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DETERMINATION OF IMPACTS OF CLIMATE CHANGE ON TEMPERATURE AND RAINFALL VARIATIONS IN SOME SOUTHERN IRAQI GOVERNORATE USING GIS

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ABSTRACT

The concept of temperature change is closely related to climate change. Global warming is one of its most prominent manifestations, and the effects of this will be significant on the climate. It will lead to an increase in the intensity of the air cycle, the encroachment of climatic regions towards the poles, an increase in the frequency of extreme weather phenomena, a change in the distribution of heat and rain in different cities of the world, and a rise in sea levels and the threat of most coastal areas. The research aims to determine the variation in temperature, the amount of rain, and its distribution system in the (Basra, Thi Qar, and Missan) during the period (1998 – 2020), and diagnosis of changes in temperature, rain amount, and their cause, as well as its distribution system by analyzing the trend of change in the annual averages of temperature and annual rainfall amounts for the same study period.

The results of spatial analysis using GIS for monthly temperature average data for the same period indicated that the general trend of temperature distribution in all study stations is high, and the peaks during the months (June, July, August, and September), where we notice a large and clear increase, especially in recent years, if compared with rates in previous years. As for the rain data analysis in Iraq, the study found that it was limited to five months (Nov., Dec., Jan., March, April), and October month, which represents the beginning of the rainy season in most monitoring stations, and the month of March, which represents its end, did not record any amount of rain, and this means that the depressions which Iraq exposed to during these two months are unable to produce heavy amounts of the rain because of their shallowness, from the spatial distribution of the amount of rain in the study area that the rainfall rates are reduced to the highest level and its irregular distribution, and therefore reflected in the decrease in water resources in the areas under study. A large amount of daily precipitation in Iraq is due to the recurrence of three atmospheric depressions the (Mediterranean, combined, and Sudanese) depression. These responsible depressions are distinguished by their differences from one region to another, the short duration of their stay and recurrence, the weather conditions that dominate them, and the pressure patterns accompanying them in the upper atmosphere layers. Or some of these depressions reach

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dryness or are accompanied by non-rainy clouds. This makes Iraq's rains few, leading to many repercussions on climate, the environment, humans, and various activities.

INTRODUCTION

Climate change is the biggest challenge facing the world, and climate system changes are mainly due to the increase in the concentration of greenhouse gases in the atmosphere. Human activities are responsible for the high concentrations of greenhouse gases since the industrial revolution due to fossil fuels burning such as coal, oil, and natural gas as an energy source. The impact of climate change may lead the world to face severe danger from dust storms, droughts, floods, and other events that may contribute to food shortages that will inevitably affect the sustainability of societies and their development (UNFCCC, 1992). Climate change affects the universe's economy and human life through unexpected disasters, water pollution, and rising temperature records. Unfortunately, recent years showed a noticeable increase in temperature that could be classified as a direct threat to human life and the ecosystem of this planet(Abdulkareem and Nemah, 2021). The scientific convictions indicate that the global climate is changing due to human activities that affect three main factors: greenhouse gases, aerosols, and land surface changes (Medany, 2015), as stated by the Intergovernmental Panel on Climate Change (IPCC, 2007) that the increase in the annual mean global surface temperature, which reached 0.74 ± 0.18 °C, and the warming which caused by human activities will increase the greenhouse gases in the atmosphere. According to the SRES (Special Report on Greenhouse Gas Emissions Scenarios), the end-century temperature forecast for the 21st century is from 1.1 – 6.4 °C, compared to the end of the 20th century (IPCC, 2007).

The impact of changes in the global average temperature on global, regional, and local levels such as ecosystem health, food production, species distributions, human health, sea level, precipitation, runoff and drought, extreme changes in temperature rates and wind patterns, these effects are associated with big uncertainties. Recently, there are two main methods (mitigation and adaptation) that are associated with climate change. The first is to reduce greenhouse gas emissions, and the second is an adaptation which means modifying natural or human systems and responding to actual or projected climatic stimuli (IPCC, 2001). Although the international community has identified the problem of climate change, it has not succeeded in reducing the causes that lead to the continuation of climate change. But If emissions follow the trajectory set by current NDCs (Nationally Determined Contribution), there is a less than 5% chance of keeping temperatures well below 2 °C above pre-industrial levels, and less than 1% chance of reaching the 1.5 °C Paris Agreement target (Quiggin *et al*., 2021). The concept of temperature change is closely related to climate change. Most environmental studies have drawn more attention to measuring the change in the earth's temperature, in an attempt to control the different variables related to the continuous increase in the annual average temperatures, knowing their causes, this is directly and indirectly attributed to human activity, which has gone into the destruction of the environment through industrial activities and the other manifestations, which requires to developing real solutions to confront that, Iraq will not be far from all the catastrophic consequences that befall the world because of its aggravation (Muhammad and Shattawi, 2016).

Therefore, most global studies that dealt with climate change have focused on the earth's temperature at a greater rate than the rest of the other elements. An estimate by the IPCC indicated there is an impact of climate change on different regions of Iraq, including the marshes region located in southern Iraq in the governorates of (Basra, Thi Qar, and Missan). (Zakaria *et al*., 2013), concluded that there is a fluctuation in average monthly temperature

giving a clear impression that the future portends a higher temperature, as for the average monthly rainfall for the future period, also fluctuated between the lowest and highest value with an average that reached 16.84 mm which represent a reduction percentage of about 36.47% relative to the historical record of rainfall for the same months. (Osman *et al*., 2017) applied the LARS-WG weather generator to examine climate change and future precipitation in an arid environment of the Middle East, future precipitation results show that most of the Iraq regions are projected to suffer a reduction in annual mean Precipitation, especially by the end of the 21st century, while on a seasonal basis most of the regions are anticipated to be wetter in autumn and winter. (Jawad *et al*., 2018) used a Geographical Information System (GIS) to create some temperature maps that could show the air temperature distribution and the difference between two different periods (past and recent) in different stations, this study showed no significant increase in the average air temperature values, and the area of high air temperature values are growing during the cold and hot months of the year. (Adamo *et al*., 2018) studied climate change and its consequences on Iraq's Environment, they refer to increasing temperatures, declining precipitation rates and changed distribution patterns together with increasing evaporation are causing water stress in Iraq. However, they trigger other changes in a sort of chain reaction; such as droughts, desertification and sand storms. (Hashim *et al*., 2019) showed in their study that the impact of climate change represented a high temperatures and lack of rain in the marshes of southern Iraq for the period (1977 – 2017), and is one of the reasons for the increase in the desertification and drought in Iraq, especially in the southern regions.

Most of the above studies gave a clear impression that the future portends a rise in temperature and a decrease in average precipitation for the coming period and depends on some mathematical models to examine climate change in the future. These studies did not show climate change and its consequences for important sectors in Iraq. The current study, determines the variation in temperature, the amount of rain, and its distribution system in some areas of southern Iraq most affected by climate changes, and identifies the natural, geographical factors and influencing human activities, and finds the mitigate and adapt solutions with the effects of climate change. In addition to finding the graphical relationships between changes in temperature and the amount of precipitation at long periods of time (1998 – 2020) in the southern regions.

PROBLEM STATEMENT AND STUDY OBJECTIVES

Temperature and rain are very important elements of the climate, or its evident effect on the various activities of man. In addition, they affect the vital system of plants and animals, different hydrological processes, and the rate of soil building. There is a close relationship between temperature, rainfall, and other climate elements. At the same time, it affects and is affected by those elements. The research aims to determine the variation in temperature, the amount of rain, and its distribution system in the (Basra, Thi Qar, Missan) during the period (1998 – 2020), and diagnosis changes in temperature; rain amount and their cause.

MATERIALS AND WORKING METHODS

1. Spatial boundaries of the study area were represented by three southern governorates (Basra, Thi Qar, and Missan). The recorded data in the meteorological stations of these three governorates (Basra/ Basrah, Thi Qar/ Nasiriyah and Missan/ Amarah) were adopted during a period (1998 – 2020), (Figure 1).
2. Draw the graphical relationships of maximum temperatures, annual and monthly rainfall rates recorded in those stations and evaluate their results.

3. Preparing maps of the distribution of annual and monthly rates of extreme temperatures and the amount of rain in study stations using GIS.
4. Comparison of the results to determine the impact of climatic changes on the three governorates.

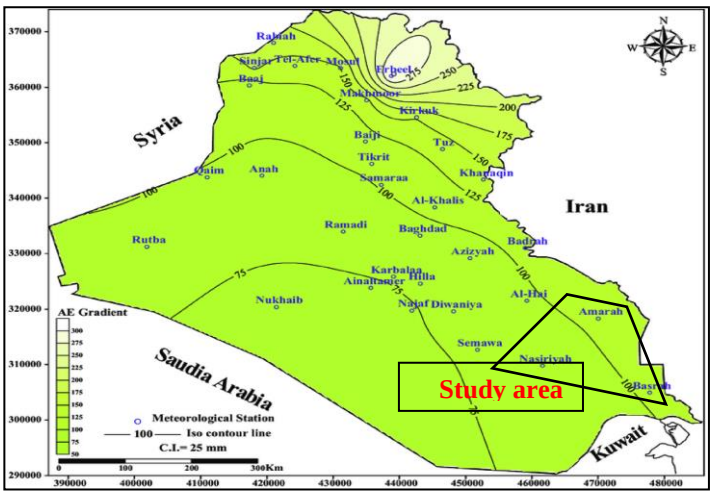

Figure 1: Map of Iraq showing the meteorological stations (Muneer, 2004).

- **Location of study area**

Basrah is the southern governorate of Iraq (30.5258° N, 47.7738° E), and borders Iran, Kuwait, and Saudi Arabia. The governorate made up of a vast desert plain, intersected by the Shatt Al-Arab waterway which is formed by the confluence of the Tigris and Euphrates rivers at Al-Qurnah and flowing into the Persian Gulf. Around Al-Qurnah and Al-Medina several lakes can be found, while marshland stretches from the north of the governorate into the neighboring governorates of Thi-Qar and Missan. The governorate is Iraq's only access to the sea and has a hot and arid climate, Figure 2. The temperatures in summer are among the highest recorded in the world. Due to the vicinity of the Persian Gulf, average High Temperatures are 17.7 °C (January) to 41.8 °C (August), and Low Temperatures: 6.8 °C in January to 27.4 °C in July. Humidity and rainfall are considered relatively high. The governorate receives an average rainfall amount of 152 mm in a year between October and May, (NCCI, 2015).

Thi-Qar governorate is located in southeast Iraq (31.1042° N, 46.3625° E), and shares internal borders with Basrah, Muthanna, Qadissiya, Wassit, and Missan governorates. The Euphrates River crosses it and feeds into the Al-Hammar marshes, which once covered one-third of the governorate's surface but shrunk drastically following the draining campaign of the 1990s. The governorate has a desert climate typical of the region, (Figure 2). The summers are hot and dry, with average high temperatures reaching above 40°C while the winters are mild. High Temperatures are 15 °C (January) to 43 °C (July), and Low Temperatures 7 °C (January) to 28 °C (July). Rainfall is limited to the months of November-April and averages 100 mm annually, (NCCI, 2015).

The governorate of Missan is located in south-eastern Iraq (31.8379° N, 47.1421° E), on the border with Iran and shares internal boundaries with the Basrah, Thi-Qar, and Wassit governorates. The Tigris River runs through this governorate and feeds the marshlands that once covered two-thirds of the governorate. The marshes have shrunken drastically following the draining campaign of the 1990s, with much of the drained landscape turning into desert. Missan has a typical desert climate, with dry, hot summers and cooler winters, (Figure 2). In

summer high temperatures easily reach over 40 °C. High Temperatures are 16.5 °C (January) to 45.5 °C (July), and Low Temperatures 6.2 °C (January) to 28.5 °C (July). Rainfall is concentrated in the winter months and averages 177 mm yearly, (NCCI, 2015).

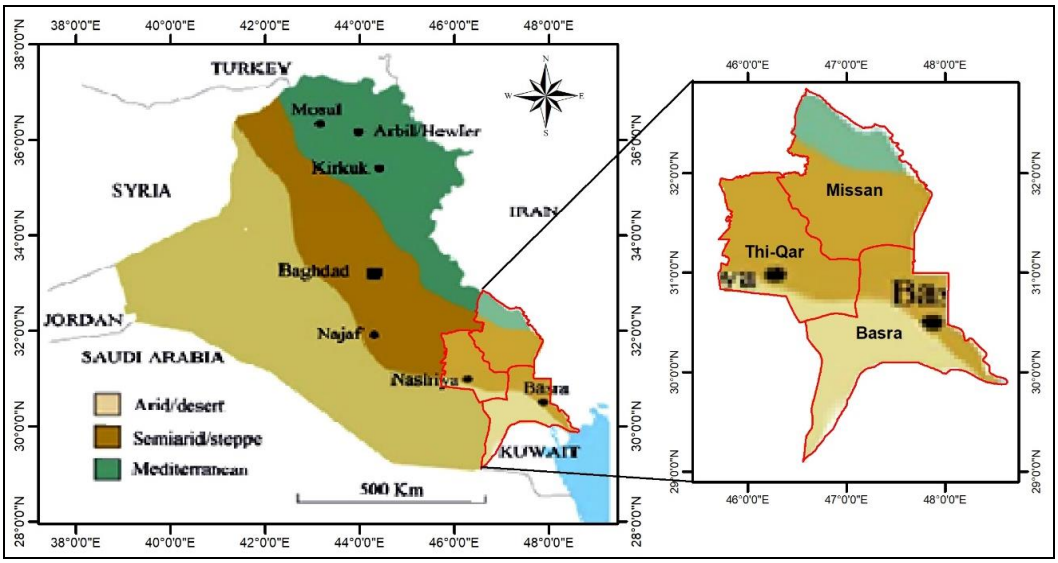

Figure 2: Climate zones of Iraq (modify by researcher).

- **Data of study area**

Annual air great temperature and rainfall data and that are used in the current study were obtained from the Iraqi General Authority for Meteorology and Seismic Monitoring (GAMSM, 2020) for the period (1998 – 2020), and some missing data have been addressed by using the website: Weather and Climate/ The Global Historical Weather and Climate Data (https://tcktcktck.org).

RESULTS AND DISCUSSION

- **Maximum temperature**

The general annual average of the Basrah station for the maximum temperature was 34.18 °C, for the period (1998 – 2020), while the annual average of the maximum temperature in Thi Qar and Missan stations was 33.94 °C; 33.46 °C respectively at the same period, (Table 1; Figure 3). Whereas the highest annual value of the maximum temperature was recorded in Basrah governorate during the study period was 49.60 °C, and the highest annual value of the maximum temperature recorded in the governorates of Thi-Qar and Missan was 51.10 °C and 49.52 °C, respectively, (Figure 4).

Table 1: Annual average of the Max.Temp. in the study area for 199 – 2020

Station	MEAN MAX. TEMP.(C)											Average Max. Temp.
	1998	1999	2000	2001	2002	2004	2005	2006	2007	2008	2009	
Basrah	34.63	34.59	34.15	34.82	34.35	36.72	34.23	34.13	33.37	33.87	34.05	34.18
Thi Qar	33.31	34.18	33.51	34.25	33.60	34.95	33.33	33.18	33.40	33.58	33.29	33.84
Missan	32.13	32.17	32.96	33.57	33.64	37.14	33.04	33.17	33.35	33.48	33.07	33.46
Station	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Average Max. Temp.**
Basrah	35.50	33.71	34.06	32.93	33.66	34.63	34.88	35.53	33.57	29.13	34.18	34.18
Thi Qar	35.85	34.80	31.07	32.81	33.20	34.23	34.29	34.95	34.55	34.84	35.50	33.84
Missan	33.84	33.27	33.56	31.50	32.85	33.91	33.63	33.99	33.79	33.85	34.51	33.46

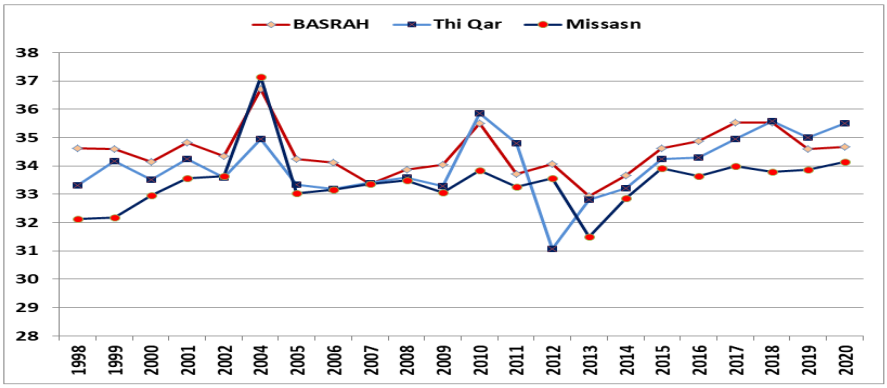

Figure 3: Annual variations of the Max. Temp. at the three stations for the period (1998 – 2020).

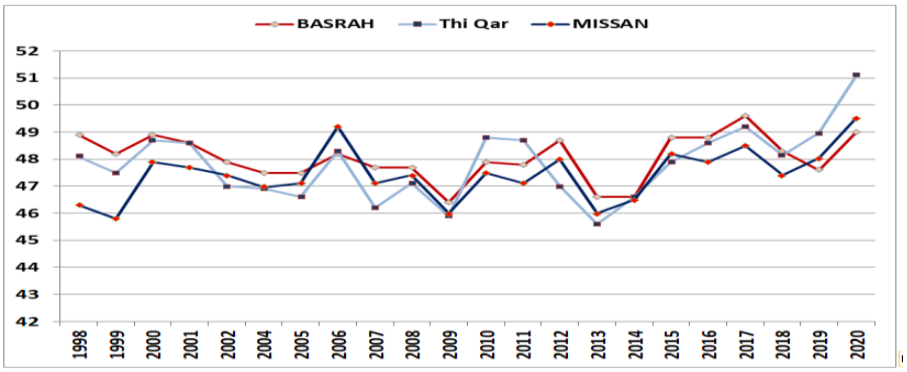

Figure 4: A highest annual average of the Max. Temp. which is recorded at the three stations for the period (1998 – 2020).

The results of data analysis of the monthly maximum temperature average at the same taken period indicated the general trend of Max. temperature distribution in all study stations is high and was rising peaks during the months (June, July, August, and September), where we notice a significant increase and clear, especially in recent years when it was compared with its rates in previous years. The highest monthly rate was recorded in Basrah station was 47.41 °C in July, then the Thi Qar station at 47.37 °C in August, and Missan station at 47.0 °C for the same month, (Table 2; Figure 5). While the highest recorded monthly value of maximum temperature was in Thi Qar station, where it reached 51.10 °C in July, then Basra station at 49.60 °C, and then Maissan station at 49.52 °C in the same month (July), (Figure 6). Study results reveal that the mean temperature in the south part of Iraq was higher than in the other parts of the country. In the winter season, the temperature distribution over Iraq can be divided into two distinct areas, northern and western regions are below 10 °C covering about 38% of the country.

Table 2: Monthly average of the Max.Temp. in the study area for 1998 – 2020.

Station	MEAN MAX. TEMP.(C)												Highest Max. Temp.
	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	
Basrah	18.58	21.76	27.33	33.13	40.00	44.92	47.41	47.41	43.35	37.60	26.79	20.54	49.60
Thi-Qar	18.43	21.62	27.54	33.39	40.12	44.76	46.92	47.37	43.53	37.02	26.64	20.40	51.10
Missan	17.49	21.01	26.81	32.61	39.54	44.67	46.58	47.00	42.91	36.08	25.52	19.57	49.52

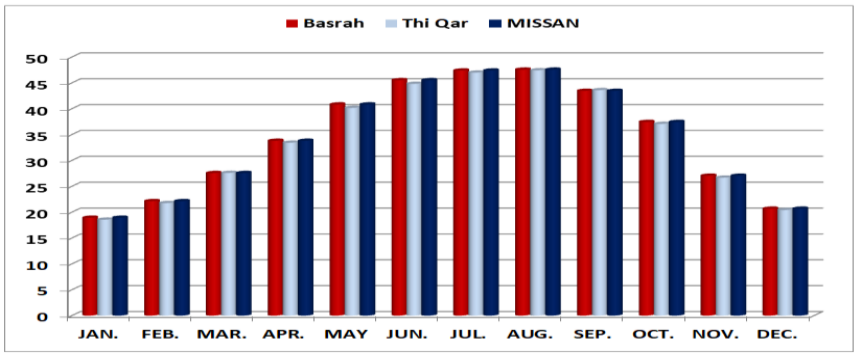

Figure 5: Monthly variations of the Max. Temp. averages at the three stations for the (1998 – 2020).

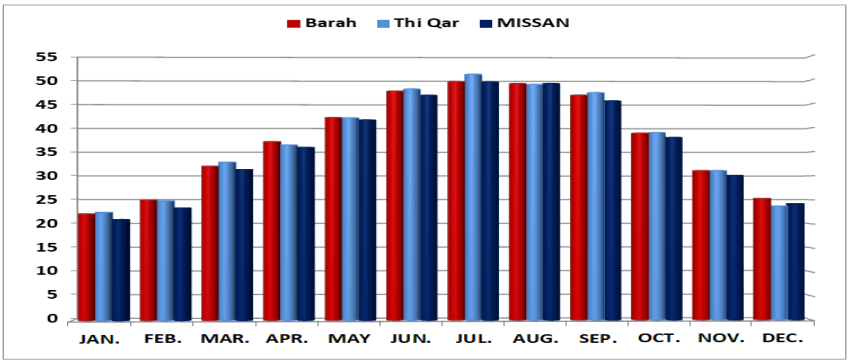

Figure 6: Highest monthly average of the Max. Temp. in the three stations for period (1998 – 2020).

In contrast, the center and the other southern parts cover 62% are 10 – 15 °C and more. In summer, the temperatures increase in the whole country, and the temperature distribution over Iraq can be divided into three distinct areas. The lowest temperature observed in the northern parts of the country was below 30 °C, the center to the north and western regions temperature between 30 – 35 °C which covers about 58%, and the southern region were more than 35 °C which covers about 40%, (Al-Timimi and Al-Khudhairy, 2017). The study stations showed a spatial variation in the recording of thermal anomalies in all study stations, which is a positive thermal anomaly, and this means that in Iraq there are factors that contributed to raising the temperature of all its regions and stations above the general average. The weather monitoring stations included in the study varied in terms of recording the degrees of anomalies according to the different climatic controls that control the climate of each station and the variation in the normal temperatures recorded in these stations. (Figure 7) showing the spatial variation of the temperature rates in the study stations from 1998 – 2020.

The results of the annual mean of temperature from 1998 – 2020 in three provinces, southern Iraq (Figure 7) shows that the highest mean of temperature focused between Missan and Basra during most of the time period, except last three years focused on Missan. From this Figure, the temperature distribution over the study area can be divided into three distinct regions can be distinguished, the small parts in the western and northwestern regions of the study area towards Thi Qar governorate are less than 20 °C, and the central region towards the east ranges between 21 – 29 °C, the third region, which is the southern and southeastern study area, it ranged from 15 °C to more than 34 °C, which occupies an area more than the study area.

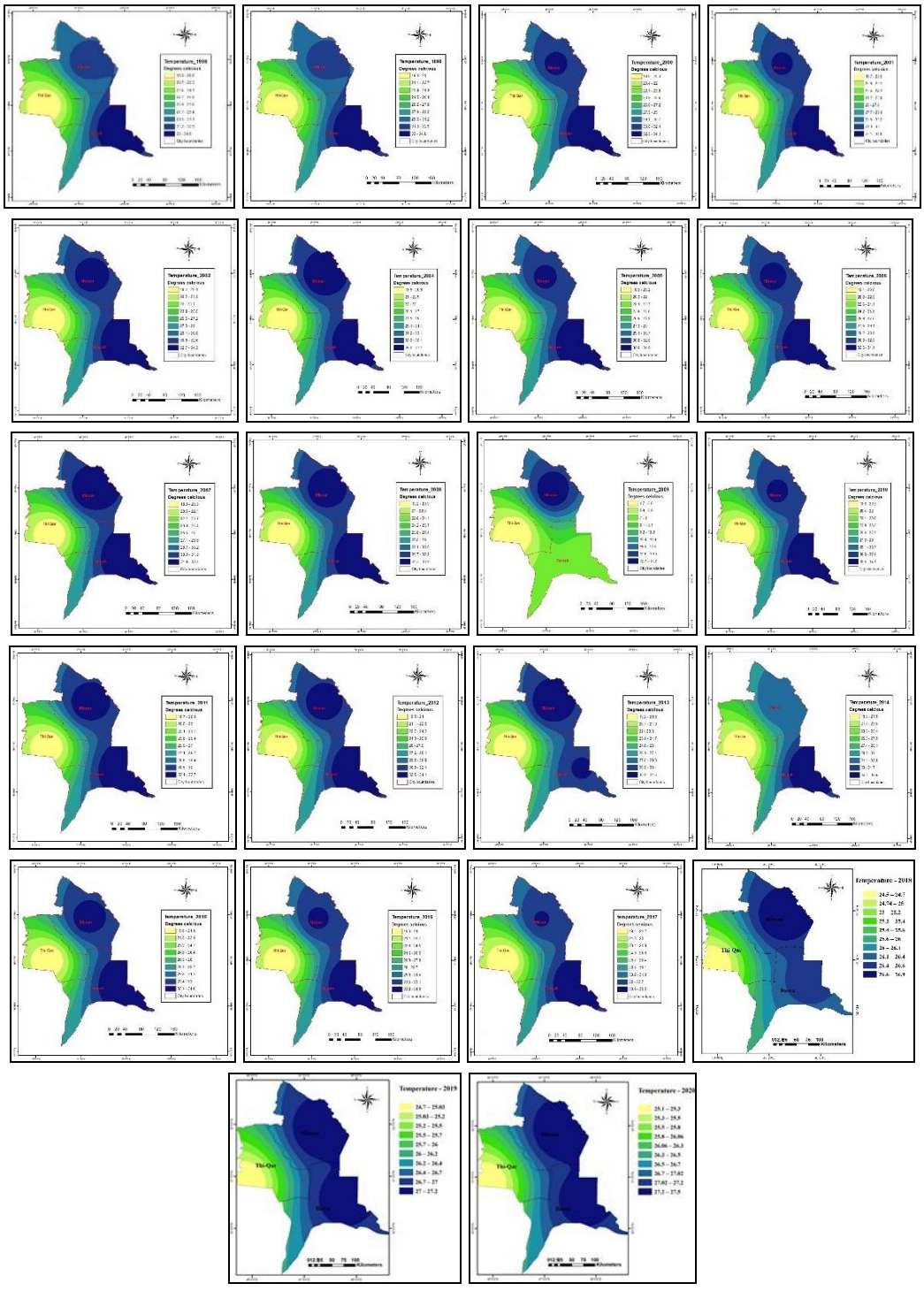

Figure 7: The spatial distribution of temperatures in the study stations for period 1998 – 2020 (Note that there is a lack of some data from the source, GAMSM).

One of the most important effects of climate change in Iraq is the significant rise in temperatures above their general rates compared to previous years, especially in recent years, which in turn has affected and will more affect in the future many sectors, the most important of which are: water resources, agriculture, energy, infrastructure, biodiversity, and the health sector. The important reasons that led to the continued rise of the temperatures in the study area during the chosen period are Because Iraq where is generally classified within

subtropical climates due to its natural geographical location located between latitudes 29 and 37 north of the tropical divide, and it is 1000 kilometers from the Mediterranean Sea. The climatic characteristics in the different regions of Iraq vary according to the geographical factors that make the climate in the south tropical, while the northern climate is Mediterranean, with hot and dry summers and cold, rainy winters. Also, because of tropical climate expansion and the Mediterranean orbit shrinking, Iraq locates in these changes, affected by natural and global climatic factors, such as the decrease in precipitation, the increase in heat waves, dust storms, and the lengthening summer season, which increases the water evaporation rate. In addition to its geographical location at the mouth of all the rivers coming from Turkey, Iran, and Syria. In addition to other factors that led to the continued high rates of temperatures, the lack of precipitation, the large difference in temperature between night and day and between summer and winter, the intensity of dust storms, the drying up of the marshes in southern Iraq, with the decrease in green areas and drought due to wars and the lack of river supplies. The Tigris and Euphrates from the source countries, other human activities, the burning of large quantities of fuel and its derivatives, a significant increase in the number of vehicles and their aging, and the more use of private electric generators due to the electricity crisis. Also, most of the oil industry, oil and gas burning processes which have increased significantly in recent years as a result of the increase in drilling, extraction, and production operations, and increase in carbon emissions are located in these regions, which led to high air temperatures and the occurrence of so-called warming.

So, Iraq is classified that one of the five most fragile and changeable countries in the world concerning climate change due to the significant rise in temperatures (IOM, 2022). The hot air is also concentrated in these areas because they are depressed areas in the Mesopotamian plain, and suffering from water scarcity. The decreasing green spaces due to water scarcity, increasing population density, and non-use of clean energy for electricity generation, play another role in increases in the temperatures in these regions. Also, these areas are affected by the northwest winds that descend from the Iranian mountains in the east and the western plateau in the west, which causes a decrease in its humidity and an increase in the falling solar radiation that almost vertically, and thus an increase in the earth's temperature. In addition, it is constantly affected by the atmospheric thermal depression that is centered in southern Iraq and the northern Gulf, with an air altitude at the top, working together to form something like a greenhouse because the air pressure works to compress the air rising from the depression and heat it by 10 degrees per 1 Km.

- **The amount of rain**

The general annual total rain amount in Basrah station was (238.6 mm) for the period (1998-2020), while the annual total rainfall amount in Thi Qar Governorate was (245.8 mm). The annual total rain amount in Missan governorate reached (352.9 mm) and the same period. The last value represents the highest annual amount of rain recorded in Missan Governorate, which was during the year 2018, compared to other governorates as well as with other years, (Table 3; Figure 8).

The highest annual rain amount recorded during the study period was reached in the governorate of in Missan governorate (164.7 mm), and the highest annual average rain amount was recorded in Thi Qar and Basrah governorates (132.1 mm), and (77.5 mm) respectively, (Figure 9). The rains that fall in Iraq during the spring months (March and April) are characterized by intensity, strength, and high intensity, as they fall in the form of showers that last for short times, and this is due to the systems that cause. As for the winter months,

the depressions usually are characterized by their long time and rainfall as varyingly and oscillating, and it's in the form of a fog, and sometimes light.

Table 3: Annual total rain means at the three stations for the period (1998 – 2020).

Station	MEAN MAX. TEMP.(C)											Highest Rain Totals (mm)
	1998	1999	2000	2001	2002	2004	2005	2006	2007	2008	2009	
Basrah	74.20	238.60	130.00	127.30	89.70	53.50	95.50	174.10	139.20	67.10	89.81	238.60
Thi Qar	153.10	157.00	108.00	62.90	151.00	98.60	105.70	245.80	112.50	65.50	56.50	245.80
Missan	210.80	328.20	210.20	102.60	78.20	235.40	158.20	251.40	125.10	90.60	175.90	352.90
Station	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Highest Rain Totals (mm)**
Basrah	31.90	65.30	115.30	50.08	5.36	131.50	86.90	65.10	151.30	191.60	84.00	238.60
Thi Qar	57.60	85.11	116.20	175.20	219.70	93.20	58.30	27.00	226.50	5.11	4.95	245.80
Missan	128.30	110.70	212.11	324.60	207.00	128.50	81.60	66.00	325.90	7.85	7.40	352.90

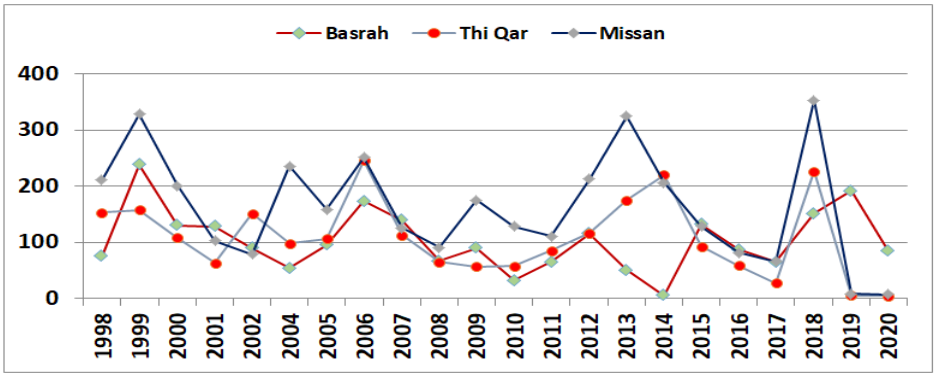

Figure 8: Variations in annual total rain at the three stations for the period (1998 – 2020).

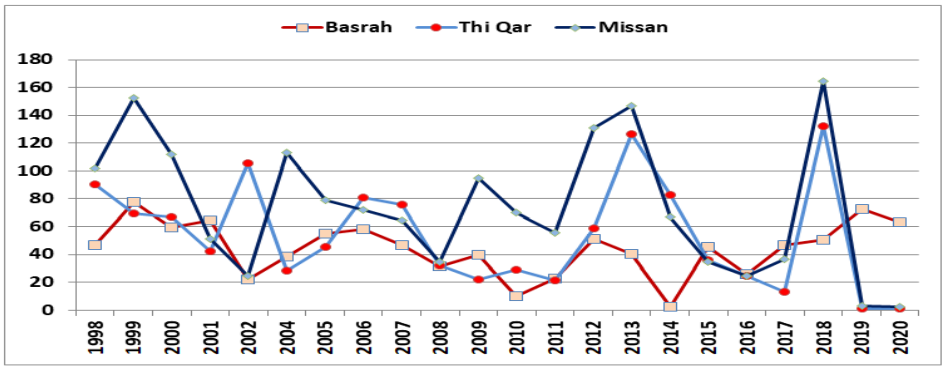

Figure 9: Highest of the annual rainfall amount at the three stations for the period (1998 – 2020).

The highest monthly average of the rain amount reached in the Missan governorate (33.23 mm) on the Dec. month in the study period, and (26.36 mm) in Basrah station on the same month, and (21.42 mm) in Thi Qar station on the Nov. month, (Table 4; Figure 10). While the highest amount of rain was recorded in Nov. month was (164.70 mm) in Missan

station, and (132.1 mm) in Thi Qar station on the same month, and (77.50 mm) in Basrah station in the Dec. month, (Figure 11).

Table 4: Monthly total rain means at the three stations for the period (1998 – 2020).

Station	MEAN RAINFALL TOTALS (mm)												Highest Rain Totals (mm)
	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	
Basrah	447.80	313.91	227.21	156.51	73.16	0.01	0.00	0.00	0.00	111.27	347.60	579.88	77.5
Thi Qar	332.27	251.45	402.25	304.06	78.44	1.10	0.01	0.00	0.20	126.60	471.22	418.29	132.1
Missan	556.95	300.35	557.53	334.86	217.25	0.40	0.30	0.10	0.80	209.94	730.997	675.11	164.7

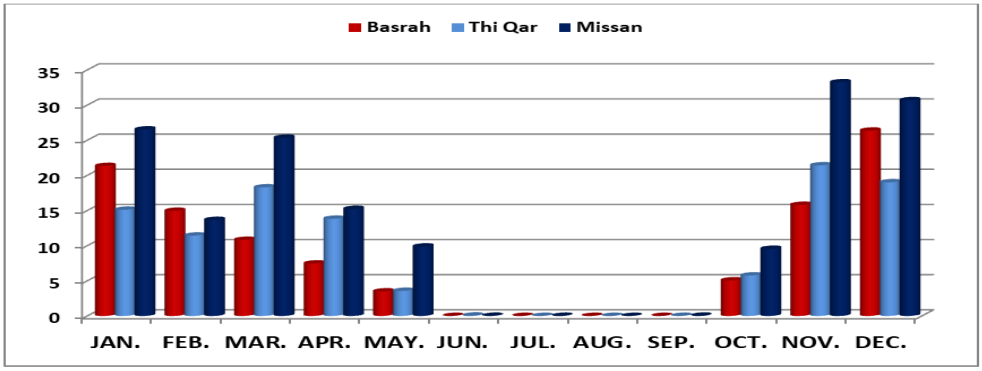

Figure 10: Monthly variations of the Rainfall averages in study area the for period (1998 – 2020).

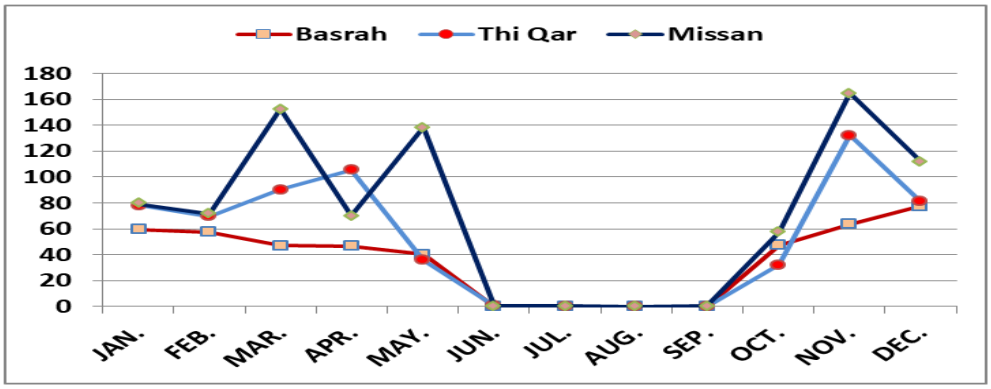

Figure 11: Highest monthly Rainfall amount which recorded at the three stations for (1998 – 2020).

The amount of rain varied spatially for the period from 1998-2020, the Figures in (Figure 12) explain it, rain amount distribution in study regions was characterized by significant differences, like that of other Iraq regions. We noticed from the spatial distribution of the rain amount in the study stations that it was decreasing in their rates to its highest level (below 10 mm), and its distribution was irregular, especially in Thi Qar and Basrah Governorate. Reverse to Missan Governorate, the rainfall rates were rather good in some periods, specifically in 2018 (more than 29 mm), but the general trend of the rainfall rates in these areas remains lower than the general average, and thus was reflected in decreasing of water

resources in the rivers, lakes, and groundwater in the areas under study. The atmospheric depressions coming from the southeast and Mediterranean Sea depressions that help in the fall of rain, and these depressions are responsible for the highest amounts of rain falling in Iraq, but sometimes are characterized by their short duration of stay, and this makes Iraq's rains few, in addition to that some of these depressions reach dry or are accompanied by non-rainy clouds.

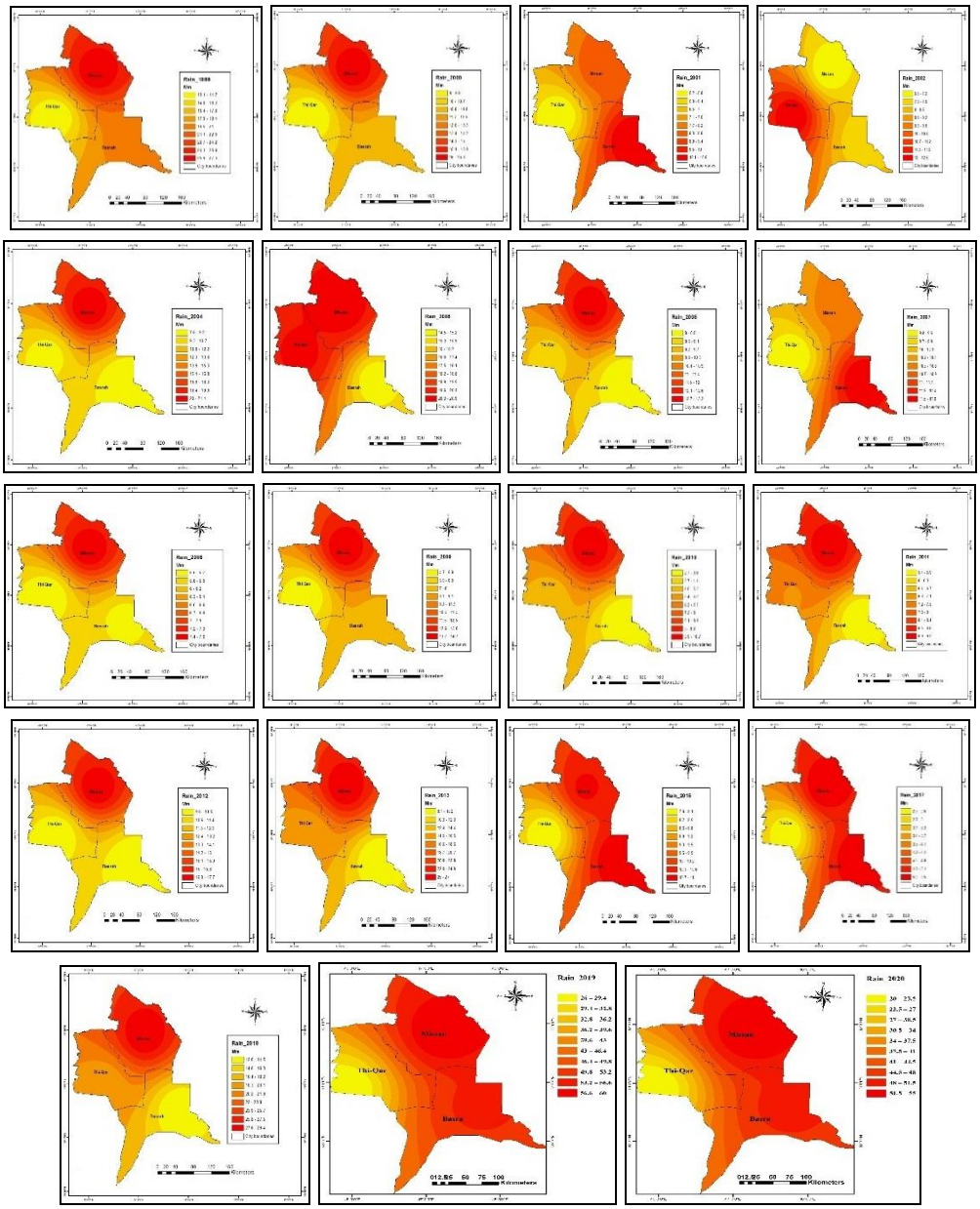

Figure 12: Spatial distribution of the rainfall amount in study stations for the period 1998 – 2020 (Noting that there is a lack of some data from the source, the GAMSM)

One of the reasons for the lack of rain in the southern Iraq regions is due to atmospheric altitude control over the central Arabian Peninsula and south of Iraq, and its impact reaches central Iraq. Also, weak cooling effects that come from Europe lead to prevention of clouds and precipitation formation. In addition rush of depressions comes from southern Europe and

the Mediterranean toward the island. While the other reasons due for the decrease in winter and spring rains are the recurrence of atmospheric heights, and the expansion of the Azorean altitude, which led to the deviation of the Atlantic depressions from entering the Mediterranean and their deflection towards the north (Abed, 2019), which led to drought over the Mediterranean and southern Europe. As well as the concentration of semi-tropical atmospheric altitude with high-pressure values on large areas of the Arabian Peninsula and southern and central Iraq, which causes a complete closure of the area and prevents the incursion of any frontal kinetic depression, especially the Sudanese depression (Al-Hathal, 2019), that feeds other depressions with surface heat and humidity in the upper layers of the atmosphere, which results in cooling the part The western part of the Arabian Sea and the decrease in humidity, and consequently, the lack of chances of cloud formation and precipitation.

CONCLUSIONS

- There is a significant increase in annual Max. Temperature averages during the period (1998 – 2020) in all study areas.
- The meteorological stations recorded the highest monthly value in Thi Qar station, where the highest value was (51.1 °C) in July.
- These areas are affected by the northwest winds that descend from the Iranian mountains in the east and western plateau in the west, which causes to decrease in their humidity and falls the solar radiation almost vertically, then, an increase in the Earth's temperature. In addition, it is constantly affected by the atmospheric thermal depression that is concentrated in southern Iraq and the northern Gulf, with an atmospheric rise at the top, working together to form what looks like a greenhouse.
- The regions of southern Iraq fall within a hot and dry desert climate or a semi-desert climate. Some human activities such as the oil industry, water scarcity due to the lack of water imports from upstream countries, and the decreasing green areas play another role in increasing temperatures in these areas.
- There is a decrease in the annual rainfall in southern Iraq and thus reflected in the decrease of water resources in the rivers, lakes, and groundwater in the areas under study.
- Because Iraq is affected by the southeastern air depressions and depressions coming from the Mediterranean and these are responsible for the largest amounts of rain that fall in Iraq, but it is sometimes characterized by its short duration, which makes Iraq's rains few.
- Depressions from southern Europe and the Mediterranean rush towards the island and high-pressure values rise over vast areas of the Arabian Peninsula and southern and central Iraq, causing to complete closure of the area and preventing the incursion of any front kinetic depression, especially the Sudanese depression, which leads to the cooling of the western part of the Arabian Sea Low humidity, and therefore fewer chances of clouds and precipitation.
- We propose to develop measures to adapt to and confront climate change, and expanding the fields of environmental and climatic studies concerned with climate change Iraq.

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