate on clean energy and the use of building materials that insulate against temperatures and the creation of tanks that collect rainwater and use it for domestic use or to irrigate gardens when needed, especially the retention of valley water to harvest it during times of water scarcity and to feed groundwater from it. Therefore, researchers have become interested in the subject of climate change and its impact on migration.

## 2. Methodology:

The study has proposed that the trend in maximum and minimum temperatures is a positive indicator of increase, while rainfall is a negative trend toward decrease. The population varies toward increase in light of climate change because migration is internal between the districts and the district center. Furthermore, the relationship between climate change and population migration was clear, and more than 4,500 people migrated from the Al-Walid district, which has a population of 6,000 people, due to climate change.

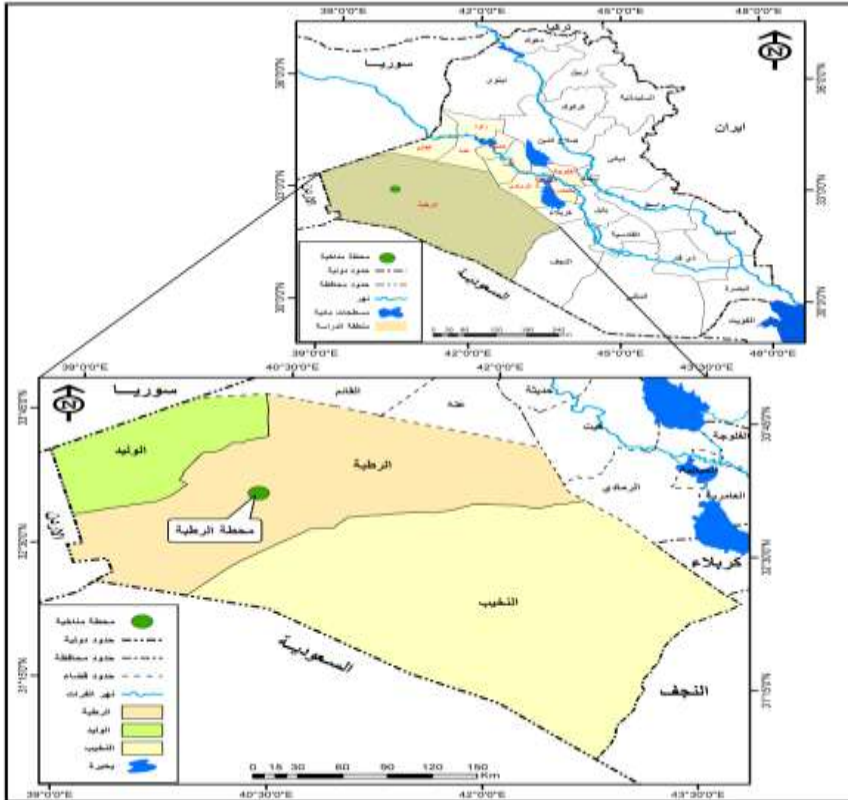
The study aims to uncover climate change and its impact on the population through population migration resulting from rising temperatures, water scarcity, and deteriorating vegetation cover. This research aims to contribute to the development of urban planning for the construction of climate-responsive housing units, modern agriculture, and the construction of rainwater storage dams for harvesting during times of scarcity.

The topic was chosen because the district is located in the far west of Iraq, among semi-arid regions with degraded land and scarce water resources. It is also far from the Euphrates River and is more than 600 meters above sea level. Therefore, climate is of great importance in determining the type of regions and population distribution. Climate change has a significant impact on the population and how it adapts to these changes.

Rutba District is located in the far west of Iraq within Anbar Governorate. It is bordered to the east and southeast by the governorates of Najaf and Karbala, to the northeast by the districts of Hit and Ana, to the north by the district of Al-Qaim, and to the east by the district of Ramadi (the center of Anbar Governorate). It also enjoys distinct international borders with the Kingdom of Saudi Arabia to the south, the Syrian Arab

Republic to the north, and the Hashemite Kingdom of Jordan to the west, as shown in Map No. (1). As for the astronomical location of Rutba District, it lies between latitudes ( $32^{\circ}45'$ ) and ( $33^{\circ}57'$ ) north, and longitudes ( $38^{\circ}85'$ ) and ( $42^{\circ}38'$ ) north.

Map No. (1) Geographical location of Rutba District in Iraq and Anbar Governorate



Source: Republic of Iraq, Ministry of Water Resources, Directorate of General Survey, Administrative Map of Iraq and Anbar, 2010, scale 1:1,000,000.

Source: Republic of Iraq, Ministry of Water Resources, Directorate of General Survey, Administrative Map of Anbar, 2010, scale 1:500,000.

The study is on attempt to answer the following questions:

- 1- What is the nature of the trend in temperature and rainfall changes at the study station?
- 2- Did the population vary during the study period within the study area?
- 3- What was the relationship between climate change and population migration in the study area?

### **3. Monthly and Annual Climate Changes Analysis of Rutba District**

Climate impacts associated with decreased rainfall and increased air temperature, particularly in desert environments, have serious implications for water resources, the biosphere, and economic activities. Climate change varies across the globe. The relationship between climate change and population migration is particularly reciprocal as result of the decrease in economic activities, cultivated crops and vegetation cover quantitatively and qualitatively (Mohammed, 2023). The study area is Rutba District, one of the districts located in the far western region of Iraq. Its climate is located in semi-arid lands. Its climate is characterized by hot, dry summers and moderate, cold winters, with rainfall varying from year to year. It is subject to global and regional climate changes. Therefore, the most prominent climatic elements that affect population migration were analyzed: minimum and maximum temperatures and rainfall.

### 3.1: Climate change analysis of the minimum temperature element:

The minimum temperature is the lowest temperature recorded at night after the Earth's surface loses its heat when solar radiation is inclined. At that point, the Earth's temperature begins to drop, especially after midnight. The air factor has a significant impact, as it gradually cools the Earth. Sometimes, it lowers temperatures due to the humidity it carries, and sometimes, it absorbs the Earth's radiation during the night until the Earth loses its heat to its lowest temperature due to the cooling factor. During the night, especially before sunrise, the lowest temperature recorded in the study area is (Al-Dulaimi, 2024). It is clear from the data in Table (1) and Figure (1) that the change in minimum temperatures varies from one month to another. The amount of change during the study period was recorded as (1.41°C) towards the positive rise. As for the monthly changes, the months in which the most change occurred were (September, February, August, March) by an amount of more than (2°C), which reached a degree of change of (2.95, 2.91, 2.70, 2.32)°C towards the rise during the study period, while the months that recorded a change of less than (1°C) were April (0.96°C) towards the rise. As for the increase in minimum temperatures, according to Figure (1), the year 1992 recorded an average minimum temperature of (10.5°C) as the lowest degree recorded during the study period due to the occurrence of a global volcano (Mount Pinatubo In the Philippines in 1991, and its influence continued into 1992), which affected the world's climate, including the climate of Iraq, which led to a decrease in temperatures. While we find that the year 2010 recorded the highest rates in minimum temperatures, reaching (14.3°C), due to the rise in global temperatures, which

affected the climate of Iraq, including the study area (Al-Dulaimi, 2020).

Table (1): Monthly changes in the minimum temperature element (°C) for the Rutba station for the period (1988-2023)

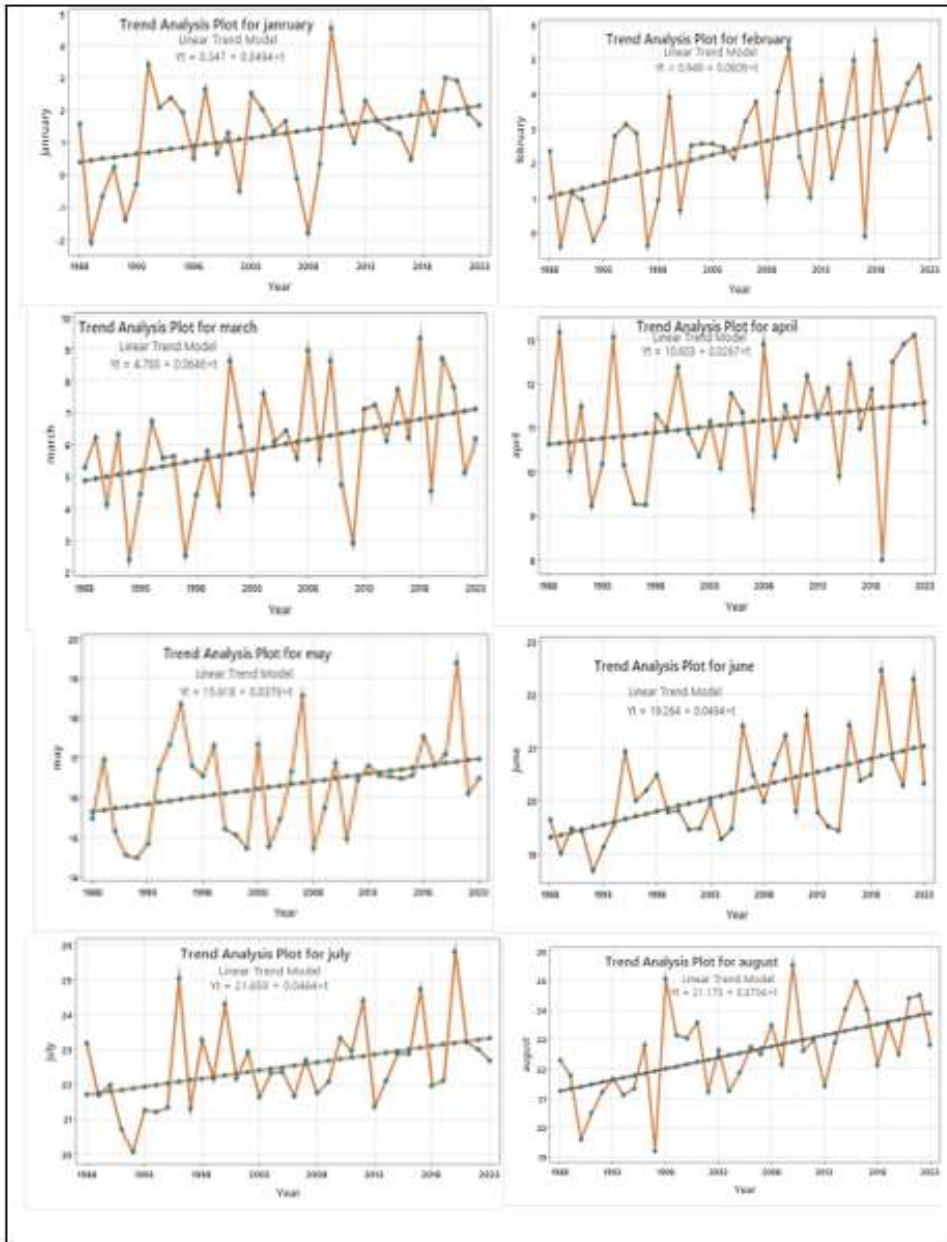
January	February	March	April	May	June	July	August	September	October	November	December	Change Value
1.77	2.91	2.32	0.96	1.36	1.77	1.67	2.72	2.95	1.04	1.02	1.5	1.41

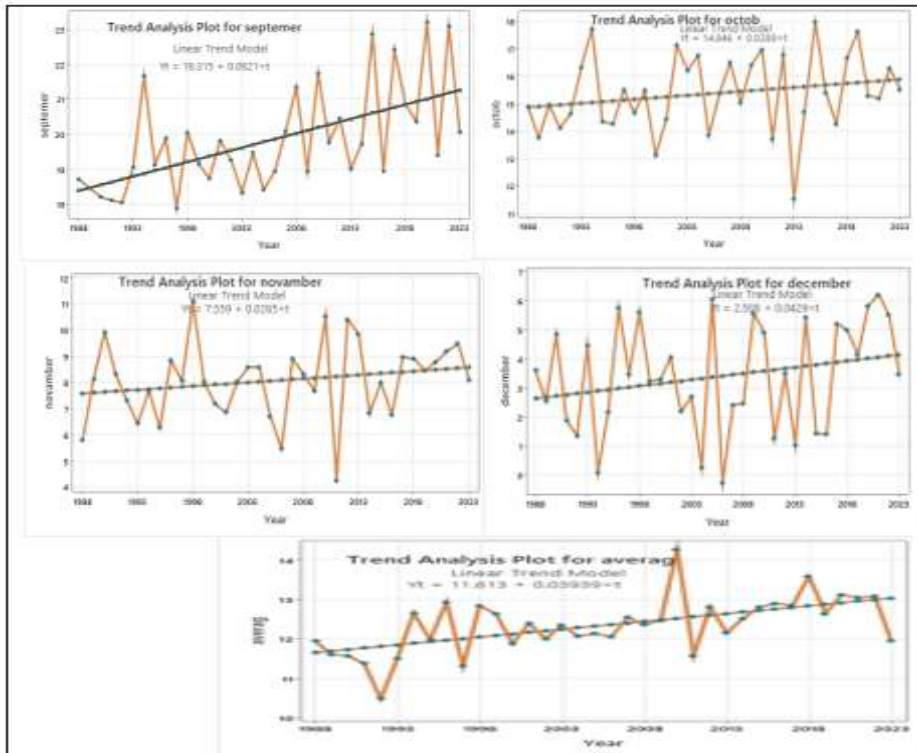
Source: The Table is conducted by the researchers based on data from the General Authority for Transport and Meteorology in Baghdad for a station using the program ((Minitab Statistical Software) Trend line equation Figure (1))

### 3.2 - Analysis of the amount of change in annual and monthly averages of maximum temperatures:

The maximum temperature is the highest temperature recorded during the day, as the net radiation becomes positive between sunrise and noon (Al-Fahdawi, 2016). Two o'clock in the afternoon is the ideal time to record maximum temperatures, as a balance occurs at this time between heat gain and heat loss. The highest average is recorded in the summer months, especially when temperatures peak in July due to increased heating of the earth by solar radiation.

Figure (1) Chart of monthly changes in the minimum temperature component for the Rutba station for the period (1988-2023)





Source: Researchers' work based on data from the Ministry of Transport and Communications, the Iraqi Meteorological Authority, Climate Department, unpublished data, 2024.

The low humidity, along with clear skies and increased heat extremes during this month, and the recurrence of heat waves (Mohammed, 2020), are evident. The data in Table (1) and Figure (2) show that the average change amounted to  $1.63^{\circ}\text{C}$ , while the highest monthly change at the Rutba station was recorded in August, February, and July, reaching  $3.57$ ,  $3.14$ , and  $3.13^{\circ}\text{C}$ , respectively, with the change index rising. Meanwhile, April recorded a negative change toward a decline, reaching  $-1.15^{\circ}\text{C}$ . The average temperature at the station recorded its highest rate in 2010, reaching  $29^{\circ}\text{C}$ , while the lowest average maximum temperature recorded during the study period was  $24.3^{\circ}\text{C}$ . The

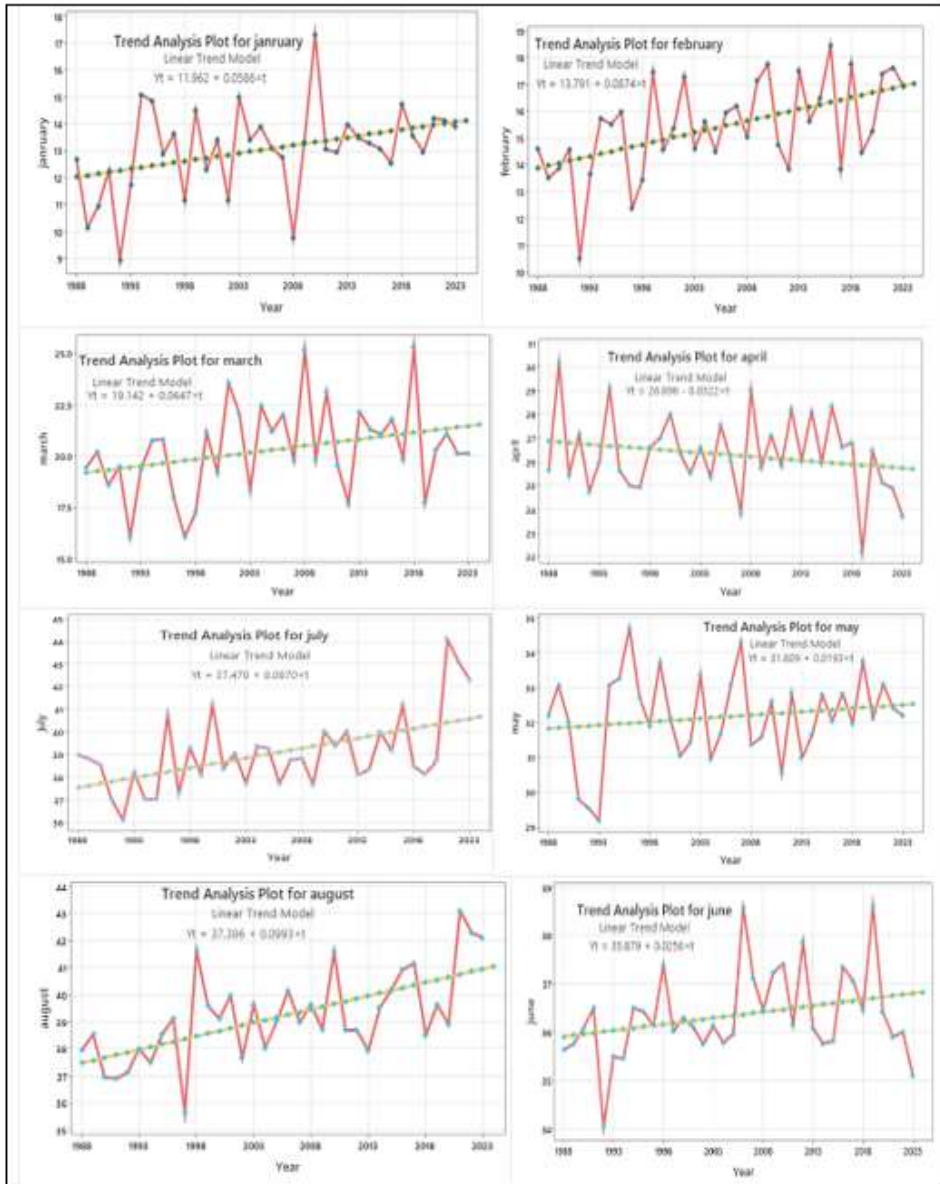
positive change in maximum temperatures has negative impacts on the lives of residents in the Rutba district, especially in the city and countryside, as it increases the use of electricity and increases the population's need for multi-purpose water, especially since the study area is located far from water sources such as the Euphrates River. Water scarcity in light of climate change plays a major role in the migration of residents and their relocation from one place to another, especially since the residents of the study area depend on rainwater, which is the main source of water for valleys and wells such as the Hajlan and Al-Abyad valleys, and others, which rely on it to irrigate agricultural lands.

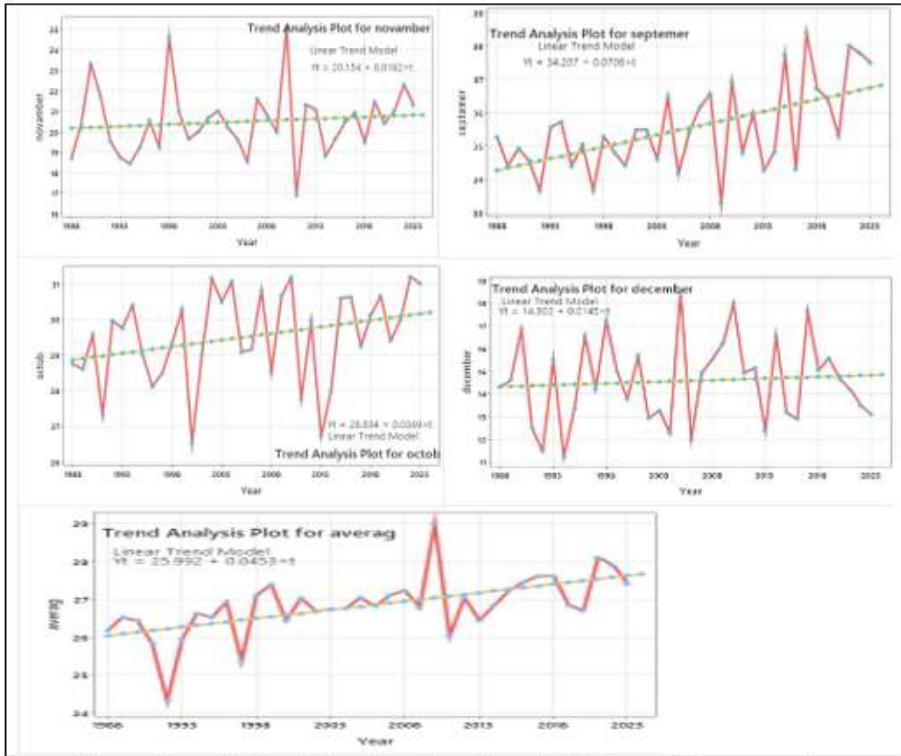
Table (2): Monthly changes in the maximum temperature element ( $^{\circ}\text{C}$ ) for the Rutba station for the period (1988-2023)

January	February	March	April	May	June	July	August	September	October	November	December	Change
2.1	3.14	2.32	1.15	0.69	0.92	3.13	3.57	2.54	1.32	0.65	0.52	1.62

Source: From the work of researchers based on data from the General Authority for Transport and Meteorology in Baghdad for a station using the program ((Minitab Statistical Software) Trend line equation Figure No. (2)

Figure (2) shows the monthly variations in the maximum temperature at the Rutba station for the period (1988-2023)





Source: Researchers' work based on data from the Ministry of Transport and Communications, the Iraqi Meteorological Authority, Climate Department, unpublished data, 2024.

### 3.3. Analysis of the annual and monthly rainfall totals changes:

Rainfall is one of the most important climate elements. It also plays a significant and fundamental role in shaping the Earth's surface and the various topographic features on it by activating water erosion processes. Rain falls when water vapor condenses as a result of the temperature of the air carrying this vapor in the upper layers of the atmosphere falling below the dew point. This causes most of the condensation to occur in the form of small water droplets that aggregate to form large drops. Rain falling on the Earth's surface occurs in the form of ice crystals, which

quickly melt as they fall through the warm layers of the troposphere, reaching the ground in liquid form. The rainy season in Iraq and the study area begins in the fall and continues through the winter and spring seasons. The largest proportion of rainfall during the rainy season falls during the winter (Hammadi & Al-Azzawi, n.d.). Rain is one of the most important forms of...

Precipitation is one of the most important climatic elements and occurs as a result of the condensation of water vapor in the atmosphere. Rainfall is of great importance in the study area, as it is the primary source of increased water supplies to the district, in addition to being primarily responsible for natural pastures and rain-fed agriculture in the study area. Increased rainfall contributes to population stability, particularly by encouraging population migration from other districts due to the abundance of grazing land for livestock, the success of rain-fed agriculture, and the abundance of truffles, which attracts a population increase in the study area. In the event of drought waves and a decline in rainfall, this contributes to an increase in population migration from the study area to other areas in search of providing the necessities of life and obtaining better job opportunities. It may be clear from Table (3) and Figure (3) that the amount of rainfall for the study period is an indicator of a negative trend towards a decrease, as it reached (-19.26 mm). As for the monthly changes in which the amount of change was recorded, it was negative and the trend line indicator towards a decrease in (December, January, November, February and October, September, June) as the amount of change reached (-15.73, -9.9, -3.20, -2.32, -2.15, -0.87, -0.75), respectively. This change has significant negative effects because the success of rain-fed agriculture, the abundance of natural pastures and the increase in water imports in the valleys

depend on the rainwater falling during those months, and the decline in its quantities contributed to an increase in drought, the expansion of desertification and the deterioration of the vegetation cover, resulting in population migration from the areas of the study area to the city center.

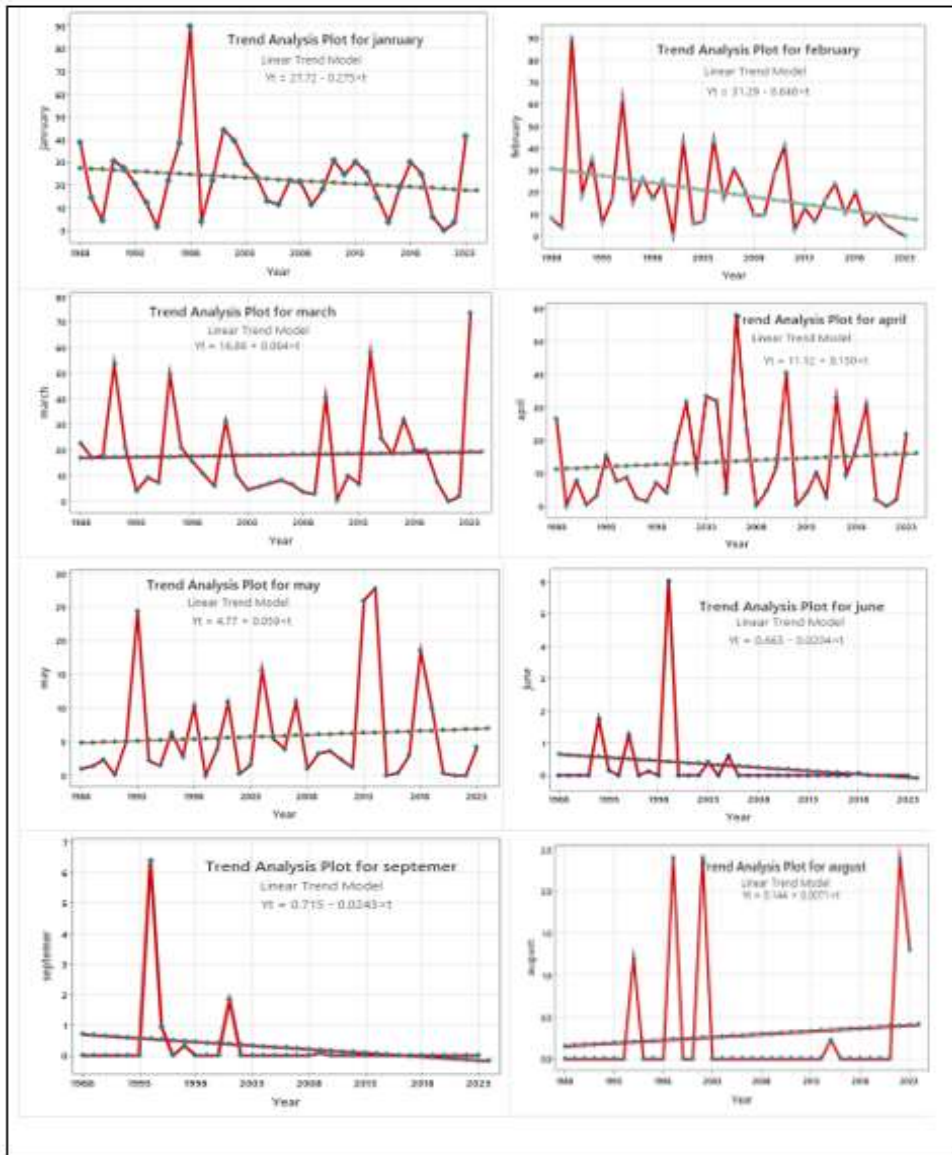
While the months that recorded a positive change and a rising trend line indicator are (April, March, May, September, June, August), the change amount in them reached (4.68, 2.30, 2.12, 0.87, 0.75, 0.25) mm, respectively, but this indicator contributes to a weak increase in water imports due to the speed of water flow and its exposure to evaporation processes and its failure to reach the large reservoirs in the main valleys in the district due to the rise in temperatures. As for annual rainfall rates, the highest rainfall rates were recorded in 2001 and 2014, reaching 185.53 and 185.01 mm, respectively, due to the increased frequency of low-pressure systems that year. The lowest rainfall rates were recorded in 2021, with 13 mm. That year was considered one of the driest years, causing numerous problems in the study area, including the deterioration of vegetation cover, increased desertification, the failure of rain-fed agriculture, the deaths of a large number of livestock (sheep and goats) due to famine, migration from the study area to other regions, and increased rates of dust and epidemics.

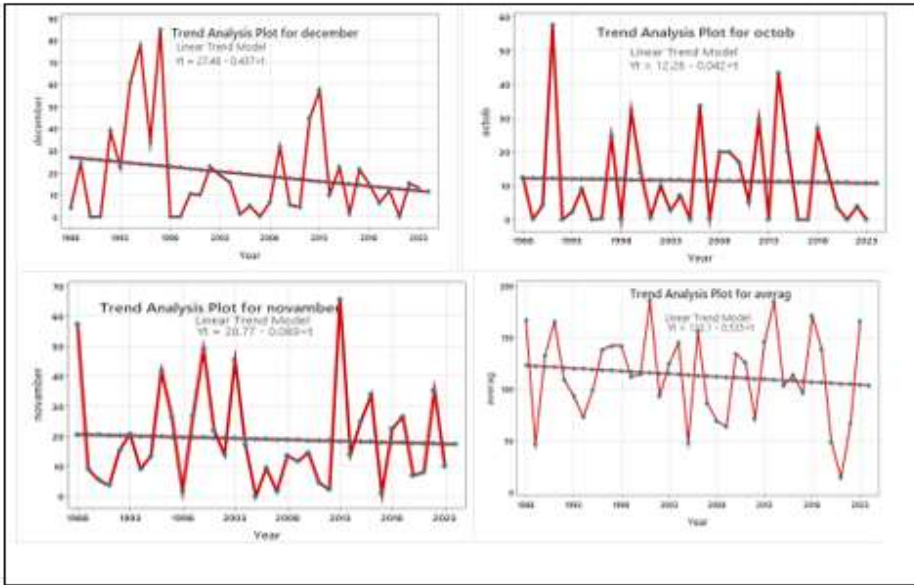
Table (3) Monthly changes in rainfall (mm) for the Rutba station for the period (1988-2023)

January	February	March	April	May	June	July	August	September	October	November	December	Change
-9.9	-2.32	2.3	4.68	2.12	-0.75	0	0.25	-0.78	-1.51	-3.20	-15.73	-19.26

Source: Researchers' work based on data from the General Authority for Transportation and Meteorology in Baghdad, using the Minitab Statistical Software. Trend line equation, Figure (3)

Figure (3) Linear trend of monthly and annual rainfall rates for the Rutba station for the period (1988-2023)





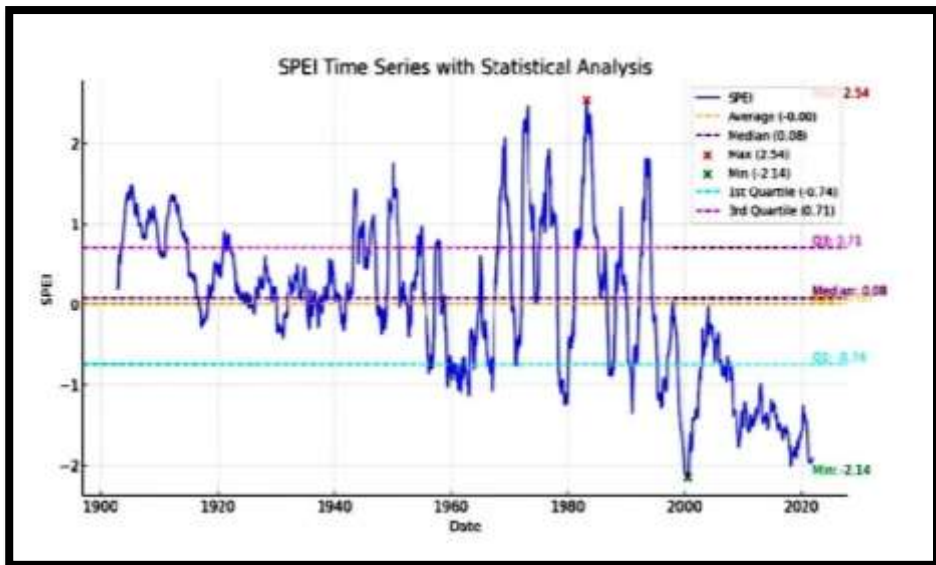
Source: Researchers' work based on data from the Ministry of Transport and Communications, the Iraqi Meteorological Authority, Climate Department, unpublished data, 2024.

#### Standard Rainfall Index for Al-Rutba Station

As for drought indicators in Anbar Governorate, including the study area, it is located in western of Iraq at 33.43 degrees north latitude and 43.33 degrees east longitude. This is a critical region facing significant challenges due to climate change, including rising temperatures, changing rainfall patterns, and increased drought. These changes can have dire consequences for the availability of water resources and exacerbate drought conditions, posing a significant threat to both the environment and the livelihoods of local communities. The original data are presented in the monthly SPEI records for the years (1903-2021). The data were divided into exposures from 1903 to 1997, and the test section displays records from 1998 to 2021. Some statistical characteristics are presented in Figure (4), where the maximum

SPEI value (2.54) was recorded in 1980, while the lowest SPEI value (-2.14) was in 2000. This year, a significant decline in the SPEI value was observed due to climate change and desertification in the study area (Afan, 2024). The figure shows that the SPEI value is lower than the period (2000-2021), and that the standard rainfall index has a significant impact on drought levels in Anbar Governorate and the study area. This is a true indicator of climate change and its impact on the management of surface and groundwater resources, particularly its impact on drought levels, which has led to population migration in some areas of Rutba District.

Figure (4) Standard Rainfall Index (drought) in Anbar Governorate for the period (1903-2021)



Source: Haitham Abdulmohsin Afan, p. 5

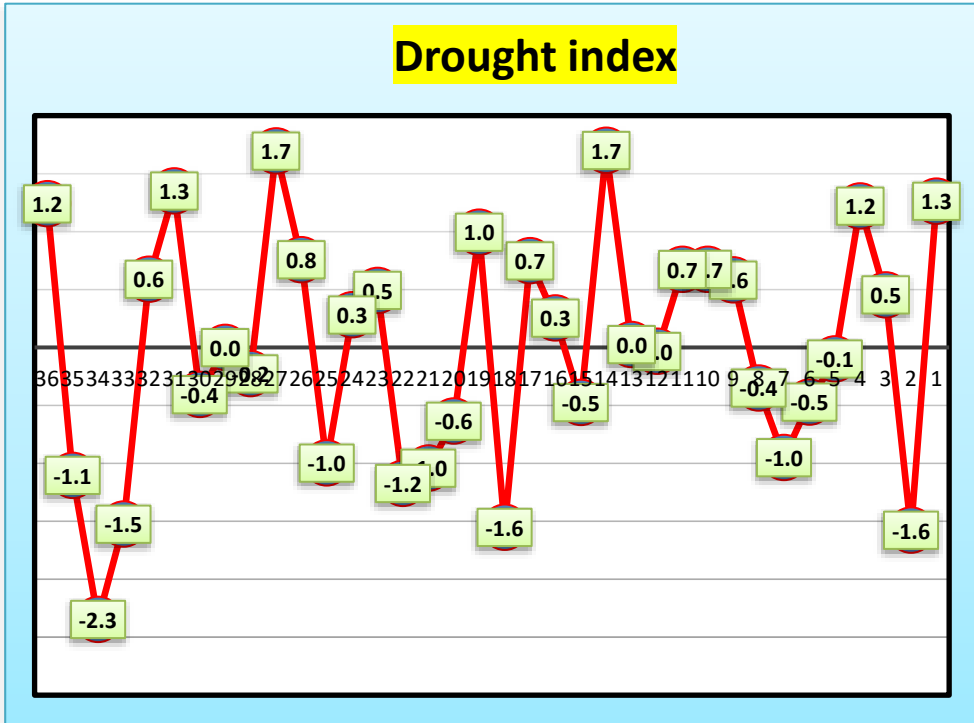
Table (4) Frequency of wet and dry seasons during the rainy season (according to the Standard Rainfall Index SPI for the period (1988-2023))

Climate station,	number of seasons	Recurrence of wet and dry seasons during the rainy season (according to the Standard Rainfall Index SPI for the period (1988–2023))							
		Extremely humid	Very humid	Partly humid	Moderately humid	Partly dry	Moderately dry	Very dry	Extremely dry
Rutba	36	–	2	4	14	8	5	3	1

The source is the researcher's work based on the application of the Standard Rainfall Index (SPI) equation (annual average - annual average / standard deviation).

Rainfall seasons vary in their timing and the amount of annual and monthly rainfall, which has a major role in the stability of the population in the study area. Drought indicators in the study area vary. Data in Figure (3) of annual rainfall rates show that the drought indicator, as shown in Table (4) and Figure (5), shows that very humid two seasons, medium humidity (4) seasons, and moderate humidity (14) seasons. While the drought index recorded (16) seasons, where the very severe drought recorded one season, while the severe drought recorded (3) seasons, while the average drought recorded (5) seasons, and the moderate drought recorded (8) seasons. The highest amount of record rainfall was in the (2001 and 2014) season with an amount of (1.7) with a very humid index. As for the 2022 season, it recorded an amount of (-2.3) with a very severe drought, which greatly affected the decline in the groundwater level in the study area, which suffers from weak rainfall in terms of its effectiveness and quantities, and also in terms of its regularity. Therefore, these problems in rainfall increase the severity of climatic drought, which is reflected in water security, and then the reduction of cultivated areas and grazing lands, and then the spread of drought problems, the manifestation of desertification, the increase in expenditure costs, the decrease in profits, and the increase in losses spent in agriculture and raising livestock beyond the

capacity of the population in the study area, which greatly reflected the reasons for population migration in the study area. Figure (5) Standard rainfall drought index at Al-Rutba station for the period (1988-2023)



The source is the researcher's work based on the data in Table (4).

## 5. Water Scarcity and Population Migration

### 5.1. Water Scarcity

The study area suffers from fluctuating and low rainfall, which is the primary source of groundwater recharge. Increased drought, rising temperatures, and poor water resource management have led to drinking water shortages, declining agricultural production, and the spread of diseases due to water pollution. Increased reliance on groundwater, coupled with its deteriorating

quality and declining water levels, has resulted in the degradation of agricultural lands. This has led to increased desertification, higher soil salinity, decreased soil fertility, and sand encroachment.

Studying groundwater levels in the study area is crucial for determining its presence and depth, clarifying how aquifers are recharged, and identifying the economic costs of optimizing investment in various groundwater-related economic activities. Water levels must be considered as an accurate measure that provides sufficient data on the storage capacity of aquifers and their fluctuations over time. Furthermore, they are used to estimate the volume of groundwater reserves and investigate the natural and human factors affecting them. The static water level represents the water level before the extraction process, while the dynamic water level represents the water level after the extraction process. The depth of the groundwater moving below the surface and the percentage of water drop between them are also considered (Al-Fahdawi, 2020:96-7). These can be represented as follows:

#### 1- Moving Groundwater Levels in Al-Walid District

The wells in this district in 2018 were characterized by high levels of moving groundwater levels throughout the area. The lowest recorded level was (49) meters below the surface, such as in Akashat and Sawab, while the highest level was (395) meters in well (65) located west of the district. Due to its distance from surface recharge sources, the overall average depth was (236) meters. The reason for the increase and fluctuation of groundwater levels in this area is due to its high surface area and the scarcity of surface recharge sources, represented by the network of valleys, and its reliance mainly on water flowing from the regional aquifers of neighboring countries, where the amount

of rainfall was (170.40 mm) and the dryness index had an average moisture value of (1.3). While the moving and fixed water level changed in 2022 to (425) m moving level, while the fixed level was (380) m and the water drop was (45) m after the withdrawal operations due to the difference in water supply sources as a result of the weak effectiveness of rainfall, which amounted to (48.50, 13.67, 66.38) mm for the (2020-2022) season, during which the standard rainfall index was recorded between severe drought, very severe drought and average drought for three consecutive seasons, which reflected on the scarcity of water in the Al-Walid district and made some of it unsuitable for human, agricultural and animal use due to its poor quality, which led people to migrate to the center in search of better job opportunities.

## 2- Fluctuating and Fixed Groundwater Levels in the District Center:

The fluctuating groundwater level varies from one location to another within the city of Rutba. Recorded ranges include a minimum of (5) meters below ground level in well (55), due to the well's proximity to the course of Wadi Hauran. The highest value is (409) meters in well (28), located south of the district center. This is attributed to its distance from the influence of the wadis, which are concentrated in the central and eastern parts of the region. The average water depth reached (125) meters after pumping operations. While in the same wells in 2022 the water level in well (55) was (40) meters, the moving level was (65) meters, and the water drop was (25) meters, while in well (28) the water level was (307) meters, the moving level was (455) meters, and the water drop was (148) meters, as a result of three dry seasons that affected the sources of feeding after water was withdrawn for different purposes, which lasted (3) years of

drought, which led to a decrease in the depth of the groundwater and a deterioration in its quality, which affected the lives of the population, whether it was used for drinking purposes or for irrigating agricultural crops, which reflected on the reality of population migration in the study area, which depended on that resource and made it the main sources for the continuation of its life. A study conducted with well owners revealed that during periods of low rainfall, when pumps are operated to raise water levels, the wells dry up after several hours, sometimes as long as 6-8 hours. This is due to a significant drop in the water level, as replenishment does not continue for a full day until the pumps are restarted to draw water. This scarcity has resulted in major problems, effectively impacting water quality, reducing its usability due to poor quality, and increasing the concentration of contaminants that diminish its value. This, in turn, has affected population migration to the district.

Table (5) Change in the level of stationary and mobile

groundwater in the wells of Al-Rubta District between the years (2018-2022)

No.	District	2018-2019			2021-2022		
		Fixed water	Moving water	Water landing	Fixed water	Moving water	Water landing
1	Rutba	103	148	45	120	178	58
2	Rutba	295	340	45	304	360	56
16	Rutba	353	363	10	366	390	24
26	Rutba	288	289	1	300	335	35
27	Rutba	291	299	8	315	369	54
28	Rutba	284	409	125	307	455	148
31	Rutba	293	304	11	310	345	35
35	Rutba	70	126	56	93	167	74
38	Rutba	172	172	0	192	210	18
37	Rutba	170	187	17	194	230	36
42	Rutba	204	206	2	221	247	26
43	Rutba	198	200	2	214	250	36
44	Rutba	109	113	4	229	268	39
45	Rutba	185	186	1	200	225	25
46	Rutba	249	251	2	255	280	25
55	Rutba	5	5	0	40	65	25
65	Al-Waleed	360	395	35	380	425	45
66	Al-Waleed	278	310	32	300	360	60
67	Al-Waleed	198	209	11	212	244	32
68	Al-Waleed	202	205	3	207	247	40
69	Al-Waleed	35	49	14	54	97	43
72	Al-Waleed	249	267	18	263	300	37
73	Al-Waleed	275	308	33	294	345	51
74	Al-Waleed	277	311	34	310	385	75

Sources: 1- Ministry of Water Resources, General Authority for Groundwater, Information Bank Division, Unpublished Data for 2024  
 2- Ministry of Water Resources, National Center for Water Resources Management, Groundwater Department, Unpublished Data for 2024

## 5.2. Population Migration

Population migration represents internally displaced persons (IDPs) who are forced to flee their homes due to armed conflict, generalized violence, human rights violations, natural or man-made disasters, but remain within their countries. In 2020, approximately 40.5 million people were displaced within their countries due to conflicts and disasters worldwide, and approximately 30.7 million were displaced due to violence and conflict. As of December 31, 2020, approximately (55) million people were internally displaced worldwide, the highest number ever recorded (Rahima, n.d.). The environment is a key factor in migration dynamics, both due to the direct impact of climate degradation or environmental disasters on human mobility and their impact on socioeconomic conditions. Although the actual impact of climate change on migration is difficult to isolate and quantify, most observers agree that it will impact people's lives and human rights, particularly those of women and girls, whether in terms of livelihoods, employment, housing, health services, or sanitation. Migration and displacement are often the last resort for people to cope with these changes (United Nations High Commissioner for Refugees, n.d.).

Migration can be precisely defined as a group of individuals making an actual decision to move from their homeland and place of residence, under the influence of either forced or voluntary motives, or head to another place to achieve the goal that prompted their migration.

As for migration in the study area, it is considered one of the most districts in Anbar Governorate facing a major challenge in confronting climate changes, which are among the most important reasons for migration due to its geographical location in the western desert region, far from the water sources of the

Euphrates River and its height above sea level of more than 600 meters, making it quickly affected by climate changes, during which temperatures rose and the amount of rainfall decreased, which reflected on the exacerbation of water problems and its scarcity and the decline of well water (groundwater) at a depth of (360) meters and the high costs of extracting it, especially its poor quality, which reflected on the lack of population stability and the occurrence of internal migrations in the district, as the number of population migration in the district reached (6020) people, according to the available data, and the number of migrants in Al-Waleed district reached 5 thousand migrants out of (6000) people who live there, while the migrants from the various administrative units of Al-Rutba district (1020) people migrated due to security policies and (5000) people migrated due to climate changes as a result of the study area being exposed to water scarcity in the valleys from surface water or through Groundwater, a decline in the amount of rainfall, and an increase in temperatures above their normal rates over (36) years by (3°C) in the summer months (Al-Dulaimi, 2025). Through this, we highlight the most important main reasons for the population migration to the study area as follows:

1- Migration due to the security situation: Security is the basis for stability for all residents in a given geographical area. This depends on the scale of societal coexistence. Providing security depends on the state's policy of deploying its military forces and extending its control over all ports and administrative units affiliated with it, in order to achieve sustainable development goals. In the study area, Table (4) shows that approximately (1,020) people were displaced, according to statistics from the study area's departments, due to the security conditions imposed by military security leaders on a specific group of residents,

fearing their association with terrorist organizations in the Rutba district. This particularly prevented them from moving from one place to another in search of natural pastures and rain-fed agriculture. This constituted an obstacle to their livelihoods, prompting them to migrate to the city center in search of job opportunities that would enable them to live better than their previous location.

2- Migration due to low rainfall: Rain is an important climatic element due to its impact on the environment, as it is linked to human life and various activities. This element, like other climatic elements, may be affected by global climate change. The amount of rainfall in the study area and its variation from one year to another, such as its location in relation to water bodies, is controlled by several factors. The region may be affected by the Mediterranean climate, which is more active in the processes of rainfall in the study area due to atmospheric depressions. It is clear from Table (3) that the trend line of rainfall in the study area is negatively declining, which affected the water resources management system in the study area. This resulted in a lack of diversity in natural plants, weak exploitation of agricultural lands, scarcity of water sources in valleys, and a decline in the groundwater level in artesian wells. Consequently, it was reflected in the population stability aspect, as the population migrated from one area to another within the administrative borders in the study area. It is clear from Figure (3) that the rainfall fluctuation between one month and another and its annual variation had a great impact on population migration, especially the dry years of (2021 and 2022). It is clear from Table (4) that the number of migrants due to the lack of rainfall amounted to (2250) people, representing (37.4%) of the total number of migrants.

### 3- Migration due to rising temperatures in recent years:

Temperature is a powerful environmental factor and a fundamental component of agriculture and plant growth. Therefore, studying temperatures is important because of their relationship to the formation of vegetation cover. Every living organism has an ideal temperature, and whether it rises or falls below it, it has a significant impact on its sustainability. The impact of rising temperatures on population migration is evident in Tables (2, 1, 3): changes in maximum and minimum temperatures are indicated by a positive trend line. Water scarcity, its decline, and low rainfall have made temperatures more effective in population migration because they increase water consumption, increase drought, and expand desertification. Table (4) shows that the number of migrants due to these temperatures reached (250) people, representing (4.2%) of the total number of migrants in the study area.

### 4- Water scarcity and scarcity are a major cause of population migration:

The Encyclopedia Britannica defines it as "drought." A short or long-term decrease in rainfall, leading to a decrease in the amount of water running in rivers, a drop in groundwater levels, and a decrease in soil moisture (Al-Naqshbandi & Al-Suwedi, n.d.). Drought, also known as the withholding of rain or the absence of rainfall even in small quantities, is common in all regions of the world. Environmental studies have shown that drought is not limited to a single year, but may extend over several years, at which point its impact is significant (Al-Khatib, 1996). The study area is exposed to hydrological drought, defined as a decline in surface water runoff rates and a drop in groundwater levels to their lowest levels. This is coupled with a decrease in rainfall, which consequently impacts surface and groundwater supplies,

and reduces the water in tributaries, reservoirs, and lake storage levels. As for groundwater, the drop in its levels occurs as a result of declining water recharge and increased investment to address the shortage of water resources resulting from drought (Al-Rikabi, 2003).

The study area is subject to rainfall fluctuations, which have affected the water level and scarcity of its sources, and have been reflected in surface water, especially the decline in groundwater levels in wells. From Table (4), it is clear that the number of migrants due to water scarcity reached (2,500) migrants, representing (41.5%). Drought in the study area has a significant impact on the population's water needs. Therefore, water is the basis for population stability. Since ancient times, the population was the first place to build their settlements on the banks of rivers. An example of this is the construction of the Mesopotamian civilization on the banks of the Tigris and Euphrates rivers, and the Egyptian civilization was built on the banks of the Nile River. The scarcity of water resources has major development dimensions and poses difficult challenges to confront its scarcity. The population of the study area relies on well water and valley dams, and the decline and scarcity of rainfall has increased environmental risks in the district, as it has contributed to the decline in the amount of water in the storage dams, which has led to the weakness of groundwater feeding operations and the decline of the groundwater level to (360) m, increasing the deterioration of its quality despite the entry of water desalination companies. However, the residents who migrated did not return to their areas because of the existence of a better life in the district center, and the well water is no longer sufficient for use in agriculture and other uses (Al-Kubaisi, 2025).

Table (4) Main reasons for population migration in the study area

NO	Migration Causes	Migrants Number	Ratio
1	Rising temperatures	250	4.2
2	Water scarcity	2500	41.5
3	Low rainfall	2250	37.4
4	Security reasons	1020	16.9
	Total	6020	100

Source: Researchers' work is based on data from the Rutba District Municipality Directorate and Al-Waleed Subdistrict.

### Conclusion:

The change in the minimum temperature at Rutba station was  $1.14^{\circ}\text{C}$ , while the monthly change recorded for the months of September, February, August, and March was  $2.95$ ,  $2.91$ ,  $2.70$ , and  $2.32^{\circ}\text{C}$ , with the trend line indicating an increase. The change in the maximum temperature was  $1.63^{\circ}\text{C}$ , while the highest monthly change at Rutba station was recorded in August, February, and July, reaching  $3.57$ ,  $3.14$ , and  $3.13^{\circ}\text{C}$ , respectively, with the trend line indicating an increase. Meanwhile, April recorded a negative change, with a decrease of  $1.15^{\circ}\text{C}$ . 4.2. The rainfall change during the study period indicated a decline, reaching  $-19.26$  mm. As for monthly changes, December recorded a negative change, with a downward trend, reaching  $-15.73$  mm. April recorded a positive change, with a rising trend, reaching  $4.68$  mm. Population migration in the study area due to rainfall amounted to  $37.4\%$  of the total number of migrants in the study area. Population migration due to rising temperatures in

recent years amounted to 4.2% of the total number of migrants in the study area. Population migration due to water scarcity in recent years amounted to 41.5% of the total number of migrants in the study area. The climate change drought index reached its highest SPEI value (2.54) or its maximum SPEI value (-2.14), and the last two decades represent a linear decline towards a negative trend for the SPEI.

The study has recommended installing advanced electronic weather stations to monitor weather conditions and record climate data, at least one station per district. It tries to establish dams and water reservoirs on valleys and collect rainwater to harvest it and replenish underground reservoirs, which constitute the best storage. These reservoirs can be utilized in various fields, including agriculture. It also proposes designing residential homes with engineering specifications that incorporate cooling and heating to keep pace with climate change, and create green oases and irrigate them with rainwater stored in residential homes. Moreover, it supports livestock with fodder, especially during dry seasons, and also rely on modern agricultural technology. Finally, it establishes solar oases to generate electricity and utilize clean energy.

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