Impacts of Global Climate Change on Temperature and Precipitation in Basra City, Iraq

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ABSTRACT

Climate change affects countries' economies and households through a variety of channels. Rising temperatures and changes in rainfall patterns affect agricultural yields of both rain fed and irrigated crops, and will change hydropower production, increased frequencies and magnitudes of floods and droughts can significantly increase the need for public investment in physical infrastructure. An investigation was carried out to identify trends in temperature and precipitation time series covering a period from (1970-2019) in the province of Basra south of Iraq, northwest of Arabian Gulf. The two variables were considered for analysis on both monthly and annual basis. The percentages of significant trends obtained for each parameter for 12 months and annually were presented. Temperature anomalies were plotted, the relationship between annual mean temperature and precipitation have been determined by Pearson's Correlation coefficients, and were statistically measured. It was observed that the monthly and annually mean temperatures have increased, while precipitation trends have decreased; moreover, there is a negative weak relationship between temperature and precipitation, while a strong negative relationship was observed between the monthly average for the whole period of minimum and maximum temperature and rainfall

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1. Introduction

Climate change is driven by increases in greenhouse gases concentrations in the atmosphere due to consequences of anthropogenic activities which led to an increase in the global temperature [1]. The warming of our planet due to the emission of greenhouse gases is now unquestionable [2]. Climate change affects countries' economies and households through different channels [3]. Rising temperatures and changes in rainfall patterns have effects on agricultural yields of both rain fed and irrigated crops [4]. The climate change phenomenon is caused by the increase of greenhouse gasses in the earth's atmosphere. Human activities were adding too much of these gases to the atmosphere, result in the rise of temperature and reduction of rainfall along with drought and devastating floods in many parts of the world [5]. The Arab region is already being impacted by climate change [3] including Iraq. Even small changes in mean annual rainfall can impact on productivity, [6] and, indirectly, population densities, of large areas of the countries in the region. Rainfall and temperature are very important parameters for both weather and climate, they are essential for describing the climate and can have extensive-ranging effects on human life and the environment. Extreme temperature leads to intense heat waves which can be dangerous causing illnesses such as heat cramps and heat stroke, or even sometimes leads to death. Decline or erratic rainfall [7] in precipitation affects the amount of water available for drinking, agriculture, industry, hydropower production, increases frequencies and magnitudes of floods and droughts which were evaluated using drought even [8].

There is a lot of literature studying the relationship between temperature and rainfall, Southern Italy, Queensland in Australia, North-east Sokoto Rima River Basin in Nigeria, and Talomo-Lipadas Watersheds in Davao City[12-9]. In this study, an investigation was carried out to identify trends in temperature and precipitation time series of Hay Al-Hussien weather stations covering a period (1970-2019) in the province of Basra south of Iraq, northwest of the Arabian Gulf.

2. Study Area

The province of Basra is located in the southern part of Iraq on the longitude (047° 48 59 E) and latitude (30° 30 03 N). It is bordered by the province of Maysan and DhiQar in the north, Muthanna in the west, and the international borders with the Arabian Gulf in the south, Kuwait in the southwest, and Iran in the east. It has an area of 19730-km^2 as shown in figure (1). The summer's climate is long, sweltering, and arid, while winters are cool and dry. Over the course of the year, the temperature typically varies from 7.2 0C to 46.6 0C and in recent years above 50 ^{o}c. Shatt al-Arab River passes through Basra, which is the principal source of surface water, it is a 195-km-long tidal river flowing south-eastwards, Iranian port of Abadan, subsequently the city of Faw and from there, it discharges into the Arabian Gulf.

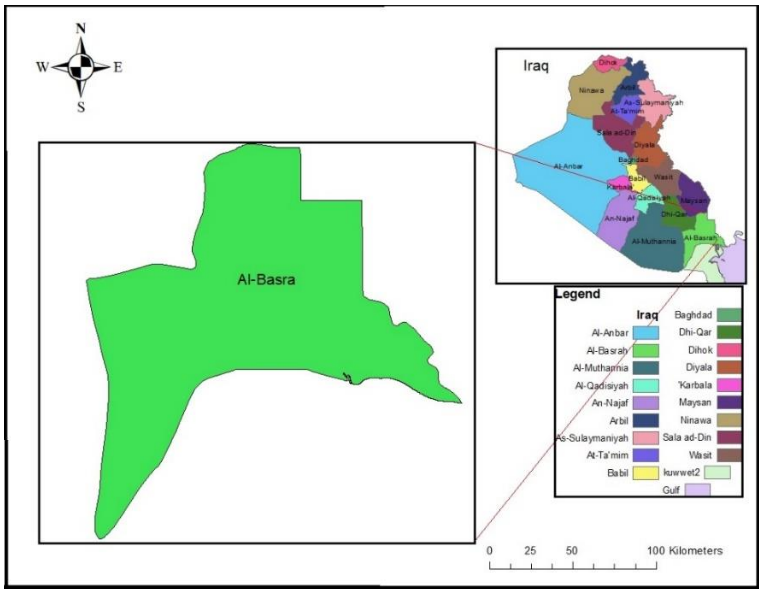

Figure 1: study area

3. Data and methodology

3.1 Data and sources

Time-series data for monthly precipitation and temperature (mean, Max. and, Min.), from Hay Al-Hussein weather station which is located on (30.28N- 47.47E) for the period of 50 years (1970–2019) have been used. The data of this study was provided by the Iraqi meteorological Organization and Seismology.

3.2 Missing data correction

The problem of missing data can be solved by spatial interpolation, in which data from nearby weather station can be used, or by temporal interpolation, in which data of the same time series before and after the data gap is used[13], adopted a procedure to fill the gaps on monthly mean temperature .

3.3 Test of homogeneity

Reliable data are free from artificial trends or changes[14], identification of the quality and consistency of the data required a homogeneity test procedure. It is a significant aspect of data quality control. The most proposed methods are single and double mass curves [15]. In the present study, single mass curve was used to test data homogeneity

3.4 Correlation coefficient (cc)

Pearson cc is used to measure statistical relationship between the two variables, a value of (-1 to +1), where: -1 indicates a strong negative correlation and +1 a strong positive correlation

$$r = \frac{(N \sum x_i y_i - \sum x_i \sum y_i)}{\sqrt{N x_i^2 - (\sum x_i)^2} \sqrt{N y_i^2 - (\sum y_i)^2}} \cdots\cdots\cdots\cdots\cdots (1)$$

Where i = 1,2,3,4 ………N element of the time series , x is precipitation elements and y is temperature elements[16]

4. Results and discussion

The two variables were considered for analysis on monthly and annual basis. it is observed that monthly and annual mean, max and min temperatures have increased, while precipitation trends have decreased. Statistical methods were used to test the relationship between monthly mean temperature and precipitation, monthly average for (mean, maximum and minimum) temperature and precipitation for the period (1970-2019) have been determining by Pearson's Correlation coefficients, was computed and statistically measured using the IBM SPSS software.

4.1 Test of homogeneity

To correct the inconsistent data set in this study, a single mass curve method has been used to test for the homogeneity of the data. Figures (2-5) represent example of 26 figures, which plot annual cumulative for rainfall and for temperature against time, monthly cumulative for rainfall and for temperature against time. All curves were almost straight lines showing that data are homogeneous.

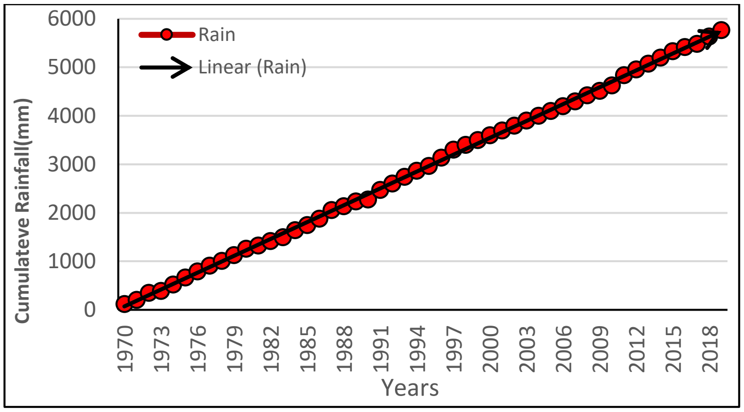

Figure2: Single mass curve for annual rainfall in Basra (1970-2019)

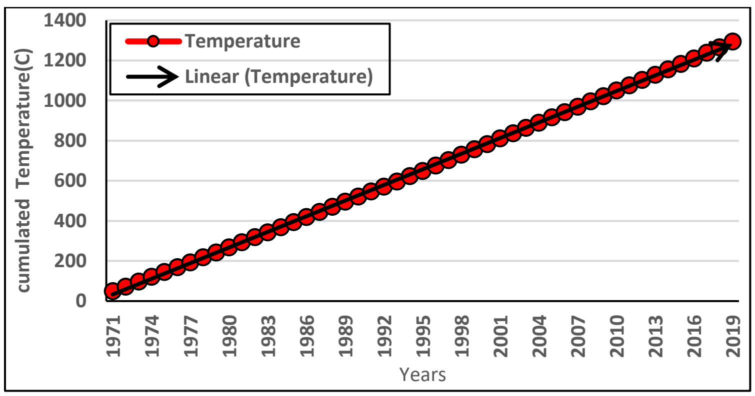

Figure3: Single mass curve for annual temperature in Basra (1970-2019)

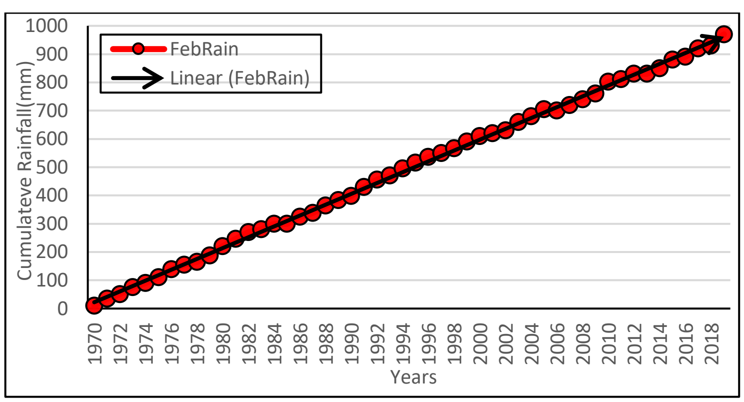

Figure4: Single mass curve for month of February rainfall in Basra (1970-2019)

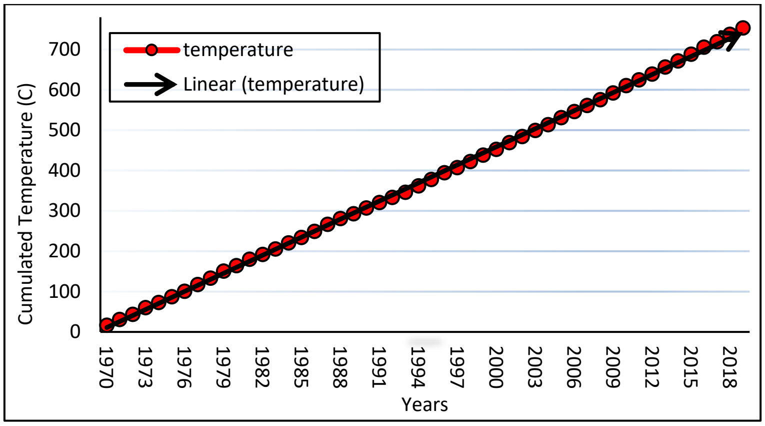

Figure5: Single mass curve for month of February temperature in Basra (1970-2019)

4.2 Monthly rainfall and temperature trends

Plotting seasonal monthly rainfall and temperature, started from October to May for the period 1970/1971 to 2018/2019, advantage of these graphs is that it provides visual assessment of the trends (black arrow) and the fluctuation of the time series. Figure (6) from letter A to H represents the months of October, November, December, January, February, March, April, and May respectively. These months are the rainy season in the province of Basra which includes the three seasons autumn, winter, and spring. In all figures, we note variation from year to year and all data show peaks and valleys according to the increase or decrease in their amount. In addition, all figures show rapid warming in the past few decades, and show that the last decade is the warmest. The result indicates how strong the trend in rainfall and temperature is, and whether it is increasing or decreasing. For baseline in Fig.6 from A to H, the light blue color indicates curve season of monthly rainfall and red curve for season of monthly mean temperature, while the black straight line represents linear trends. It is clear from these shapes that the linear trend shows the magnitude of the rise in temperature and the fall in rainfall except the month of November, (figure B), the linear trend increased. Figures 7 & 8 show the strength of steepness of trend line for temperature and rainfall respectively, in Fig.7 the less one in the temperature trend line slope is the month of November which is the highest rainfall in the period of study (Fig.8) while highest steepness of trend line of temperature is month of October.

In summer (dry season), the climate of Basra is rainless and clear skies prevail , all months show no trend during this season. In Fig.9, there is no rainfall but for the temperature the highest month is August not just for the dry season but in the whole year, and lowest month during this season is September, in addition the trend line for all months increase and the highest slop trend line is August. Increases in temperature is expected to continue to cause changes in the hydrological cycle and affect water resource managers in different ways, including reduced water supplies due to reduced runoff, increased evapotranspiration, and increased urban and agricultural demand.

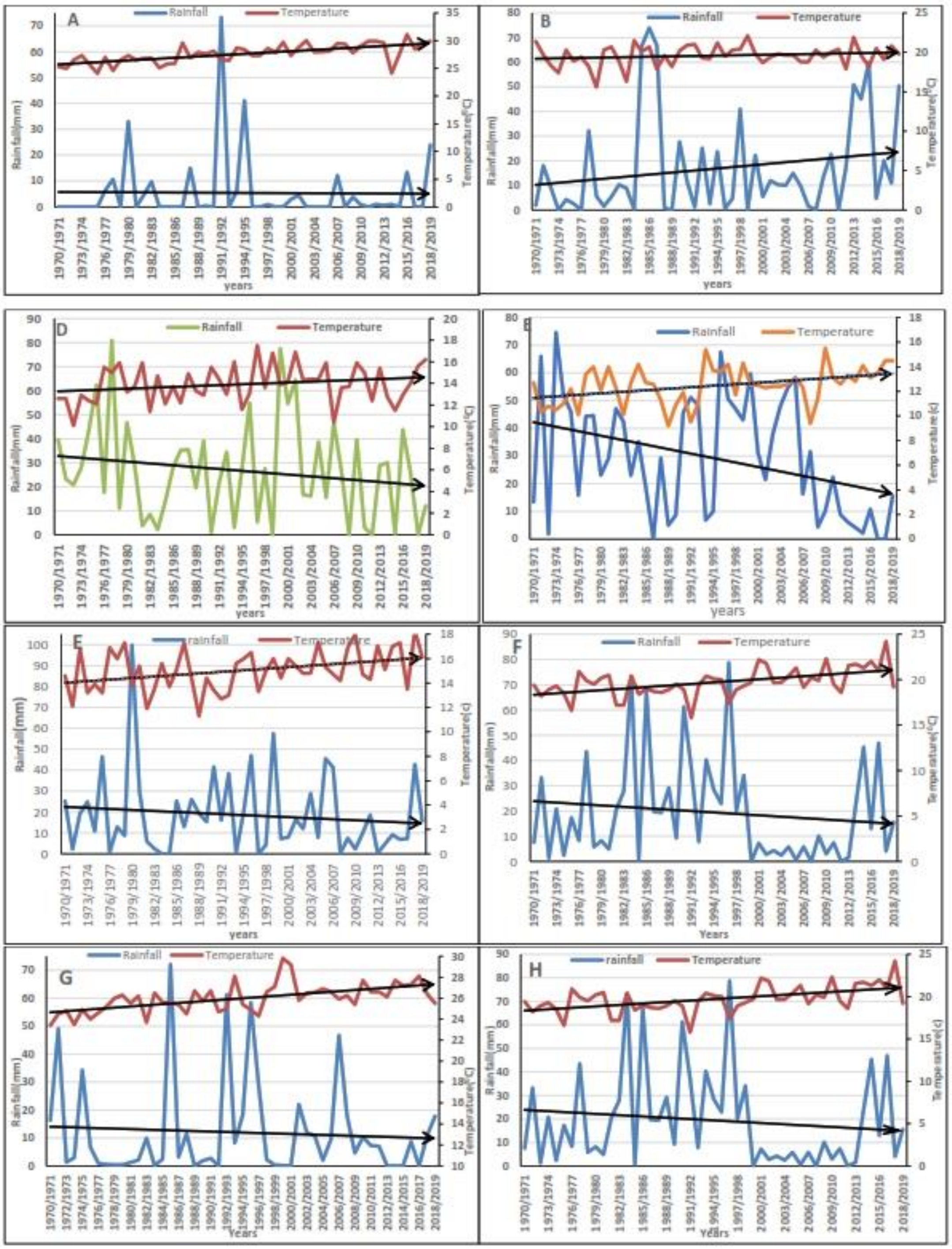

Figure6: Seasonal rainy months and temp. (A to H) represent the months (October ,November, December, January, February, March, April, and May)

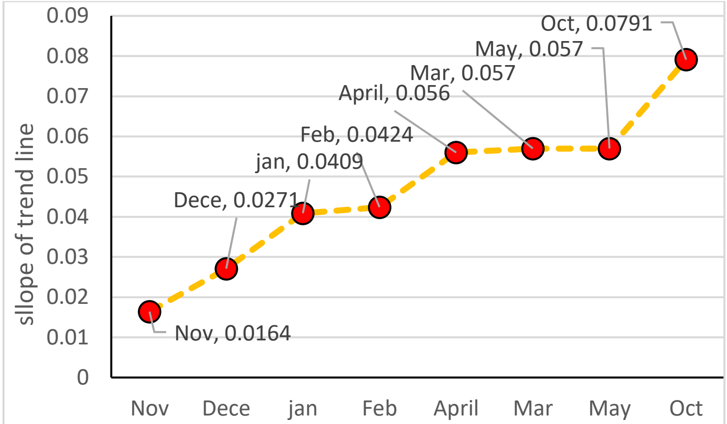

Figure7: Slope of seasonal temp. trend line for the period (1970/1971 to 2018/2019)

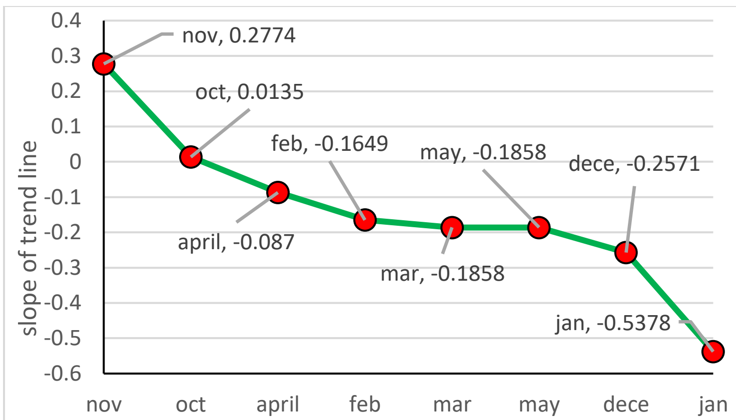

Figure8: slope of seasonal rainfall trend line for the period (1970/1971 to 2018/2019)

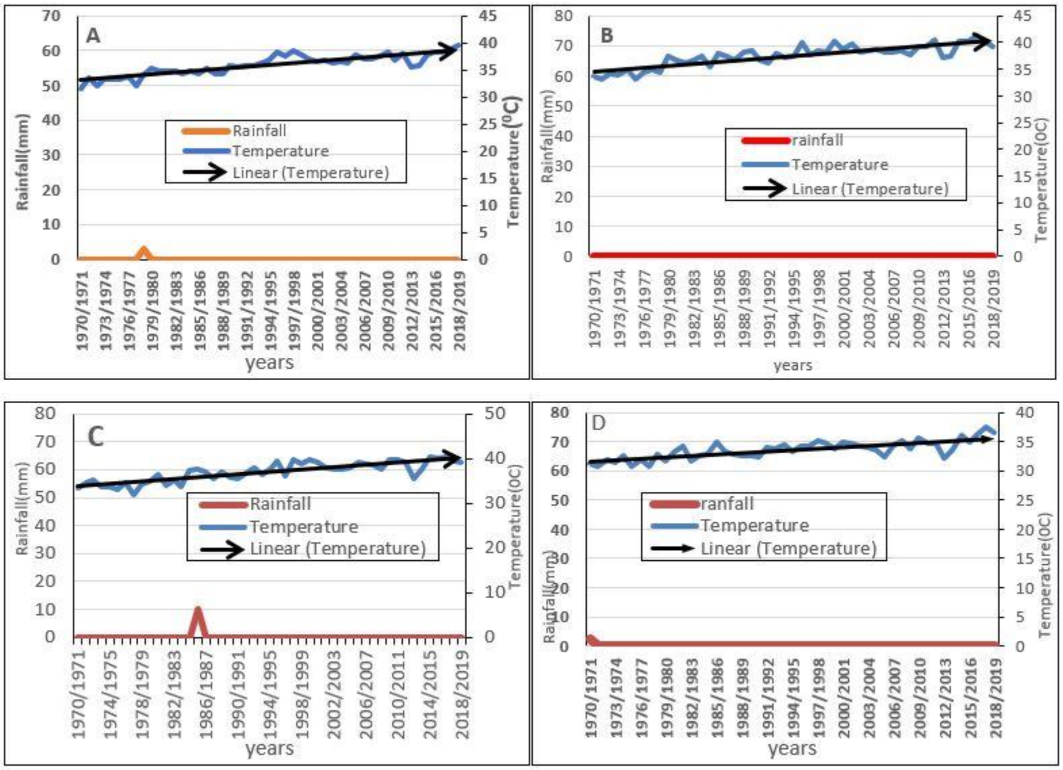

Figure9: Seasonal dry months letters (A to D) represent months of June, July,August and September respectively.

4.3 Annual temperature and rainfall anomaly

Figure 10 shows annual temperature anomaly for the period (1970 to 2019). In this graph, we note the period 1970 to 2019 divided into two parts; the first part extends from 1970 to 1993 marked in red, have negative values, means that the temperature was lower than the average. The second period from 1994 to 2019, the bars marked in light blue are all positive, which means that the temperature is higher than the average and in the last years in the series there was high temperature. The trend line in black color is growing higher than the average form year 1994 and on. Figure 11 shows the annual rainfall anomaly, noticed that there is a fluctuation with an increase and decrease from the average in the period. The values in the light blue color are positive, meaning above the average, while the values in red are negative and are less than the average. The trained line in black color is decreasing.

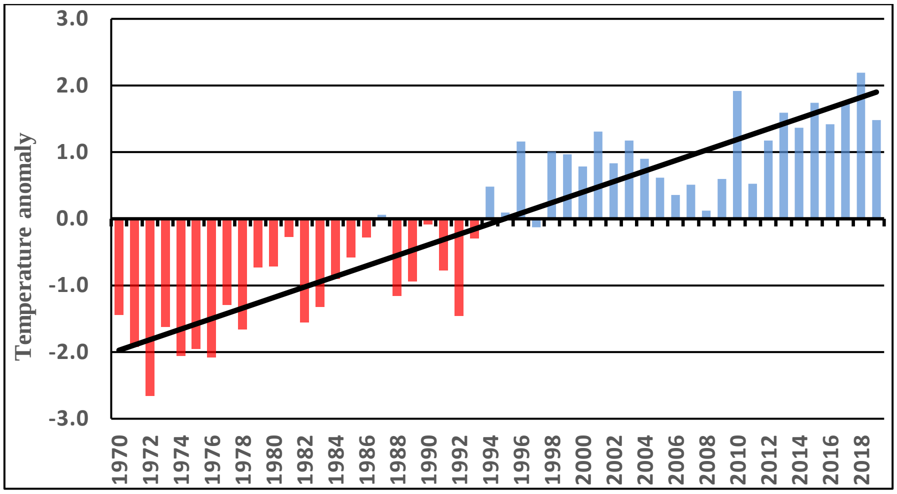

Figure10: Annul temp anomaly for the period (1970–2019), for the baseline, the bars show the anomalies of the years, and the black straight line indicates the long-term linear trends.

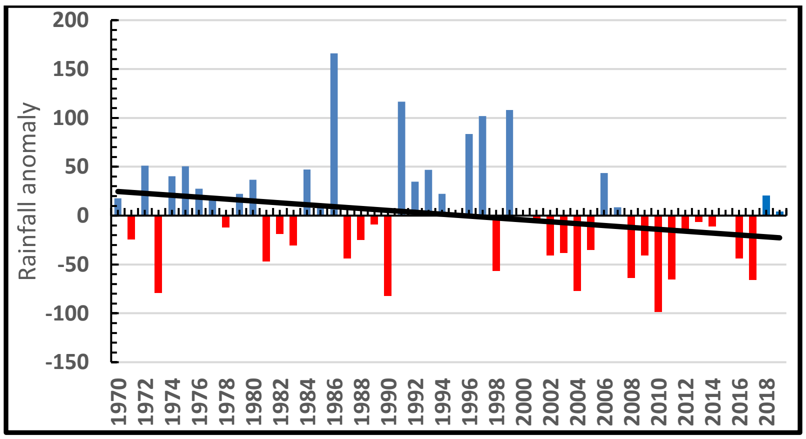

Figure11: Anomaly of annual rainfall for the period (1970–2019), for the baseline, the bars show the anomalies of the years, and the black straight line shows the long-term linear trends

4.4 Analysis of Seasonal Max., Min. and Mean temperature and precipitation

Figure 12 illustrates a consistent temporal pattern of rainfall compared to mean, max. and min. temperatures, the shape of the change in the monthly average of mean, max. and min. temperature with the monthly average of precipitation. We note that the months of rainy season are eight months, starting with the October and ending in May, and the cooler months tend to be associated with more rainfall and vice versa. The greatest precipitation is in January, which corresponds to the lowest mean, min. and max. temperature during the rainy season, as it is represented by the curve, the mean temperature is in green, the max. temperature is in red color and the Min. temperature is in orange. In the remaining months (June, July, august, September) as seen in Fig.12 there are no rainfall and mean, min and max temperature in the peak, these months of the dry summer season. This result is consistent with what was obtained by A.H. Labban and M.J. Butt where the high temperature and the low amount of rainfall are responsible for the strong heating as a result of the convection disturbance happen in the lower layer of the atmosphere[17].

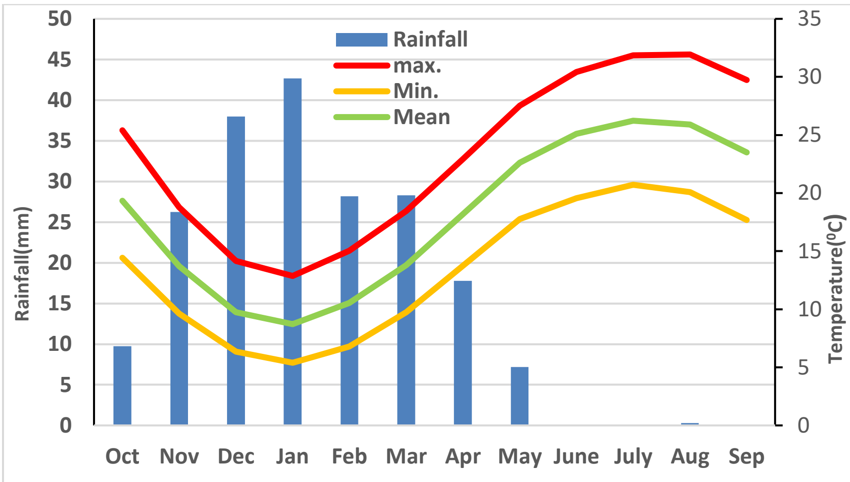

Figure 12 Seasonal monthly average for rainfall and Mean, Max., Min. temperature for the period 1970/1971 to 2018/2019, for baseline, bars indicate rainfall, red, purple and green color curve are Max. Mean and Min. temperature respectively

4.5 Annual rainfall

Figure 13 shows the annual rainfall during the period of the study in descending order, a largest amount in the year 1986 equal to 286.6 mm and the smaller amount 31.9 mm in the year 2010, with intermediate value in other years. It is clear from this Fig., the rainfall in the province of Basra seldom exceeds the largest amount 286.6.

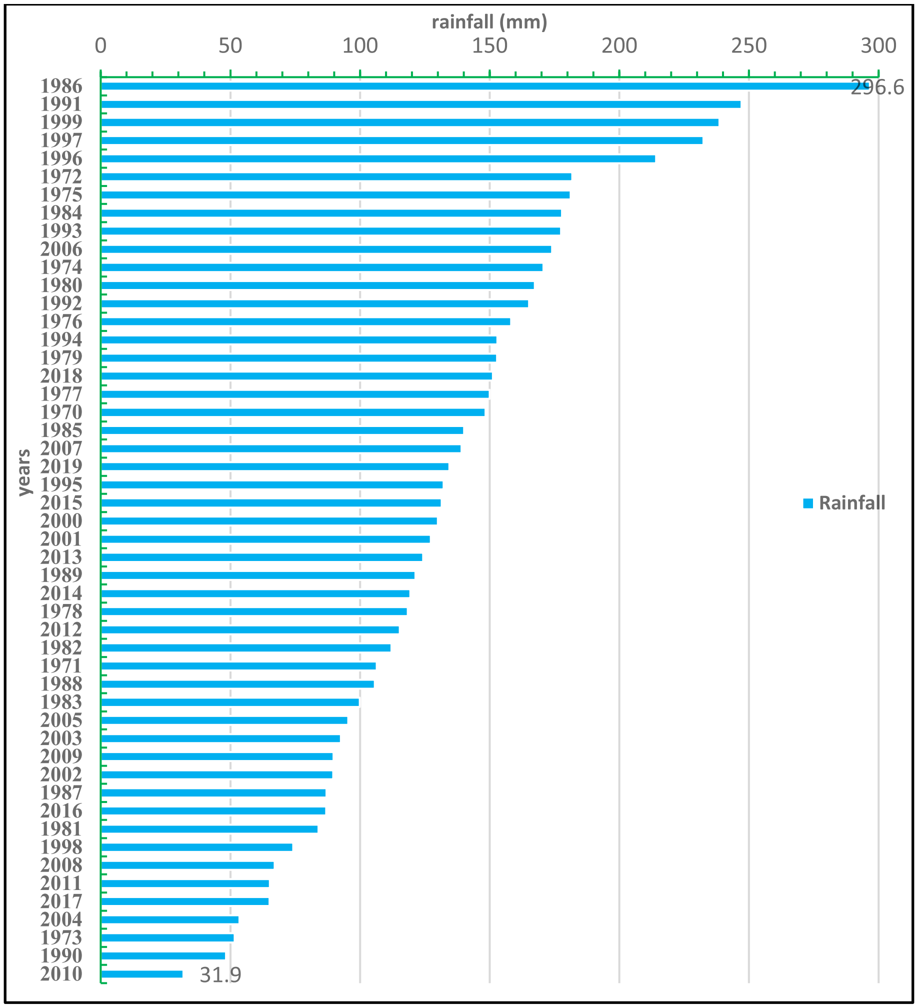

Figure13: Annually rainfall as a descending order for period (1970 to 2019)

This is an indicator that rainfall in the city of Basra is scarce and therefor the agriculture in Basra Governorate does not depend on rainfall.

4.6 Statistical analysis of the data

To identify the form and nature of the relationship between temperature and rain, we used the Pearson parameter, using IBM SPSS Statistics 21 to know how strong it is. Table 1 shows that the monthly seasons of rainfall and temperature have opposite change except for October and November, and all values of correlation coefficient are weak with significant values larger than alpha (0.05) , the strongest is month of April, with a value (-0.315) which indicates an opposite weak relationship and the significant value 0.027 less than alpha 0.05. In addition all standard deviation values for temperature are between (1.3087 and 1.7093) and for rainfall ranges from

(7.8054 to 21.1705). In table 2, found a strong and opposite relationship between monthly average rainfall and mean, max., and min. temperature with significant value less the alpha 0.01 According to that result, it is difficult to perform a simulation between temperature and rainfall because of the interdependence between them.

Table 1: Correlation coefficient between monthly seasons of rainfall and temperature

Month		**Mean**	**Stander deviation**	**correlation**	**significant**
October	Temperature.	27.620	1.6749	0.026	0.861
	Rainfall	5.420	13.0678		
November	Temperature.	19.594	1.3087	0.018	0.9
	Rainfall	16.880	20.1004		
December	Temperature.	13.914	1.7055	-0.199	0.17
	Rainfall	26.600	20.6246		
January	Temperature.	12.455	1.5252	-0.216	0.135
	Rainfall	29.264	21.1705		
February	Temperature.	15.043	1.6636	-0.093	0.525
	Rainfall	18.517	19.2344		
March	Temperature.	19.704	1.5635	-0.251	0.082
	Rainfall	19.402	20.3124		
April	Temperature.	25.992	1.3615	-0.315	0.027
	Rainfall	11.935	17.5966		
May	Temperature.	32.300	1.7093	-0.149	0.307
	Rainfall	4.309	7.8054		

Table2: Correlation coefficient between monthly average rainfall and mean, max., and min. temperature

Temperature	correlation	significant
Mean	-0.980	00**
maximum	-0.986	00**
minimum	-0.976	00**

** Correlation is significant at the 0.01 level (2-tailed).

5. Conclusions

The study confirmed that climate change has a clear impact on increasing temperature and decreasing rainfall in Basrah City. It became clear from the temperature anomaly, the study period 1970-2019 was divided into two stages, the first from 1970 to 1994 in which the annual temperature is lower than the average while the second from 1995 to the year 2019 the annual temperature is higher than the average. Also, we can say from this year (1995) that the temperature has started to gradually increase from its average. There is a strong inverse relationship between the rate of rainfall and temperature. Agriculture in the city of Basra cannot depend on rainfall, because of its decrease and variation in its quantity from year to year.

References

[1] S. Doulabian, S. Golian, A.S. Toosi, S. Murphy, Evaluating the effects of climate change on precipitation and temperature for Iran using RCP scenarios, J. Water Clim. Chang, 12(2021)166-184. doi.org/10.2166/wcc.2020.114

[2] Z.A. Alemu, M.E. Dioha, Climate change and trend analysis of temperature: the case of Addis Ababa, Ethiopia, Environ. Syst. Res, 9(2020)1-15,doi.org/10.1186/s40068-020-00190-5

[3] D. Verner, C. Breisinger, Economics of climate change in the Arab world: case studies from the Syrian Arab Republic, Tunisia and the Republic of Yemen. World Bank Publications, 2013, doi.org/10.1596/978-0-8213-9846-3

[4] G.C Nelson, M.W. Rosegrant, A.Palazzo, I. Gray, C. Ingersoll, R. Robertson, S. Tokgoz, T. Zhu, T.B. Sulser, C. Ringler, S. Msangi, L. You, Food security, farming, and climate change to 2050: scenarios, results, policy options, International Food Policy Research Institute (IFPRI), USA, 2010, doi.org/10.2499/9780896291867

[5]A. Sayadi, N.T. Beydokhti, M. Najarchi, M.M. Najafizadeh Abolghasemb Sayadi, N.T.B. Mohsen, M.M.N. Najarchi, Investigation into the effects of climatic change on temperature, rainfall, and runoff of the Doroudzan catchment, Iran, using the ensemble approach of CMIP3 climate models, J Adv. Meteorol, 2019(2019)16 doi.org/10.1155/2019/6357912

[6] J. Gornall, R. Betts, E. Burke, R. Clark, J. Camp, K. Willett & A. Wiltshire, Implications of climate change for agricultural productivity in the early twenty-first century, Philosophical transactions of the Royal Society of London. Series B, Biological sciences 365(2010)2973-2989, doi.org/10.1098/rstb.2010.0158

[7] S.A Zaheed Hasan, M Islam, Climate change and trend of rainfall in the south-east part of coastal Bangladesh. J European Sci. J, **10** (2014)25-39, doi.org/10.19044/esj.2016.v12n9

[8] Q. Tang, S. Hosseini-Moghari, X. Liu, T.G. Gebremicael, G Leng, A.Kebede, X.Xu, X. Yun, Projected impacts of climate change on drought patterns over East Africa, Earth's Future, 8(2020)1-23, doi.org/10.1029/2020EF001502

[9] E. Ferrari, R. Coscarelli, B. Sirangelo, Correlation analysis of seasonal temperature and precipitation in a region of Southern Italy, Geosci, 8(2018)160-169, doi.org/10.3390/geosciences8050160

[10] R.-G. Cong, M. Brady, The interdependence between rainfall and temperature: copula analyses. Sci. World J., 2012(2012)11, doi.org/10.1100/2012/405675

[11] D. C. Ledger, Recent hydrological change in the Rima basin, Northern Nigeria, Geogr. J., 127(1961) 477-487, doi.org/10.2307/1792801

[12] N.E. Branzuela, F.J.F. Faderogao, Downscaled Projected Climate Scenario of Talomo-Lipadas Watershed, Davao City, Philippines, J. Earth Sci. Clim. Change, 6(2015)268-277, doi.org/10.4172/2157-7617.1000268

[13] W.M.Organization, Guide to climatological practices (WMO-No.100), 2011: World Meteorological Organization Geneva, Switzerland.

[14] H. Alexandersson, A homogeneity test applied to precipitation data, J Climatol, **6**(1986) 661-675, doi.org/10.1002/joc.3370060607

[15] J. Hamisi, Study of rainfall trends and variability over Tanzania. University of Nairobi Kenya ,2013, 67.

[16] H.X. Honghui, Y. Deng, Dependent evidence combination based on shearman coefficient and pearson coefficient, IEEE Access, **6(**2018)11634-11640 doi.org/10.1109/ACCESS.2017.2783320

[17] A.H. Labban, M.J. Butt, Analysis of sand and dust storm events over Saudi Arabia in relation with meteorological parameters and ENSO, Arab. J. Geosci., 14(2021)1-12, doi.org/10.1007/s12517-020-06291-w

تاثير تغيرات المناخ العالمي على درجة الحرارة وهطول الأمطار في مدينة البصرة بالعراق

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المستخلص

تؤثر التغيرات المناخيه على اقتصاديات الدول والمجتمع من خلال مجموعة متنوعة من القنوات حيث يؤثر ارتفاع درجات الحرارة والتغيرات في أنماط هطول الأمطار على المحاصيل الزراعية لكل من المحاصيل البعلية والمروية ، سيؤدي ذلك إلى تغيير إنتاج الطاقة المائية ، ويمكن أن تؤدي زيادة تواتر وحجم الفيضانات وحالات الجفاف إلى زيادة كبيرة في الحاجة إلى الاستثمار العام في البنية التحتية المادية. تم إجراء تحليل للبيانات للتعرف على الاتجاهات في السلاسل الزمنية لدرجات الحرارة وهطول الأمطار التي تغطي الفترة من (1970-2019) في محافظة البصرة جنوب العراق شمال غرب الخليج العربي. تم الأخذ بعين الاعتبار المتغيرين، درجة الحرارة والامطار ، للتحليل على أساس شهري وسنوي. كما تم إيجاد النسب المئوية للاتجاهات الهامة التي تم الحصول عليها لكل متغير شهرياً وسنوياً. بالاضافة الى رسم الشذوذ في درجة الحرارة والامطار. احصائيا تم التعرف على شكل العلاقة بين متوسط درجة الحرارة السنوية وهطول الأمطار من خلال ايجاد معامل ارتباط بيرسون. وقد لوحظ من النتائج هناك ارتفاع في متوسط درجات الحرارة الشهرية والسنوية ، بينما انخفضت اتجاهات هطول الأمطار. علاوة على ذلك ، هناك علاقة سلبية ضعيفة بين معدلات درجة الحرارة الشهريه وهطول الأمطار بينما لوحظ وجود علاقة سالبه قويه بين المعدل الشهري لكل الفتره لدرجة الحراره الصغرى والعظمى والامطار.