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Historical Overview of Air Temperature of Kurdistan Region -Iraq from 1973 to 2017

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Abstract

Kurdistan air temperature records from 1973 to 2018. Kurdistan's climate is marked by daily and annual temperature and rainfall variations. Kurdistan's environmental and climatic conditions vary due to its latitude and altitude, ranging from Mandali at 150 m to Halgurd (Hasarost) at 3607 m. In Iraq, the Kurdistan Region is located between latitude 34-37 and longitude 41-46.

Remarkably, Sulaimani is the coldest and wettest province. In 1982, the annual average temperature was 12.45 °C. In 2017, Erbil, Kurdistan's capital, reached 25°C, with an annual mean of 19.05°C. Kurdistan's average temperature change was 2.09 °C. From ancient times to the present, the world average temperature was less than one (0.80 °C). The Washington Post reported in 2021 that Iraq's temperature had risen 4.1 degrees Fahrenheit (2.27 °C) since the turn of the century. However, the average global surface temperature rose by 0.75°C (1.3 °F). From October 31 to November 14, 2021, over 200 countries agreed to intensify efforts to keep global temperatures below 2 °C.

Introduction

H. Walter had published the historical and rare fantastic meteorological map of Iraq (Stuttgart Hohenheim, Germany), covered mean monthly seasonal rainfall and temperature from Penjwen, Halabja, Sulaimani, Ruwandiz, Rayat, Mosul, Rutba, Baghdad and other famous locations of Iraq at least for more than 20 years. The climatic data of Shalash (1966) and Guest and Al-Rawi (1966) represented reasonably available information on the climate of Iraq nearly from first world war 1918 up to the second world war 1942.

Resently, Hama *et al.* (2014) described the climatic conditions of the Iraq and Kurdistan region from 1918 to 2019. Like the other parts of the world, Iraq and Kurdistan is affected seriously by climate change (Fig. 1). Climate change contributed to an increase in 2.5 -2.0 °C. from 2018 to 2020. Climate conditions have changed and caused a shortage of everything from food production to electric generation, and fishing has decreased or depleted. In Kurdistan and other areas of the north part of Iraq, wheat and other cereal crops are declined to less than half of the previous year's, nearly by 70%.

The earth's surface warmed notably from 1910 to 1940 and clearly appeared after 2000, especially in 2017; after that, it was increased again in summer 1970. In the world, the warmer year was 1990, while the warmest was 1998 with an average temperature of 14.3 °C (57.8 °F) -15 °C (Duxbury and Duxbury, 1997; Nebel and Wright, 1998; Hill, 2004; Weart, 2003; Anup, 1995; USGCRP, 2009; Alcock and Hegarty 2006).

In Iraq and Kurdistan region during the last few decades, the climate change caused rare drought conditions, dry deposition (Aziz. 2017) and decreasing rainfall in 2016-2017, with irregular wet deposition from year to year and temperature, also rising with fluctuation (Wood and Wratt, 2007; Desonie, 2007; and Hama *et al.*, 2014).

In the dry condition in 2021 the maximum and the minimum air temperature was between 11 °C in January and 44 °C in August, indicating dry, hot and wormer years during the last ten decades (100 years ago). In July 2021, the air temperature of Erbil was very high, reached to 47 °C, in Duhok to 45 °C, in Sulaimani to 46 °C and in Khanaqin to 52 °C, while in Bagdad and Basrah, air temperature reached 55 °C. Historically, such hot and warm conditions in Iraq have never been found in the last 100 years. And the fallen own of rainfall has never occurred since last 100 years.

Climatic condition change in Iraq and Kurdistan received more attention after relaxing an increase in temperature and decreasing rainfall with fluctuation. The amount of precipitation in desert areas did not exceed 100mm. In the south part of Iraq, 150mm, around Baghdad, not much more than 300-400mm. In Kurdistan, especially in Erbil province, it varies from 250-600 to more than 1200mm. The mean annual and monthly rainfall and temperature of Duhok, Erbil and Sulaimani provinces, particularly temperature of Erbil province (Zohary, 1950; IMOB, 1954; Guest and Al-Rawi, 1966 and Hama *et al.*, 2014). This research aims to investigate the past and present air temperatures of the Kurdistan region of Iraq.

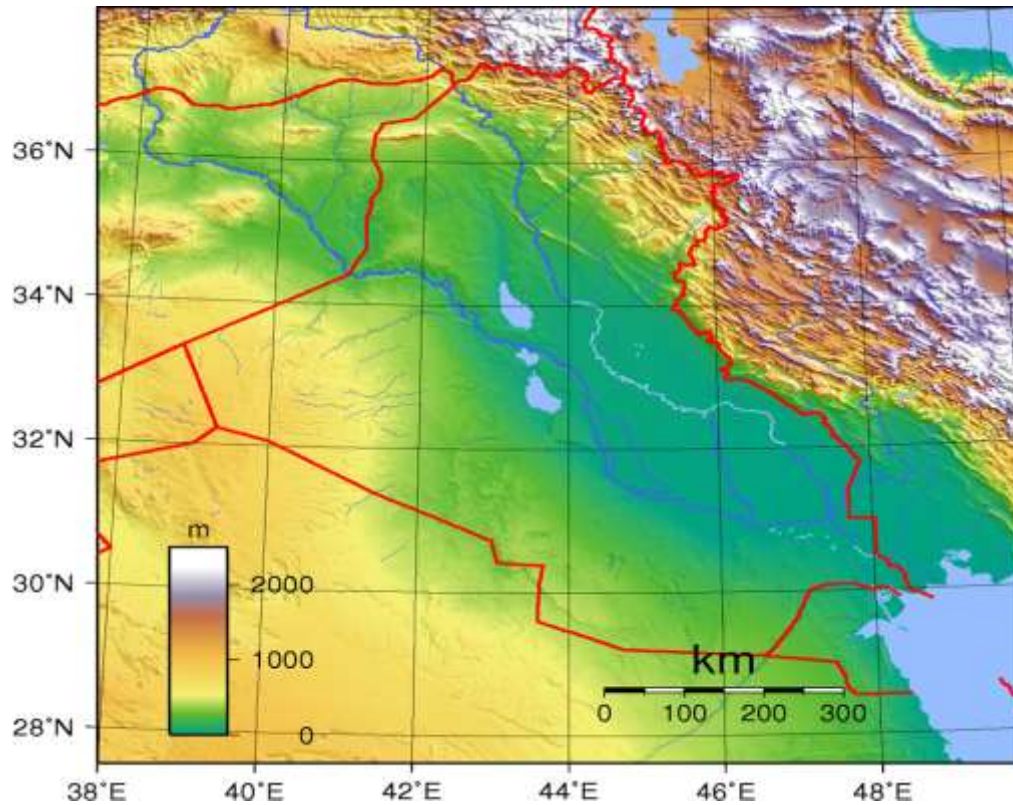


Figure (1): Map of Iraq and Kurdistan Region-Iraq showing climatic conditions

Data collection

The historical temperature data were obtained from meteorological stations and a series of bulletins from Iraq, the ministry of communication and British meteorological offices extracted and reviewed by Zohary 1955; Shalash (1966) and Guest and Al-Rawi (1966). The recent data from 2009-2017 has been obtained from the Ministry of Agriculture and Water Resources of the Iraqi Kurdistan regional government, the ministry of transport and communication and Erbil airport (Hama *et al.*, 2014). However, some more recent meteorological data from 2017 to 2021 was obtained from the ministry of transport and communication Erbil airport and the ministry of agriculture and water resources (KRG). Also, the meteorological information of Erbil was obtained in Erbil, Duhok and Sulaimani weather stations. The statistical analysis of variances, frequency distribution, mean, median, mode, standard deviation, range, and normal distribution of the data were determined by using the SPSS computer program (Hama *et al.*, 2014).

Results and discussion

The temperature data of Erbil, the capital of the Kurdistan region of Iraq, located in the middle part of Kurdistan, is represented in Fig.1. The annual average temperature during the past 50 years from 1973 to 2017 was ranged from 16.25 °C to 25.00 °C with the mean value of 19.05 °C, median 18.55 °C, mode 17.08 °C, SD 2.09 °C, and the range was 8.85 °C (Tables 1 and 2).

Regarding monthly temperature (Figs. 1-5), the higher temperature 32.75, 32.32°C was recorded during July and August in 1973-2011, while the lower one was 7.15°C occurred during January and February. Therefore, the warmest months are the summer season (Jun, July, August), while the cooler months were December, January and February, for the above duration (1973-2011).

The mean temperature for every five years and distribution of ten years' interval was represented in Figs. 2, 3, 4 and 5. The yearly average temperature during the 50 years from 1973 -to 2017 was ranged from 16.25 °C to 25.0 °C with a mean of 19.05 °C. The results suggested that temperature was irregular and variable, with a variation of 2.09 °C. The lower average degree, 17.14 °C, occurred during 1973 -1977, and the high average degree, 24.1 °C, was during 2013-2017. The results revealed that temperature and rainfall in an early historical review of the entered time of this study were more than a late one, which means the area's climate relatively little changed.

From Table (2), the frequency distribution of yearly temperature of Erbil indicated that more years of repetition was 16 with 18.33-19.66 °C, while four years' repetition was with 23.65-24.97 °C. The results indicated that the temperature of Erbil as a sample of Kurdistan was indicated gradually increasing from 1973 to 2017, especially after 2010 with a bit of fluctuation (Fig3). The more interesting point of the review was that the temperature variation from 1973 to 2017 in Erbil province is between 17-21, and the fundamental differences have not arrived at 1.0 °C.

One of the significant greenhouse signs and warming phenomena was heat Island Effect Temperature, which varied significantly worldwide depending on the altitudes and latitudes, time of the year, ocean activities, wind current, and other weather conditions. Pollutants such as CO₂, N₂O, NO₂, O₃, methane, particulates, chlorofluorocarbons, and halocarbons are limited due to a lack of attention to climate change. (MAWRE, 2014; MAWRE, 2017; MTCE, 2014; UNEP, 2009; USA, 1991).

In Kurdistan (Table 3 and 4), represented by Duhok, Erbil and Sulaimani provinces, the decreasing and fluctuations of temperature from 1973 to 2017 are noticeable. However, the increase in temperature was visible and fluctuated from 1973 to 2017. These agree with the general phenomenon of wide world global warming (Duxbury and Duxbury, 1997; Nebel and Wright, 1998; Hill, 2004; Weart, 2003; Anup, 1995; USGCRP, 2009; and Alcock and Hegarty 2006). As in this study, the previous work indicated that global warming has been occurred by an increase in average world temperature and caused an increase in the sea level. The results revealed that the hottest year was 2017, as the temperature reached 25 °C and a relatively more minor amount of rainfall 377.1 mm. It is better to realize that the local climate change differed from the average of the world climate change this was due to the narrower climatic factors (Duxbury and Duxbury, 1997; Nebel and Wright, 1998; Hill, 2004; Weart, 2003; Anup, 1995; USGCRP, 2009; and; Alcock and Hegarty 2006). These were the general and common climatic conditions of the Iraq and Iraqi Kurdistan region.

Al- Ansari *et al.* (2014) explained that in Iraq, the variation in the average temperature does not exceed between 21.08 °C and 23.4 °C from 1900-2009 (Fig.4). they reported that limited increase in annual temperature during the historical period 1900- 2009, but the increase will be more noticeable from 2020 to 2099. The figures of annual temperatures showed that increases were restricted between 1900 and 2009 but will be more evident between 2020 and 2099. As shown in Fig.4, the differences between 21.8 and 23.1 °C are 2.4 °C. (Al-Ansari et al., 2011). While according to our data, the actual and expected change was 2.09 °C. These are agreed with the comments and predictions of the same authors (Duxbury and Duxbury, 1997; Nebel and Wright, 1998; Weart, 2003; and Hill, 2004).

Table 1: Erbil province's annual mean temperature (°C) from 1973 to 2017.

| Year | Temperature (°C) | Year | Temperature (°C) |
|------|------------------|------|------------------|
| 1973 | 17.08 | 1997 | 17.72 |
| 1974 | 17.08 | 1998 | 19.67 |
| 1975 | 16.97 | 1999 | 19.95 |
| 1976 | 16.77 | 2000 | 18.84 |
| 1977 | 17.82 | 2001 | 19.06 |
| 1978 | 18.15 | 2002 | 18.39 |
| 1979 | 18.81 | 2003 | 18.51 |
| 1980 | 17.43 | 2004 | 18.33 |
| 1981 | 17.88 | 2005 | 19.59 |
| 1982 | 16.52 | 2006 | 19.08 |
| 1983 | 17.56 | 2007 | 19.32 |
| 1984 | 17.94 | 2008 | 19.81 |
| 1985 | 18.21 | 2009 | 18.29 |
| 1986 | 18.68 | 2010 | 20.62 |

| | | | |
|------|-------|------|-------|
| 1987 | 18.74 | 2011 | 18.55 |
| 1988 | 17.86 | 2012 | 21.00 |
| 1989 | 18.85 | 2013 | 23.16 |
| 1990 | 18.51 | 2014 | 22.25 |
| 1991 | 18.06 | 2015 | 22.40 |
| 1992 | 16.15 | 2016 | 22.00 |
| 1993 | 17.7 | 2017 | 21.00 |
| 1994 | 18.64 | | |
| 1995 | 18.95 | | |
| 1996 | 19.18 | | |

Table (2): Distribution with frequency percentage of Temperature (°C) for Erbil province from 1973-2017.

| | |
|--------------------|-------|
| Mean | 18.15 |
| Standard Error | 0.312 |
| Median | 18.55 |
| Mode | 17.08 |
| Standard Deviation | 02.09 |
| Sample Variance | 4.37 |
| Range | 8.850 |

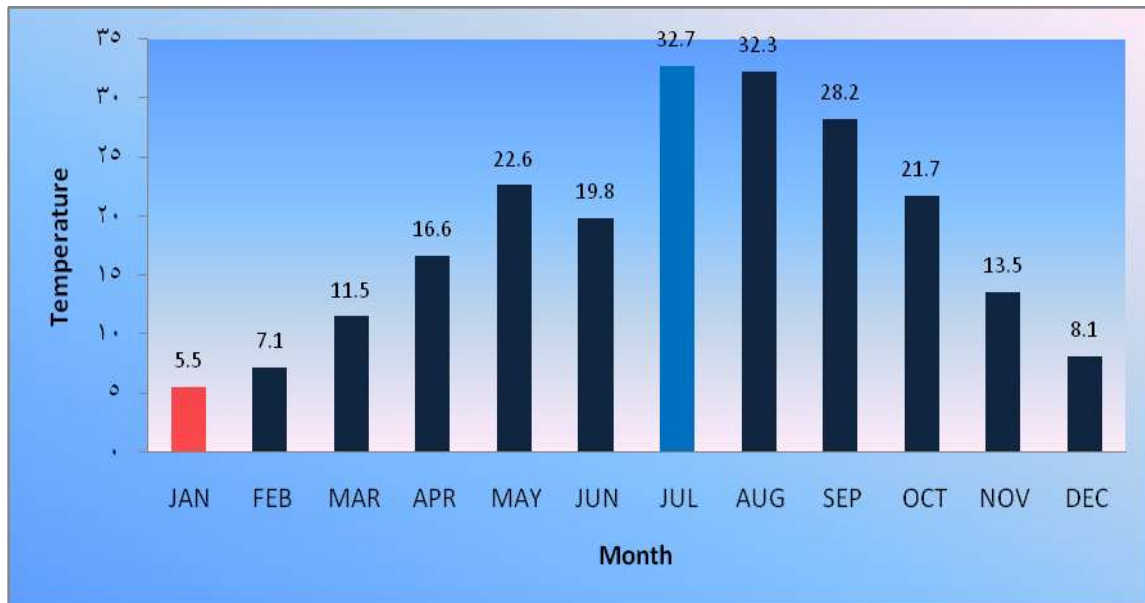


Figure (2): Mean monthly temperature (°C) for Erbil province from 1973-2011 (General director of meteorology and seismology).

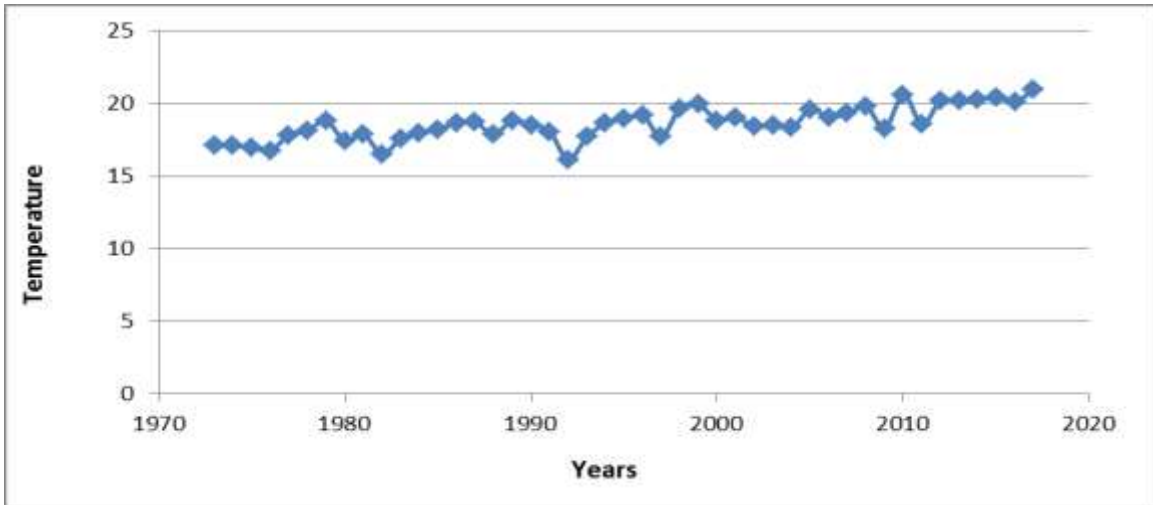


Figure (3): Yearly average recorded temperature (°C) of Erbil province from 1973-2017.

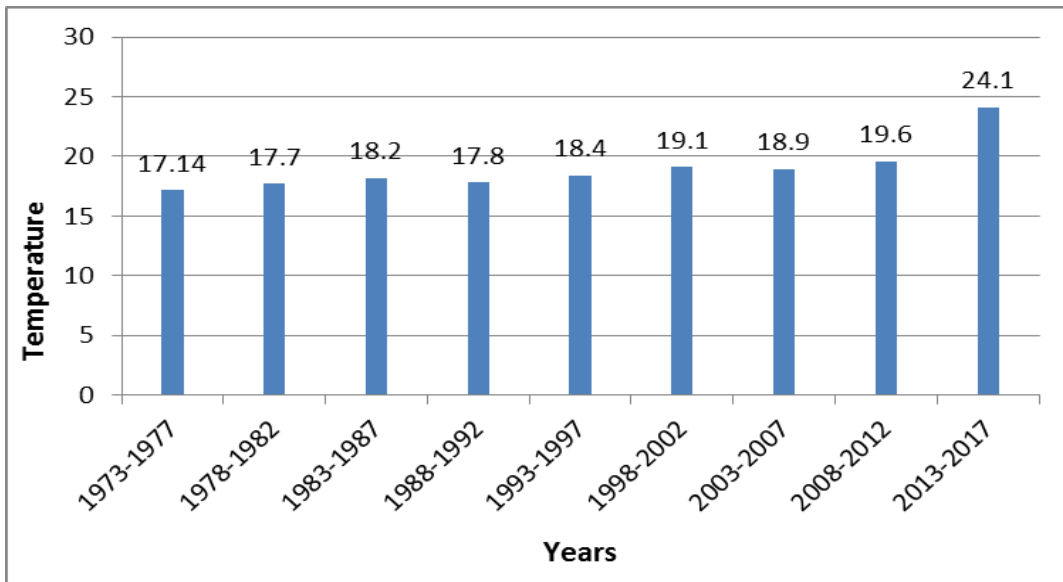


Figure (4): Mean of five-year intervals of annual recorded temperature (°C) of Erbil province from 1973-2017.

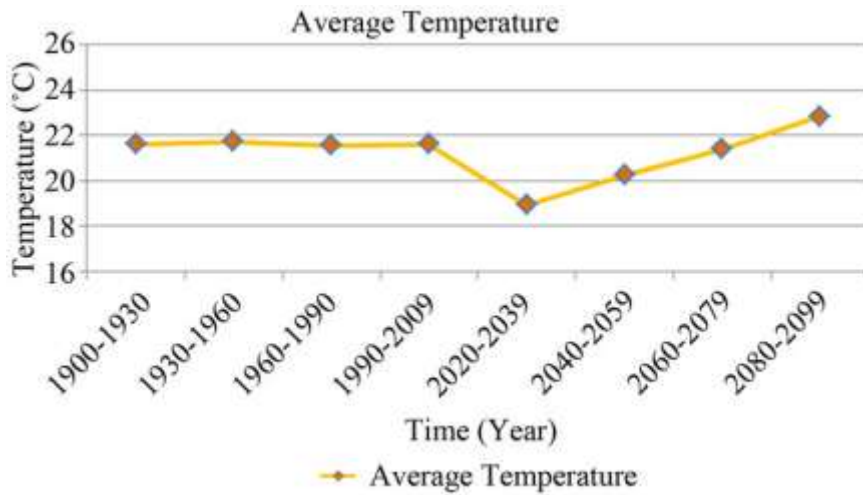


Figure (4): Average annual temperature over the historical and future study periods. (Al- Ansari *et al.*, 2014a)

Table (3). Estimated average temperature (°C) of Duhok, Erbil and Sulaimani provinces 1975-2017.

| | Duhok | Erbil | Sulaimani | | Duhok | Erbil | Sulaimani |
|------|-------|-------|-----------|------|-------|-------|-----------|
| Year | Temp. | Temp. | Temp | Year | Temp. | Temp. | Temp. |
| 1975 | 15.37 | 16.97 | 15.8 | 1997 | 14.63 | 17.72 | 14.22 |
| 1976 | 14.66 | 16.77 | 15.18 | 1998 | 17.04 | 17.67 | 15.52 |
| 1977 | 19.59 | 17.82 | 16.50 | 1999 | 16.10 | 17.95 | 17.47 |
| 1978 | 19.81 | 18.15 | 14.83 | 2000 | 15.32 | 16.84 | 15.35 |
| 1979 | 13.48 | 18.81 | 15.32 | 2001 | 16.11 | 17.06 | 17.33 |
| 1980 | 12.11 | 17.43 | 16.27 | 2002 | 15.11 | 16.39 | 15.72 |
| 1981 | 13.38 | 17.88 | 16.03 | 2003 | 13.36 | 17.51 | 16.32 |
| 1982 | 12.81 | 16.52 | 12.45 | 2004 | 16.94 | 17.33 | 16.52 |
| 1983 | 13.46 | 17.56 | 13.82 | 2005 | 18.39 | 18.59 | 15.51 |
| 1984 | 17.48 | 17.94 | 15.22 | 2006 | 12.42 | 17.08 | 17.12 |
| 1985 | 18.89 | 16.21 | 16.21 | 2007 | 15.09 | 17.32 | 15.51 |
| 1986 | 22.41 | 17.68 | 21.41 | 2008 | 15.93 | 16.81 | 16.53 |
| 1987 | 25.11 | 17.74 | 22.23 | 2009 | 11.69 | 16.29 | 14.37 |
| 1988 | 15.32 | 17.86 | 17.42 | 2010 | 17.64 | 17.62 | 15.94 |
| 1989 | 18.63 | 16.85 | 18.88 | 2011 | 18.16 | 18.55 | 16.51 |
| 1990 | 20.13 | 16.51 | 16.52 | 2012 | 19.33 | 17.21 | 16.25 |
| 1991 | 12.55 | 16.06 | 12.42 | 2013 | 18.52 | 17.16 | 17.83 |
| 1992 | 13.41 | 16.15 | 16.72 | 2014 | 17.75 | 18.25 | 17.61 |
| 1993 | 14.64 | 17.71 | 17.18 | 2015 | 17.22 | 18.43 | 16.25 |
| 1994 | 12.89 | 17.64 | 16.42 | 2016 | 16.88 | 18.11 | 16.33 |
| 1995 | 16.44 | 17.95 | 17.41 | 2017 | 17.63 | 18.33 | 16.51 |
| 1996 | 16.47 | 17.48 | 15.67 | | | | |

The highest and minimum air temperatures in dry conditions in 2021 were 11 °C in January and 44 °C in August (table 4), indicating dry, hot, and warmer years during the previous ten decades (100 years ago).

Table (4): Average air temperature during drought conditions in 2021 (from Erbil International Airport)

| Months | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Temp. (°C) | 11 | 12 | 18 | 25 | 31 | 38 | 43 | 44 | 38 | 30 | 19 | 12 |

In July 2021, the air temperature in Erbil was very high, reached to 47 °C, in Duhok to 45 °C, in Sulaimani to 46 °C and in Khanaqin to 52 °C, while in Bagdad and Basrah, air temperature reached 55 °C. Historically, such hot and worm conditions in Iraq have never been found in the last 100 years. And rainfall has never occurred in the last 100 years. Finally, as shown in (table 4) the air temperature in Kurdistan, in general, is high in 2021, and the year 2021 is the warmer year, the maximum temperature was more than 44 °C of which is never recorded in the past 100 years south is parallel with drought conditions which the average rainfall in Kurdistan province was between 167.6 from Erbil and 403.0 from Sulaimani, while that of Kirkuk was 102.7 mm/year.

Causes of climate change in Iraq and the rest of the globe:

1. Deforestation of rainforests; every year helps to absorb almost 20% of manufactured CO₂ emission. Therefore, deforestation can be classed as a significant contributor to the causes of climate change.
2. Irregular precipitation in the world was caused by O₃ depletion. It affects drought conditions when a region stays abnormally dried for an extended period enough to cause an imbalance in the water cycle.
3. This would be caused mainly by the thermal expansion of the upper layers of the ocean as they warm, with some contribution from melting glaciers (Anon, 1975; Naome, 2004; Hegeret et al., 2007; Mike, 2009; UNDP, 2009; Judith, 2010; Aziz and Al-Dabagh, 2012 and Aziz, 2017).
4. Climate condition has changed and caused a shortage in everything from food production to electric generation. Fishing has been decreased or depleted. In Kurdistan and other areas of the north part of Iraq, wheat and other cereal crops are declined to less than half of the previous year's, nearly by 70.
5. Migration started to increase from villages to towns and cities.
6. Salt and soil pollution kills the reeds (type of aquatic weeds). So, the land becomes useless for farming and settling.
7. Lack of clean drinking or potable water for more than 20000 people in 2019.
8. To keep their animals alive, residents fill rickety boats with drinking water purchased miles away from the marshes.
9. The situation becomes more severe in Iraq and Syria due to building more dams on the Tigris and Euphrates Rivers by Turkey and Iran.

Conclusion:

1. Mean variation in climatic changes was narrower in the large scales in comparison with the small scales. This is found in the variations in temperature and rainfall bases in Kurdistan, Iraq, and the world (2.0- 2.09 °C, 2.27-2.4 °C and 0.75- 0.80 °C, respectively)
2. The summer months (June, July, August) were hot, dry and had less rain; while it was cold, wet, and rainfall in late fall, it does continue during winter months from January to the end of April.
3. The temperature was irregular and variable; the average temperature during 50 years from 1973 to 2017 was 19.05 °C with a local variation of 2.09 °C.
4. The fewer degree (17.14 °C) occurred during 1973 -1977, and high degree (24.1°C) was during 2013-2017, which means both temperature and rainfall in an early historical review of entered time of this study was more than of the world and less than of Iraq.
5. The climate of the area, relatively little changed. At the same time, Al Ansari reported that in Iraq, the expected differences could be 1.3 °C from 1900 to 2099. Salim (2021) from Washington Post reported in Iraq that the temperature has been rising by 4.1-degree Fahrenheit (2.27degree cent degrees since the end of the last century. in our report, as mentioned before, the temperature variation is about 2.5 of from 1918 to 2020). The amount of precipitation in desert areas was not exceeded 100mm; in the south part of Iraq, 150 mm, around Baghdad was not much more than 300-400mm, and in Kurdistan, it varied from 250 - 600 to 1200mm in Iraq.
6. Mean annual rainfall in Kurdistan between 1941- 2017 approximately was equal to 531.847 mm, while, from 1918-1941, the actual mean was 754.521mm, and the correct mean was 655.35 mm; this indicated that rainfall from 1941 was decreased by 100-200mm.
7. In 2019-2020, the annual rainfall was about 1000mm in most parts of Kurdistan. In contrast, the temperature was also high and was reached 48- 52 °C in the middle and south parts of Iraq, even in both September and October months. In Kurdistan, the temperature was not below 38 °C and not more than 41 °C.

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