

Changing Patterns of Climate in Kuwait

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Abstract: Climatic changes are recognized as a major threat to the survival of species and integrity of ecosystems world over. Little research has been focused to assess the climatic changes in the state of Kuwait. In this context, a study was conducted at the department of biological sciences, Kuwait University to assess the changing climatic patterns of Kuwait. The variations in the average weather parameters between two periods (1962-1998 and 1999-2004) were studied. Distinct variations in the climatic patterns were noticed between these periods. Compared to 1962-1998 period, during 1999-2004 period, there was an increase in period mean maximum temperature by 1.29°C, period mean minimum temperature by 0.73°C and period mean temperature by 1.14°C. The period average rainfall increased by 18.67 mm while the period average pan evaporation increased by 0.97 mm d⁻¹. The period average wind speed increased by 0.21 m s⁻¹ during the second period. The only weather parameter that showed a decreasing trend was relative humidity (period mean relative humidity by 1.14 percent). The change in the climatic patterns of Kuwait environment in terms of increasing temperature, wind speed and pan evaporation may be viewed with serious concerns. The increasing trend in the rainfall pattern is a happy signal from environmental and agricultural point of view. In the context of changing climatic patterns, it is necessary to assess the exact causes of the same and to take possible remedial measures.

Key words: Weather, temperature, wind speed, humidity, rainfall, changing climate.

Introduction

Kuwait is a small country of the Middle East (location: 29° 30' N, 45° 45' E) with a geographical area of 17,344 sq km. Large proportion of the land area is sandy desert involving oil fields. Kuwait Institute of Scientific Research (KISR, 1999) estimated that 2.71 percent of the land in Kuwait is suitable for irrigated agriculture. In the recent years, agricultural activities are gaining momentum in this country. Information on weather is essential especially for the planning and implementation of various agricultural activities. Apparent changes in the climatic parameters of Kuwait were observed in the recent years. Kuwait international airport is regularly recording the weather parameters of Kuwait and KISR (1999) estimated the average weather conditions of Kuwait during 1962-1998. Weather data for the period 1999-2004 is available now for studies. In this context, an attempt

was made to compare the weather data of the recent years with that of the past. This study specifically focuses to compare the weather conditions of 1999-2004 period with that of 1962-1998 period, to assess the change in weather patterns between the two periods.

Methodology

Collection of Climatic Data

The climatic data of Kuwait such as air temperature (minimum and maximum), air humidity (morning and afternoon), rainfall, pan evaporation and wind speed for a period of six years (1999-2004) were collected from Kuwait International Airport. The mean weather data of the six years was worked out. The mean weather data of 1962 to 1998 period reported by KISR (1999) was taken for comparison. The annual and period means of different weather parameters of the two periods were also estimated. The mean weather parameters of 1962-1998

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period and 1999-2004 period were plotted and the differences compared to assess the changes.

Results

Rainfall

The mean data on weather parameters of two periods viz. 1962-1998 and 1999-2004 are presented in Table 1 and Table 2 respectively. The period mean rainfall of the 1962-1998 period was 128.9 mm whereas during the

1999-2004 period it was 147.57 mm showing an increase of 18.67 mm. The rainfall pattern of the two periods (Figure 1) shows that there was more rain during 1999-2004 period in the months of January (46.3 mm) and December (52.9 mm) compared to 1962-1998 period. But during the remaining months, the rainfall was low during the 1999-2004 period compared to the 1962-1998 period. However, an overview of the rainfall data indicates that the rainfall pattern of Kuwait is showing an increasing trend over time.

Table 1: Average monthly weather parameters for Kuwait (1962-1998 period)

<i>Month</i>	<i>Daily max. Temp. (°C)</i>	<i>Daily min. Temp. (°C)</i>	<i>Daily mean Temp. (°C)</i>	<i>Rainfall (mm)</i>	<i>Daily Pan Evap. (mm)</i>	<i>Max Daily RH (%)</i>	<i>Min. Daily RH(%)</i>	<i>Mean Daily RH (%)</i>	<i>Daily Wind speed (m/s)</i>
January	18.1	7.4	12.7	26.1	3.2	86	40	63	3.1
February	20.7	9.1	14.8	18.5	4.6	81	31	56	3.5
March	25.4	13.1	19.2	16.8	6.7	73	24	48.5	3.7
April	31.6	18.2	25	14.9	9.9	63	20	41.5	3.7
May	38.6	24	31.6	5.7	14.3	47	13	30	3.9
June	43.7	27.5	36.1	0.5	19.9	31	8	19.5	5
July	45.3	29.1	37.9	0	20.6	31	8	19.5	4.8
August	44.8	28.6	37	0	18.9	36	9	22.5	4.1
September	42.0	25.1	33.5	0	14.2	47	11	29	3.2
October	35.3	20.0	27.4	8.2	8.9	65	19	42	2.8
November	26.6	14.3	20.1	17.9	5.4	75	29	52	3.1
December	19.9	8.9	14.2	20.3	3	85	38	61.5	3
Mean	32.67	18.78	25.79	128.9	10.80	60.00	20.83	40.42	3.66

Table 2: Average monthly weather parameters for Kuwait (1999-2004 period)

<i>Month</i>	<i>Daily max. Temp. (°C)</i>	<i>Daily min. Temp. (°C)</i>	<i>Daily mean Temp. (°C)</i>	<i>Rainfall (mm)</i>	<i>Daily Pan Evap. (mm)</i>	<i>Max Daily RH (%)</i>	<i>Min. Daily RH(%)</i>	<i>Mean Daily RH (%)</i>	<i>Daily Wind speed (m/s)</i>
January	19.22	8.26	13.69	46.27	3.12	91.18	42.68	66.93	3.14
February	21.45	9.37	15.45	7.67	4.68	83.89	30.12	57.005	3.52
March	27.16	13.28	20.37	14.5	7.64	68.33	20.25	44.29	3.78
April	33.7	19.64	26.79	7.75	11.59	53.92	15.49	34.705	4.15
May	40.67	25.12	33.38	0.9	17.21	36.75	9.07	22.91	4.31
June	44.98	28.46	37.46	0	21.94	26.13	5.8	15.965	5.12
July	46.87	29.71	39.01	0	21.27	32.27	7.75	20.01	4.5
August	46.61	29.77	38.62	0	19.24	40.81	9.58	25.195	4.29
September	42.9	25.75	34.56	0	16.27	43.71	9.28	26.495	3.98
October	37.22	20.87	28.8	1	9.76	64.73	15.52	40.125	3.04
November	26.71	13.96	20.24	16.63	5.51	74.21	27.29	50.75	3.23
December	20.04	9.91	14.84	52.85	3.04	90.1	43.84	66.97	3.33
Mean	33.96	19.51	26.93	147.57	11.77	58.84	19.72	39.28	3.87

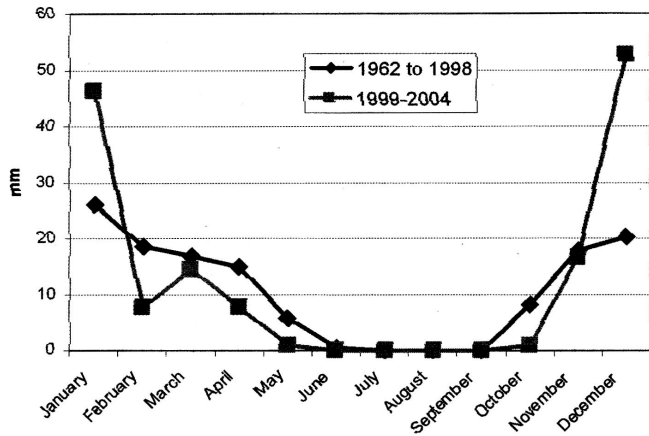


Figure 1: Change in rainfall pattern between 1962-98 and 1999-2004 periods.

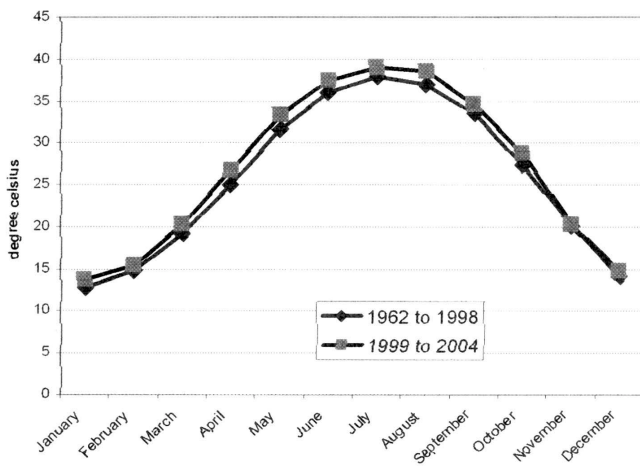


Figure 2: Change in mean temperature pattern between 1962-98 and 1999-2004 periods.

Temperature

The mean data of monthly maximum, minimum and mean temperatures of the two periods (1962-1998 and 1999-2004) indicate that Kuwait is getting warmer in

the recent years (Figure 2). The highest value of monthly mean maximum temperature of 1962-1998 period was 45.3°C in July while during 1999-2004 period, it was 46.87°C during the same month, showing an increase of 1.57°C. Similarly, the highest values of monthly mean minimum temperature of 1962-1998 period was 29.1°C during July while during 1999-2004 period, it was 29.71°C during the same month, showing an increase of 0.70°C. The highest values of monthly mean temperature of 1962-1998 period was 37.9°C while during 1999-2004 period, it was 39.01°C, showing an increase of 1.11°C.

The period average of the daily maximum temperature of 1962-1998 period was 32.67°C while during 1999-2004 period, it was 33.96°C, showing an increase of 1.29°C. The period average of the daily minimum temperature of 1962-1998 period was 18.78°C while during 1999-2004 period, it was 19.51°C, showing an increase of 0.73°C. The period average of the daily mean temperature of 1962-1998 period was 25.79°C while during 1999-2004 period, it was 26.93°C, showing an increase of 1.14°C (Table 3).

Relative Humidity (RH)

The highest value of mean maximum RH of 1962-1998 period was 86 percent in January while during 1999-2004 period, it was 91.18 percent during the same month. Similarly, the highest value of mean minimum RH of 1962-1998 periods was 40 percent during January while during 1999-2004 period, it was 43.84 percent (December). The highest value of mean RH of 1962-1998 period was 63 percent in January while during 1999-2004 period, it was 66.97 percent during December.

The period average of the mean maximum RH of 1962-1998 period was 60 percent while during 1999-2004 period, it was 58.84 percent, showing a decrease of 1.16 percent. Similarly, the period average of the mean minimum RH of 1962-1998 period was 20.83 while during 1999-2004 period, it was 19.72 percent, showing a decrease of 1.11 percent. The period average of the mean

Table 3: Period average of weather parameters for the two periods (1962-98 and 1999-2004) and the difference

Period	Daily max. Temp. (°C)	Daily min. Temp. (°C)	Daily mean Temp. (°C)	Rainfall (mm)	Daily Pan Evap. (mm)	Max Daily RH (%)	Min. Daily RH (%)	Mean Daily RH (%)	Daily Wind speed (m/s)
Mean (1999-2004)	33.96	19.51	26.93	147.57	11.77	58.84	19.72	39.28	3.87
Mean (1962-1998)	32.67	18.78	25.79	128.9	10.80	60.00	20.83	40.42	3.66
Difference	1.29	0.73	1.14	18.67	0.97	-1.16	-1.11	-1.14	0.21

RH of 1962-1998 period was 40.42 percent while during 1999-2004 period, it was 39.28 percent, showing a decrease of 1.14 percent (Figure 3).

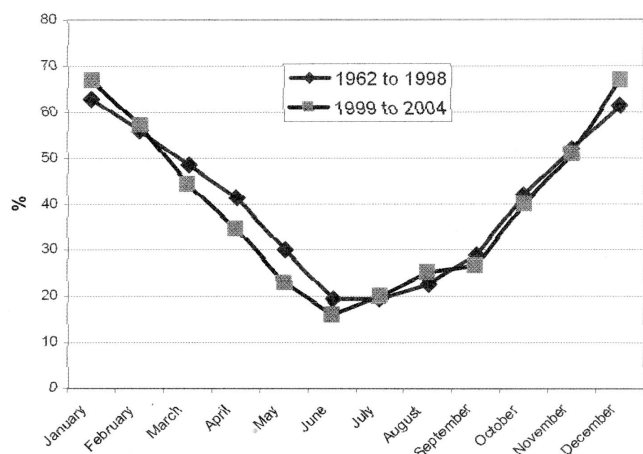


Figure 3: Change in mean RH pattern between 1962-98 and 1999-2004 periods.

Pan Evaporation (PE)

The highest value of pan evaporation of 1962-1998 period was 20.6 mm d^{-1} in July while during 1999-2004 period, it was 21.94 mm d^{-1} during June, showing an increase of 1.34 mm d^{-1} . The period average of the pan evaporation of 1962-1998 period was 10.80 mm d^{-1} while during 1999-2004 periods; it was 11.77 mm d^{-1} , showing an increase of 0.97 mm d^{-1} (Figure 4).

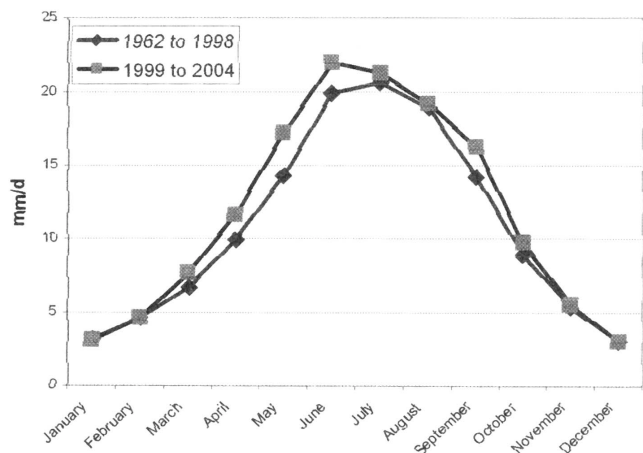


Figure 4: Change in mean Pan Evaporation pattern between 1962-98 and 1999-2004 periods.

Wind Speed

The patterns of wind speed between two periods were also different. The highest value of wind speed of 1962-

1998 period was 4.8 ms^{-1} in July while during 1999-2004 period, it was 5.12 ms^{-1} during June, showing an increase of 0.32 ms^{-1} . The period average of the wind speed of 1962-1998 period was 3.66 ms^{-1} while during 1999-2004 period, it was 3.87 ms^{-1} , showing an increase of 0.21 ms^{-1} (Table 3). The change in wind speed pattern between the two periods (Figure 5) clearly indicates that the wind speed in Kuwait was increasing during the 1999-2004 period.

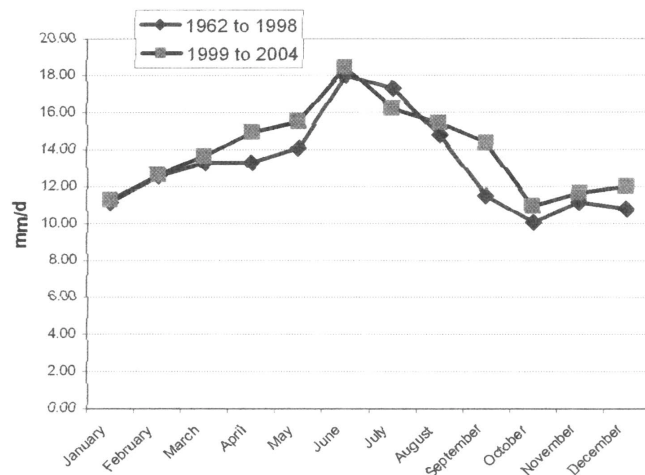


Figure 5: Change in mean wind speed pattern between 1962-98 and 1999-2004 periods.

Discussion and Conclusions

A comparison of the climatic pattern of the two periods (1962-1998 and 1999-2004) clearly indicates that weather parameters like rainfall, temperature, pan evaporation and wind speed show an increasing trend in Kuwait. Increasing trend in the rainfall pattern in the country is a very positive sign, particularly from the agricultural and environmental point of view (Figure 1). This can boost the biomass production of the native vegetation and help to improve the agricultural production.

The change in mean temperature pattern between the two periods (Figure 2) clearly indicates that the temperature of Kuwait is increasing during the 1999-2004 period. This situation causes great concern. It has been reported that global surface temperatures tended upward by about 0.1°C per decade (Jones, 1994 and Parker et al., 1997). Effect of green house gases, particularly CO_2 is thought to cause “global warming”—severe increase in earth’s atmospheric and surface temperatures with disastrous environmental consequences. CO_2 levels have increased substantially since the Industrial Revolution and are expected to continue doing so. It is reasonable to believe that humans have been responsible for much of

this increase and the effect on the environment is likely to be benign. Total human CO₂ emission primarily from use of coal, oil and natural gas and the production of cement are currently about 5.5 GTC per year. Fluctuations in solar activity can cause variations in earth's temperature. (<http://www.oism.org/pproject/s33p36.htm>).

Temperature is not the only climatic variable likely to change as a result of increase in green house gases. In some regions changes in precipitation, relative humidity, radiation, wind speed and /or potential evapotranspiration may be more marked than for temperature. (<http://search.epnet.com/LOGIN.aspx>).

In Kuwait, perhaps the increased industrialization based on use of oil and natural gas, production of cement, enhanced emission from vehicles etc. may presumably be the reasons for the possible higher CO₂ levels and thus temperature increase. Green house gases such as H₂O_v and CO₂ in the earth's atmosphere decrease the escape of terrestrial thermal infrared radiation. Increasing CO₂, therefore, effectively increase radiative energy input to the earth. It is distributed by various physical processes, including advection, convection, and diffusion in the atmosphere and ocean. The hypothesis of a large atmospheric temperature increase from greenhouse gases (GHGs), and further hypotheses that temperature increases will lead to flooding, increase in storm activity, and catastrophic world-wide climatological changes have come to be known as "global warming" (Kyoto Protocol to the United Nations Framework Convention on Climate Change, 1997). However, a review of the research literature (Arthur et al., 1998) concerning the environmental consequences of increased levels of atmospheric carbon dioxide leads to the conclusion that increases during the 20th century have produced no deleterious effects upon global weather, climate, or temperature. Increased carbon dioxide has, however, markedly increased plant growth rates. Predictions of harmful climatic effects due to future increases in minor green house gases like CO₂ are in error and do not conform to current experimental knowledge. There is a close link between local climate and the occurrence or severity of some diseases and other threats to human health. Warmer temperatures are likely to decrease the number of people who die each year from cold weather. However in the United States, only 1000 people die from the cold each year while twice that many die from the heat (USEPA). (<http://www.climate.org/topics/health/index.shtml>).

Kuwait is a tiny nation in the oil rich gulf area with Iraq and Saudi Arabia as the immediate neighbours. Kuwait shares a land boundary of 240 kms with Iraq and

220 kms with Saudi Arabia. It also has a coastal line of 499 kms. The closest neighbour Iraq with about 25 times of land area compared to Kuwait continues to remain in high levels of environmental pollution, with the beginning of Gulf War in 1991. The war still continues, and as a result of excessive oxidation of chemicals and oil-based resources, it is possible to enhance pollution not only in Iraq but also the neighbouring environment at large. Kuwait being the closest, the environmental pollution in Iraq may be the probable cause for the observed climatic changes, particularly temperature in Kuwait. However, only further detailed environmental analysis can confirm the validity of this guess.

Increase in temperature will result in greater rates of evaporation and evapotranspiration (Marrienne et al., 1998) which may deteriorate the water balance situation of this environment. Increase in evaporation and ET could eliminate most bog ecosystems, and increasing water temperature may increase bio-accumulation, and possibly bio-magnification, of inorganic and organic contaminants (Marrienne et al., 1998). The increase in temperature that is observed in the Kuwait environment may pose threat to the biodiversity level of this dry desert ecosystem. It may also aggravate the desertification process resulting in further degradation of the environment. The environmental health of the neighbouring country Iraq would be very critical to decide the environmental health of Kuwait.

The change in RH pattern between the two periods (Figure 3) clearly indicates that the RH in Kuwait is decreasing during 1999-2004 period. While there is an increasing trend in the temperature pattern during 1999-2004 periods, the RH showed an opposite trend. The change in pan evaporation pattern between the two periods (Figure 4) clearly indicates that the PE in Kuwait was increasing during the 1999-2004 period. An increased PE can cause a decreased water balance in the environment. An increased wind speed (Figure 5) can also cause an increase in PE and a decreased water balance.

The study revealed that there is a distinct change in the climatic patterns of Kuwait in the recent years compared to the past. There was an increase in temperature, rainfall, wind speed and pan evaporation during 1999-2004 compared to 1962-1998. The values of relative humidity showed a declining trend. The increasing temperature in the Kuwait environment may be viewed with serious concerns and it is essential to assess the causes of the same and to take possible remedial measures. The positive trend in rainfall pattern is a good sign from environmental and agricultural point of view.

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